Emission Reduction in the Shipping Industry: Regulations, Exposure and Solutions

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Environmental and social impacts from shipping are increasing
Shipping emissions represent 3% of the world’s air emissions and the industry’s share is increasing. Exposure to toxic emissions from shipping is reported to cause cardiovascular and respiratory diseases, especially in densely populated areas. Through the release of greenhouse gases (GHG), the industry also contributes significantly to climate change.

More stringent regulations will apply to ship owners
Regulators, led by the International Maritime Organization, have started to act. Since January 2013, an Energy Efficiency Design Index and a Ship Energy Efficiency Management Plan are mandatory for all ships of 400 gross tonnage and above. From 2015, ships operating in Emissions Control Areas will be required to use fuels with 0.1% or less sulphur content (versus 1% now). From 2016, new thresholds will also apply to nitrous oxide emissions.

A high level of preparedness will be key
Ship owners with the highest level of preparedness (such as having a board committee overseeing environmental, social and governance risks, a strong fleet renewal program with targets, and a relatively low fleet average age) will be best positioned to comply with the new regulations.

New opportunities are emerging
A number of solutions will enable ship owners to comply with the more stringent regulations. To tackle GHG emissions, fuel-efficient engines and propelling systems are the most promising technologies. Low-sulphur fuel, liquid natural gas, and scrubbers will be three options for compliance with regulations governing sulphur oxide emissions. Companies offering such solutions stand to benefit from the push to mitigate impacts from the shipping industry.

With the current global trend towards a reduction of air emissions from all sectors, the shipping industry is experiencing increased pressure from stakeholders in general, and regulators in particular, to tackle its emissions and improve its energy efficiency. Emissions from shipping currently represent 3% of the world’s total greenhouse gas (GHG) emissions, and the industry’s share is increasing. A continued increase in international marine transport without any significant gains in energy efficiency may result in shipping being responsible for 6% of the world’s GHG emissions by 2020 and 15% by 2050.
The past three years have seen a number of new initiatives and regulations implemented around the world. These regulations, together with those anticipated to come into force in the coming months, will have a major impact on the future of the shipping industry.

In this report we will first address the different types of emissions released by ships as well as their associated social and environmental impacts. We will then examine the regulatory context and its consequences on the shipping industry. Finally, we look at the different solutions that are currently available to the shipping industry to tackle its emissions and the opportunities that more stringent regulations are creating for the companies offering such solutions.

Shipping Emissions and Associated Impacts

In the current era of globalization, the shipping industry has become a key component of the world’s economy. Over 90% of global trade is carried by sea. The world fleet of sea-going merchant ships of more than 100 gigatonnes (GT) comprises over 104,000 ships.¹

Like other transportation companies, shipping companies require fossil fuel to conduct their operations. The combustion of fossil fuel used by a vessel’s engines produces greenhouse gases (GHG) as well as non-GHG emissions.

GHG Emissions

Under the GHG Protocol, six gases are categorized as greenhouse gases: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorooctane sulphonate (PFCs), and sulphur hexafluoride (SF₆).²

- Carbon dioxide (CO₂): CO₂ is the GHG most relevant to the shipping industry. Globally, 1,050 million tonnes of CO₂ were emitted by shipping in 2007, doubling 1990 levels. CO₂ emissions represent approximately 3% of the world’s total CO₂ emissions.

- Other greenhouse gases: The shipping industry also emits other GHGs such as CH₄, N₂O, and HFCs. Annual aggregated emissions of these GHGs represent 21 million tonnes of CO₂ equivalent. Emissions of PFCs and SF₆ are considered negligible.¹

![Global CO₂ Emissions from Shipping](source: International Maritime Organization, “Second IMO GHG Study 2009.”)
Non-GHG Emissions

In addition to GHGs, shipping produces other air emissions, most notably sulphur oxides (SO\textsubscript{x}), nitrogen oxides (NO\textsubscript{x}) and particulate matter (PM).

- **Sulphur oxides (SO\textsubscript{x})**: The shipping industry is among the top emitters of SO\textsubscript{x}.\textsuperscript{3} A total of 2.3 million tonnes of SO\textsubscript{2} (the most common sulphur oxide) was emitted by ships in the seas surrounding Europe in the year 2000.\textsuperscript{3} Globally, 15 million tonnes of SO\textsubscript{x} were emitted by shipping in 2007, representing a 50% increase from 1997 levels.\textsuperscript{3} SO\textsubscript{x} emissions from shipping represent between 5% and 8% of the world’s total SO\textsubscript{x} emissions.

- **Nitrogen oxides (NO\textsubscript{x})**: Shipping also accounts for a significant portion of the world’s NO\textsubscript{x} emissions.\textsuperscript{6} A total of 3.3 million tonnes of NO\textsubscript{x} was emitted by ships in the seas surrounding Europe in the year 2000.\textsuperscript{3} Globally, 25 million tonnes of NO\textsubscript{x} were emitted by shipping in 2007, representing a 39% increase from 1997 levels. NO\textsubscript{x} emissions from shipping represent around 15% of the world’s total NO\textsubscript{x} emissions.

- **Particulate Matter (PM)**: In 2000, 250,000 tonnes of PM was emitted by ships in Europe. Globally, 1.8 million tonnes of PM was released in 2007, representing a 50% increase from 1997 levels. The amount of PM released by ships is much lower than that of SO\textsubscript{x} or NO\textsubscript{x} emissions. Note that PM and SO\textsubscript{x} emissions are correlated: a decrease in SO\textsubscript{x} emissions reduces emissions of PM.\textsuperscript{1}

**Global Non-GHG Emissions from Shipping**


Shipping emissions are an important contributor to several major environmental problems. GHG emissions contribute to climate change\textsuperscript{4} (i.e. longer term, less instantaneously visible effects), while non-GHG emissions can cause acid rain, damage to monuments, a reduction of agricultural yields, water contamination, modification of soil biology and deforestation\textsuperscript{5} (i.e. more short term, visible effects). Some non-GHG emissions are also linked to increases in ground-level ozone.\textsuperscript{6}
Shipping emissions can also cause negative social impacts. The effects of climate change, such as drought or rising sea levels, can lead to social conflict over resources (i.e., water, energy, agricultural products). Air pollution from non-GHG emissions can affect the heart and lungs, consequently worsening the condition of people with cardiovascular and respiratory diseases. For instance, in Hong Kong, 519 premature deaths have been linked to marine SO₂ emissions. Additionally, non-GHG emissions can react chemically in the atmosphere to form particulate matter; prolonged exposure to which can affect a person’s mood and cognitive abilities. Another negative consequence of pollution is smog which can reduce the quality of life and inhibit the attractiveness of tourist sites.

The Legislative Context

Shipping emissions are expected to double by 2050, as are the related social and environmental effects. In order to mitigate environmental and social risks associated with these emissions, regulators around the world have started to act. Generally speaking, when it comes to reducing emissions and supporting energy efficiency, regulators deploy four primary policy mechanisms: emissions trading, financial incentives/taxes, emission reporting/monitoring obligations and energy efficiency/emissions standards. We will address each of these policy mechanisms and see how relevant they are for shipping companies. As the most prominent regulators in the shipping industry are the International Maritime Organization (IMO) and the European Union (EU), we will also look at the regulations set by these two bodies. Finally, we will examine the voluntary initiatives that have emerged in some countries.

IMO Regulations

The International Maritime Organization (IMO) is a United Nations-backed organization that is in charge of developing and maintaining a regulatory framework for shipping. The IMO routinely enacts regulations on both GHG and non-GHG emissions (see Appendix 1 for more information on the IMO and its power to establish new regulations).

GHG Emissions

GHG emissions from shipping are currently not regulated by the United Nations Framework Convention on Climate Change (commonly known as the Kyoto Protocol). No new regulations covering shipping emissions were proposed at the most recent UN Climate Change Conference in Durban in late 2011. Inclusion in the Kyoto Protocol is crucial since it addresses the overall obligations of governments with regard to reducing GHG emissions. However, the nature of the shipping industry (emissions from shipping cannot be the responsibility of a specific country) means it is too complex to include its emissions in the Protocol.

Aware of these complexities, the international shipping community believed that the only way to reduce emissions from the shipping industry was to have the IMO direct the measures. The past three years have seen two new policy mechanisms set by the IMO to tackle GHG emissions: the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP). Both mechanisms, which fall under the category “energy efficiency/emissions standards,” are the first ever mandatory GHG regulations for the shipping industry. These mechanisms, which came into effect on 1 January 2013, apply to all ships of 400 tonnes gross tonnage and above. While the EEDI sets a minimum energy efficiency standard for new ships, the SEEMP enables ship owners to measure the fuel efficiency of existing ships and to monitor the effects of any changes in operation. The EEDI, which is probably the most important measure, will allow ship designers and builders to use the solutions that they believe are the most cost-efficient to comply with the regulations. Based on the the EEDI, the CO₂ reduction level
(grams of CO₂ per tonne mile) for the first phase (2015-2019) is set to 10% and will be tightened every five years as outlined in the graph below. The baseline is the average efficiency for ships built between 2000 and 2010. Note that developing countries will not have to implement the standards until 2017, allowing them time to develop shipbuilding capacity. The EEDI and the SEEMP are further described in Appendix 2.

**CO₂ Reduction from EEDI Baseline**
Source: International Maritime Organization

Non-GHG Emissions
Non-GHG emissions are also regulated by the IMO. The most prominent convention, the International Convention for the Prevention of Pollution from Ships (MARPOL), was adopted in 1973 and targets several aspects of air pollution caused by ships. “Annex VI,” which was added to the convention in 1997, addresses exhaust gas emissions such as SOₓ, NOₓ, and particulates as well as emission control areas, volatile organic compounds for tankers and shipboard incineration. This Annex also sets emissions standards to limit air pollution, as outlined below. Regulations apply to both newly built and existing ships.

- There are currently four active Emissions Control Areas (ECAs) in the world:
  - Baltic Sea area: only for SOₓ;
  - North Sea area: only for SOₓ;
  - North American area: for SOₓ, NOₓ and PM;
  - United States Caribbean Sea area: for SOₓ, NOₓ and PM (came into force in January 2013 and will be in effect from January 2014).

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1 An emission control area is a specific area in a sea or ocean where more stringent emissions regulations have been established. ECAs with only sulphur regulations are called Sulphur Emissions Control Areas (SECAs).
The map below shows the current and upcoming ECAs. Some new ECAs in the Mediterranean region, Singapore and Japan may enter into force in the coming years.

**Existing and Future ECAs in the World**

Source: DNV

- There are two main thresholds on sulphur emissions that currently apply to shipping:
  - In Sulphur Emissions Control Areas (SECAs) the maximum sulphur content in marine fuels used must be under 1.00% of total mass (m/m) until 31 December 2014 and reduced to 0.10% m/m or less by 1 January 2015.
  - In areas outside SECAs the maximum sulphur content in marine fuels used must be reduced from 3.50% m/m to 0.50% m/m by 1 January 2020.

**MARPOL Annex VI SO\(_x\) Content Limits**

Source: International Maritime Organization

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• Regarding nitrogen oxide emissions, thresholds depend on the vessel category (Tier I, Tier II, and Tier III) as highlighted in the table below. The category is determined based on the vessel’s construction date and engine speed. Ships constructed before 1 January 2000 with diesel engines above 5000kW are required to have installed a certified Approved Method or a certification stating the compliance with Tier I standards. Ships that will be built after 2015 will be required to comply with Tier III standards in ECAs (outside ECAs Tier II standards can be applied). Note that NOx regulations do not apply to vessels used for emergency operations or to marine engines that underwent major conversions before May 2005.

### NOx Emissions Limit and Tier Calculations

Source: International Maritime Organization

<table>
<thead>
<tr>
<th>Tier</th>
<th>Ship Construction Date On or After</th>
<th>NOx Emissions Limit (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n&lt;130</td>
</tr>
<tr>
<td>I</td>
<td>1 January 2000</td>
<td>17</td>
</tr>
<tr>
<td>II</td>
<td>1 January 2011</td>
<td>14.4</td>
</tr>
<tr>
<td>III</td>
<td>1 January 2016</td>
<td>3.4</td>
</tr>
</tbody>
</table>

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### Regulations in the European Union

Regarding GHG emissions, the EU has set specific targets and is discussing various policy development mechanisms. For non-GHG emissions, the EU generally follows the standards set by the IMO.

#### GHG Emissions

The EU has set a target to reduce GHG emissions by 20% by the year 2020, compared to 1990 levels, and is aiming to reduce shipping emissions by 40-50% by 2050. To achieve these targets, the EU supports the implementation of an emissions trading scheme for the shipping industry, a move similar to what occurred with the airplane industry. However, the EU will not push for a shipping inclusion too quickly given the issues that arose following the inclusion of the aviation industry into an emissions trading scheme.

In October 2012, the EU announced that it was considering the adoption of a system for the monitoring, reporting and verification (MRV) of fuel-based emissions. The EU believes an MRV is a first step towards the implementation of an emissions trading system. With a policy mechanism such as an MRV in place, ship operators would be required to monitor and report their fuel consumption and CO2 emissions, and a third party would need to verify the data. The scope of the MRV is expected to cover only vessels of 5,000 gigatonnes and above, such vessels accounting for 90% of total shipping emissions. The EU has yet to pass a bill that would support the creation of a pilot project for a global MRV. It is likely that any market-based measures proposed by the EU will not enter into force until 2017.

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ii Approved Method is a certification aimed at controlling if an engine operates within NOx Tier I standards. The certificate is used for engines that were previously non-compliant with the standards and underwent approved methods of redesign in order to reach compliance.

iii Conversions include any modification to a marine diesel engine as classified by Regulation 13 in the MARPOL Annex VI.

iv The EU included aviation in the EU emissions trading scheme in 2008. In March 2013, the European entity suspended for one year the regulation requiring payments for carbon emissions for international flights. EU warns that if the United Nation’s International Civil Aviation Organization does not reach an agreement on a realistic timetable for a global market-based measure, the regulation will be reinstated.
Non-GHG Emissions
With regard to sulphur emissions, IMO standards have been incorporated into EU laws, and member states are required to transpose the regulations into national laws. By 18 June 2014 all EU member states must transpose the emissions standards into their national legislations and establish penalties if necessary. After this date, shipping companies might be fined or sanctioned for not complying with emissions thresholds.

Voluntary Initiatives Around the World
In areas where Emission Control Areas (ECAs) are not established and where shipping represents a major source of SO\textsubscript{x} and NO\textsubscript{x} emissions (e.g. in Asia), voluntary initiatives have emerged in an effort to anticipate future ECAs.

In Singapore a voluntary initiative was set up by shipping companies to reduce SO\textsubscript{x} emissions. Singapore port authorities offer financial incentives for companies that use low-sulphur fuel or abatement technologies. Maersk also participates in the Singapore initiative despite its claims that the switch to a more expensive, low-sulphur fuel has resulted in financial losses.

In Hong Kong, Maersk, together with 18 other shipping companies, entered into a voluntary pact (the so-called Fair Winds Charter) to use fuel with up to 0.5% sulphur content (an ambitious threshold if compared to the current legal obligation of 3.5%). The agreement lasted for two years and, in January 2013, 17 of the participating companies decided to extend the agreement until the end of 2013. The government also supported the initiative by offering a 50% reduction in certain fees to ships at berth that used low-sulphur fuel.

Note that Hong Kong authorities are also considering regulations to enforce the use of low-sulphur fuel at berth. In January 2013, the Hong Kong government officially announced its plan to do so. A timeline for implementation is unclear at this stage, but the government has stated that it will submit its proposal after discussing with the maritime sector. If Hong Kong implements these regulations, it will become the first port in Asia where the use of low-sulphur fuel will be required by law.

Assessment
Among the four primary policy mechanisms used by regulators to reduce emissions and support energy efficiency, those that consist of setting new energy efficiency/emissions standards and encouraging reporting and monitoring of emissions are preferred by policy makers in the shipping industry. The table below lists each of these policy mechanisms and highlights their relevance for shipping companies.

Policy Mechanisms and Relevance for Shipping Companies

<table>
<thead>
<tr>
<th>Policy Mechanism</th>
<th>Examples</th>
<th>Likelihood</th>
<th>Severity of Impact</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions trading</td>
<td>• Trading Schemes (e.g. the European Union Carbon Trading Scheme and the US Acid Rain Program) to include shipping emissions</td>
<td>Rather likely</td>
<td>Medium to High</td>
<td>5-10 years</td>
</tr>
<tr>
<td>Financial incentives/taxes</td>
<td>• New taxes on fossil fuel</td>
<td>Rather unlikely</td>
<td>High</td>
<td>Unknown</td>
</tr>
<tr>
<td>Emission reporting/monitoring obligations</td>
<td>• EU’s MRV system&lt;br&gt;• US Mandatory Greenhouse Gas Reporting Rule</td>
<td>Likely</td>
<td>Low to Medium</td>
<td>1-5 years</td>
</tr>
<tr>
<td>Energy efficiency/emissions standards</td>
<td>• EEDI/SEEMP SO\textsubscript{x} and NO\textsubscript{x} standards</td>
<td>Already in place</td>
<td>High</td>
<td>1-5 years</td>
</tr>
</tbody>
</table>
The IMO-backed EEDI and SEEMP and the EU-supported MRV system are the first steps towards global regulations on CO₂ emissions from shipping. Market-based instruments are under discussion and it is rather likely that a cap-and-trade scheme will be implemented in the coming years. However, complications arising from the addition of the airline industry to the EU emissions trading scheme is slowing down the process. SOₓ and NOₓ emissions standards are also being set at both the IMO and EU levels. However, the outcome of an IMO study on fuel availability (due to be released in 2018) may delay the enforcement of the 2020 0.5% SOx limit set by the IMO. The shipping industry has also expressed concerns about whether the supply of low-sulphur fuel will be sufficient to enable compliance. To date, there is no certainty as to whether supply will be sufficient.

For the purpose of this report, we have selected 10 companies across different industries (see Appendix 5). The names of these 10 companies are highlighted in bold in the report.
Together with safety aspects and major oil spills, the issue of SO\textsubscript{x} emissions is the sustainability-related issue that is currently most important to Maersk’s business. Of the 30 sustainability issues listed by the company, the issues CO\textsubscript{2} emissions, energy consumption and NO\textsubscript{x} emissions rank fifth, seventh and eleventh, respectively. Similar observations are made by other companies that disclose a materiality matrix, such as Pacific Basin. As suggested in this graph, issues such as SO\textsubscript{x} emissions are perceived as increasingly material by shipping companies. It is expected that, as soon as regulations on NO\textsubscript{x} becomes more stringent, the issue of NO\textsubscript{x} will rank among the top five most material sustainability issues.

Regulations have significant impacts on shipping companies largely because they affect fuel costs, which represent around 50% of total costs for a shipping company. By 2030, fuel prices are expected to double or triple over the lifetime of a vessel.\textsuperscript{18}

**GHG Regulations**

With regard to the regulations on GHG emissions, the policy mechanism supported by the EU, namely the monitoring, reporting and verification (MRV)/cap-and-trade system, will have impacts on the financial performance of companies. The main consequences will be an increase in operational costs (cash flow risks) and, depending on the legislation, an increase in capital costs.

Major players in the industry such as Maersk,\textsuperscript{19} Mitsui O.S.K.,\textsuperscript{20} and Nippon Yusen\textsuperscript{21} all acknowledge that the international regulations described above will have significant financial impacts. Mitsui states that cap-and-trade schemes and EEDI place its competitiveness at risk, but agrees with Maersk that the regulations can also generate a competitive advantage. Maersk states that regulations will have a direct impact on its performance in the next one to five years and considers the EEDI/SEEMP and the SO\textsubscript{x}/NO\textsubscript{x} emissions standards as having the highest magnitude of impact. However, all shipping companies believe that the exact costs associated with the regulations are difficult to determine.
Companies that are the best prepared to comply with new GHG regulations will be the ones that have an adequate governance structure in place (e.g. a board committee addressing ESG and climate change-related issues), strong fleet management programs backed by group-wide emissions reduction targets, and a good track record in terms of fleet management (e.g. a carbon intensity that is in line or below the industry average). The table below shows the carbon performance of some of the world’s largest stock-listed shipping companies.

### Carbon Performance of Some of the World’s Largest Shipping Companies

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Overall Carbon Performance</th>
<th>Board Oversight of ESG Issues</th>
<th>GHG Emissions Reduction Targets</th>
<th>Fleet Management Programs</th>
<th>Carbon Intensity (tCO2e/USD m. sales)</th>
<th>Carbon Intensity Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.P. Moller - Maersk</td>
<td>Strong</td>
<td>ESG committee</td>
<td>Targets set</td>
<td>Strong programs</td>
<td>In line with the industry average</td>
<td>Insufficient disclosure</td>
</tr>
<tr>
<td>Kawasaki Kisen Kaisha</td>
<td>Relatively strong</td>
<td>ESG committee</td>
<td>Targets set</td>
<td>Strong programs</td>
<td>Above industry average</td>
<td>Decline by 25% or more over the last 4 years</td>
</tr>
<tr>
<td>Mitsui OSK</td>
<td>Relatively strong</td>
<td>ESG committee</td>
<td>No targets set</td>
<td>Strong programs</td>
<td>Well above industry average</td>
<td>Decline by 25% or more over the last 4 years</td>
</tr>
<tr>
<td>Neptune Orient Lines</td>
<td>Weak</td>
<td>No formal ESG committee</td>
<td>No targets set</td>
<td>Activities</td>
<td>Insufficient disclosure</td>
<td>Insufficient disclosure</td>
</tr>
<tr>
<td>Nippon Yusen Kabushiki Kaisha</td>
<td>Adequate</td>
<td>ESG committee</td>
<td>Targets set</td>
<td>Adequate programs</td>
<td>In line with the industry average</td>
<td>Insufficient disclosure</td>
</tr>
<tr>
<td>Orient Overseas</td>
<td>Relatively weak</td>
<td>ESG committee</td>
<td>Targets set</td>
<td>Adequate programs</td>
<td>Above industry average</td>
<td>Insufficient disclosure</td>
</tr>
</tbody>
</table>

Maersk shows the strongest performance, followed by Japanese carriers Mitsui OSK, Kawasaki KK and Nippon Yusen KK. Singapore-based Neptune Orient Lines and Hong Kong-based Orient Overseas are lagging behind, in part due to a lack of transparency.

Several methods can assist shipping companies in reducing their GHG emissions and costs. Maersk states that it uses methods such as speed reduction, route optimization and efficient use of turbo chargers.\(^22\) Pacific Basin states that it reduces its emissions through improved fuel consumption, hydrodynamics and operating practices.\(^23\) Pacific Basin, whose average fleet age is currently 8.2 years, is expected to order 16 new ships between 2013 and 2015. Additionally, Mitsui OSK Lines,\(^24\) Nippon Yusen,\(^25\) Orient Overseas\(^26\) report various methods of reducing GHG emissions. However, some companies, such as Great Eastern Shipping, do not disclose information on emissions reduction methods.

### Non-GHG Regulations

Possibly the most significant change in the industry will be caused by \(\text{SO}_x\) emission regulations and, to a lesser extent, \(\text{NO}_x\) and PM emissions. In order to comply with the \(\text{SO}_x\) regulations, companies will need to opt for either fuel/energy alternatives (e.g. low-sulphur fuel and liquefied natural gas [LNG]) or equip
themselves with scrubbers.\textsuperscript{27} Shipping companies agree that the shift to such technologies will result in increased costs. According to Maersk, opting for low-sulphur fuel will result in an additional USD 250 million in fuel costs. Shipping companies are likely to pass on this increase in costs to customers, and some may request financial support from national governments. In Europe, the changes will apparently have to be implemented without much financial assistance of EU member states. Indeed, in this period of financial crisis, only one EU member, Finland, is committed to provide ship owners with funding.\textsuperscript{28}

Companies that are the best prepared to comply with new non-GHG regulations will be the ones that have, in addition to the criteria mentioned earlier in this report, strong disclosure of all types of emissions (SO\textsubscript{x}, NO\textsubscript{x}, and PM), globally and per region/country, strong programs to mitigate risks backed by targets that go beyond compliance with current regulations (e.g. worldwide use of fuel with a 1% sulphur content outside SECA\textsubscript{s} by 2017), and a good track record in terms of fleet management (e.g. a sulphur intensity that is in line or below the industry average). The table below shows the sulphur performance of some of the world’s largest stock-listed shipping companies.

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Overall Sulphur Performance</th>
<th>Sulphur Emissions Reduction Targets</th>
<th>Sulphur Emissions Reduction Programmes</th>
<th>Sulphur Intensity (tSO\textsubscript{x}/USD m. sales)</th>
<th>Disclosure of Absolute SO\textsubscript{x} Emissions</th>
<th>Disclosure of Absolute NO\textsubscript{x} Emissions</th>
<th>Disclosure of Absolute PM Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.P. Moller - Maersk</td>
<td>Strong</td>
<td>No targets set</td>
<td>Strong programs</td>
<td>Below industry average</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Kawasaki Kisen Kaisha</td>
<td>Relatively strong</td>
<td>Target set</td>
<td>Strong programs</td>
<td>Above industry average</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Mitsui OSK</td>
<td>Relatively strong</td>
<td>Target set</td>
<td>Adequate programs</td>
<td>Above industry average</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Nippon Yusen Kabushiki Kaisha</td>
<td>Adequate</td>
<td>Limited targets set</td>
<td>Adequate programs</td>
<td>Below industry average</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Orient Overseas</td>
<td>Relatively weak</td>
<td>No targets set</td>
<td>Limited programs</td>
<td>Insufficient disclosure</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Neptune Orient Lines</td>
<td>Weak</td>
<td>No targets set</td>
<td>No programs disclosed</td>
<td>Insufficient disclosure</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Maersk and Nippon Yusen show the strongest performance followed by Mitsui OSK and Kawasaki KK. Maersk and Nippon Yusen have the lowest sulphur intensities. Nonetheless, Mitsui OSK and Kawasaki KK are the only companies that have set concrete targets to reduce SO\textsubscript{x} emissions (1% annual reduction for Mitsui OSK and the goal of eliminating all leased ships not using required low-sulphur fuel for Nippon Yusen KK). Neptune Orient Lines and Orient Overseas are lagging behind mainly because of a lack of transparency. Companies generally report on the different options for compliance, which we will describe later in this report.
Opportunities for Fuel and Equipment Providers

As described above, regulations related to GHG emissions and other forms of pollution increasingly require shipping companies to operate more efficiently in order to reduce their environmental footprint. Emerging from these requirements are new opportunities for many companies that supply the shipping industry, including engine/scrubber manufacturers, ship designers/builders and fuel/energy providers. For these companies opportunities lie in the demand for more efficient and pollution-reducing technologies. Failure to offer such technologies could put shipping suppliers at a competitive disadvantage. This section identifies and assesses the various opportunities that have emerged, focusing on technological solutions that address both GHG and non-GHG emissions, and highlighting a number of companies that offer such solutions.

Opportunities Emerging from GHG Regulations

Regulations governing GHG emissions have given rise to a multitude of opportunities for companies serving the shipping industry. Below we focus on opportunities for engine manufacturers, ship builders and coating companies.

Engine Manufacturers

One of the key means to reduce GHG emissions is to improve the efficiency of engines. Technologies exist that can help ship engines potentially reduce emissions by 40%. The market for ship engine makers is currently dominated by seven players: Rolls-Royce, Wärtsilä, MAN, Caterpillar, Mitsubishi Marine Engines, MTU, and Cummins. At present, Wärtsilä, Rolls-Royce, MAN and Caterpillar, are best positioned in the market to benefit from the new regulations on shipping emissions. Wärtsilä and Rolls-Royce currently offer the largest portfolio of marine products. In addition, Wärtsilä, Caterpillar and MAN all offer dual-fuel engines, which can run on diesel and natural gas. This may constitute a competitive advantage for ships operating in and out of ECAs.
Designers and Shipbuilders

The Energy Efficiency Design Index (EEDI) will require ship builders to pay greater attention to energy efficiency, presenting an opportunity for the companies that have invested significantly in R&D over the past few years. The global shipbuilding market, which has a market size of around USD 167 billion, is currently dominated by South Korean companies, followed by Chinese and Japanese companies. Examples of South Korean companies active in this market include Hyundai Heavy Industries, Samsung Heavy Industries, Daewoo Shipbuilding & Marine Engineering, STX Shipbuilding and Hanjin Heavy Industries. Daewoo Shipbuilding & Marine Engineering was the company that built the world’s largest containership: the UK flagged Marco Polo. Launched in November 2012 by French carrier CMA CGM, the vessel has the latest energy efficient technologies: an exhaust gas by-pass system, a ballast water treatment system, an electronically-controlled Wärtsilä engine that can reduce NO\textsubscript{x} emissions, and a pipe plan to facilitate use of hyphenate low-sulphur fuel. The CMA CGM vessel already meets the 2025 target (an EEDI reduction of 30% from a 2000-2010 baseline).

Marco Polo Vessel Features

In addition to South Korean shipbuilders, other Asian companies are well-positioned to benefit from an increased demand in more efficient vessels, for example Sembcorp Marin and Keppel Offshore & Marine. Sembcorp, which has specialized in rig building and vessel maintenance, has recently acquired a 20% equity interest in R&D company and scrubber maker Ecospec Global Technology to strengthen its expertise in regulatory-compliant environmental solutions to ship owners. The company has a net orderbook of USD 11 billion until 2019 and is well-positioned to face future growth due to its presence in Singapore, Brazil and India. Keppel Offshore & Marine, which also specializes in offshore rig design, ship repair, and specialized shipbuilding, has a net orderbook similar to Sembcorp (USD 10.3 billion until 2019).
Aero Dynamism and Wind Power

Shipping companies will also consider other options for improving vessel efficiency, including unconventional and innovative opportunities. One example is marine coating. A recent study has found that the value of the marine coating market could double by 2018 and reach a market size of USD 10.2 billion (as opposed to USD 5 billion in 2011). The global marine coating industry is highly concentrated and is composed of four major players: AkzoNobel, PPG, Jotun, and Chugoku. Among these companies, some offer innovative, environmentally friendly ship coating solutions that can increase the efficiency of vessels, consequently reducing fuel consumption. AkzoNobel is one of them. The company estimates that coating can reduce fuel consumption by up to 9%. Chugoku Marine Paint also offers painting solutions that reduce friction and contribute to CO₂ reduction. The company explains that the paint can prevent the adhesion of living organisms such as shells and algae to the bottom of a ship and thereby reduce friction. Chugoku’s most promising product is called “Thermo Shadan.” This heat-reflective (high solar-reflective) paint, when applied to roofs and walls, can reduce the need for indoor air conditioning. DSM also offers an innovative solution called “Skysails,” which consists of a kite capable of towing giant ships. The company estimates an emission reduction potential of 35%. Some vessels are already equipped with this technology and 3,000 more ships will install Skysails by 2020. As the expected price of a Skysail is approximately USD 250,000, the market size is deemed to represent approximately 1 billion per year until 2020.

Opportunities Emerging from Non-GHG Regulations

Opportunities are also emerging as a result of non-GHG regulations. In February 2012, Lloyd’s Register, a voluntary association of ship owners, ship builders, engine builders, and insurance underwriters, asked 14 of the world’s leading shipping companies about their intention to implement technologies to mitigate non-GHG emissions. The results, which are reported in the table below, point to four types of solutions as the most relevant to comply with upcoming non-GHG related regulations. The first two solutions...
consist of using low-sulphur marine gas oil (MGO), more commonly called low-sulphur fuel, and a fuel mix (dual-fuel) usually made of natural gas and diesel. The third solution is the use of scrubbers and the fourth involves the use of liquefied natural gas (LNG). Low-sulphur fuel is currently considered the best short-term solution for mitigation, with scrubbers being a solution in the medium term, and dual-fuel/LNG being considered longer-term solutions.\(^{37}\)

### Solutions

In order to comply with the new regulations, the shipping industry will need to choose one of three technologies; scrubbers, low-sulphur fuels, or LNG. These three technologies are described in detail below. Appendix 3 provides a complementary SWOT analysis.

#### Scrubbers

A scrubber is a system that uses sea water and chemicals to remove sulphur from engine exhaust gas.\(^{21}\) The scrubber uses a chemical reaction to neutralize the SO\(_x\) present in the exhaust gas. This reaction generates sulphates, which are then discharged into the sea. Scrubbers can be included in new ships or retrofitted into existing vessels.

Scrubbers are generally regarded as a good short-term investment to comply with regulations. BIMCO (Baltic and International Maritime Council) considers this to be a solution that is cheaper than low-sulphur fuel in the longer term.\(^{38}\) However, the use of scrubbers still presents some risk for shipping companies. While Royal Caribbean has used scrubbers and claimed that they show great promise,\(^{39}\) other ship owners see scrubbers as unproven technology.\(^{40}\) Swedish consultancy SWECO points out that the price spread between high- and low-sulphur fuels will, to a significant degree, determine the rate of adoption of scrubber technology. SWECO predicts that adoption of the technology will be postponed until 2015, allowing for improvements in technology and more trustworthy predictions of the price spread.\(^{41}\)

Some studies have also concluded that scrubbers would not be a solution for all vessels. In addition, the type of vessel determines which type of scrubber is best to use — either wet (which can be further classified into closed loop, open loop, or hybrid) or dry. Wet scrubbers use sea or fresh water (further specification depends on its waste disposal method) while dry scrubbers use calcium hydroxide. Research has concluded that for container vessels a hybrid wet scrubber is optimal because of its low cost, for cruise ships a closed-loop scrubber is best for lowering air pollution, and none of the scrubbers are recommended for tug boats due to their small size.\(^{42}\)
Sustainability Assessment

The use of scrubbers has substantial social and environmental benefits as they can reduce SO\textsubscript{x} emissions by at least 95% and PM by at least 80%. Scrubbers can also reduce NO\textsubscript{x} emissions, although there is no consensus as to by how much. Through this significant drop in non GHG-related emissions, the widespread use of ship scrubbers can benefit populations (e.g. by avoiding some diseases) and the environment (e.g. by avoiding acid rain). Furthermore, scrubbers can also help reduce GHG emissions to some extent. However, there is some concern regarding the sulphates being discharged into the sea as they can change the acidity of water. This change in acidity could have an impact on seawater biodiversity, especially among fish species. Research on this particular aspect has been limited so far. Another element of concern is the scrubber’s end-of-life management and the production of the scrubber system itself which might be energy intensive.

Low-Sulphur Fuel

Another option for shipping companies trying to reduce their sulphur emissions would be to opt for low-sulphur fuel. Low-sulphur fuels are typically marine fuels with a sulphur content that is much lower than heavy fuel oil, which has a sulphur content up to 4.5%. Lloyd's List states that since vessel owners typically have little available cash, retrofitting their vessels is not an option, and vessels will be forced to use low-sulphur fuels instead. Compared to scrubbers and LNG, low-sulphur fuel investment costs are considered negligible because most vessels’ engines can run on both heavy fuel (currently the most used fuel in the industry) and low-sulphur fuel. Technically speaking, the use of low-sulphur fuel is therefore the best solution as it requires limited initial investment costs. However, the cost of refining fuel and converting it into low-sulphur fuel represents a significant cost for oil companies. These costs will surely be passed on to shipping companies. It is estimated that prices would rise by 87%. In the end, low-sulphur fuel that is too expensive could cause charterers to reconsider the transport modes for
some products. Road or rail transportation could benefit from this shift. The impact could be especially high for short sea shipping as some studies report that half of the cargo handled by short sea shippers could become handled by trucking companies.

**Sustainability Assessment**

The widespread use of low-sulphur fuel has some social and environmental benefits as it can contribute to lowering SO\(_x\) emissions. However, in contrast to some other solutions, low-sulphur fuel still allows the release of substantial NO\(_x\) and PM emissions and does not eradicate SO\(_x\) emissions. With regard to the shift to other transport modes as highlighted above, the shift to rail transportation might benefit the environment and society (trains emit much lower levels of emissions than trucks) and minimize land use. However, given that most trucks still run on fossil fuels and emit more emissions per kilometre than trains, the shift to road transportation is a concern.

**Liquefied Natural Gas**

Liquefied natural gas (LNG) is another technology that could be used by shipping companies to comply with non GHG-related regulations. DNV, a Norwegian maritime consultant, regards LNG as the most economically promising solution. DNV predicts that the cost of a new vessel equipped with LNG propulsion will require additional investment of between 10% and 50%. Lloyd’s List acknowledges LNG as a possible solution, but claims that its main problem is its high flammability and toxicity. The UK Chamber of Shipping (UKCS) deems the UK fleet unsuitable for LNG due to its age and the lack of a proper supply chain. Despite admitting to LNG’s potential, SWECO also acknowledges the lack of infrastructure available for LNG. Currently, the most developed network of LNG-fuelled ships and LNG bunkering is in Norway, whose flag is flown by 22 of 23 LNG ships operating in SECAs. The Norwegian network consists of mostly small-scale supply at LNG bunkers. DNV admits that LNG might not be a solution for current ships, but regards it as most promising for new vessels.

**Sustainability Assessment**

LNG has some social and environmental benefits. First, the burning of LNG results in no SO\(_x\) and negligible NO\(_x\) and PM emissions. Secondly, LNG has a higher hydrogen-to-carbon ratio, which makes it less CO\(_2\) intensive than oil (CO\(_2\) emissions can be 25% lower with LNG). However, compared to other fuels, the combustion of LNG emits significant amounts of another GHG: methane (CH\(_4\)). Methane has a high global warming potential. So far, there has been too little research done on the life-cycle analysis of LNG to determine if this solution is actually sustainable.

The Appendix 3 includes a complementary SWOT analysis for the solutions highlighted above.

**Companies Involved**

The solutions that are currently on the market will require a number of players to deploy them. Players can be found in five industries: scrubber manufacturers, engine manufacturers, infrastructure builders, designers/shipbuilders, and others.
**Scrubber Manufacturers**

The market for ship scrubbers is currently dominated by four players: U.S.-based company DuPont, Wärtsilä of Finland, Denmark’s Alfa Laval, and Singapore-based company Ecospec. New entrants such as GreenTechMarine are an additional sign of a promising market but face the barrier of high investment requirements. In recent years, the industry has gone through a phase of consolidation, with DuPont acquiring Belco, Wärtsilä acquiring Hamworthy, and Alfa Laval purchasing Aalborg. Wärtsilä also entered into a partnership with Ecospec.

The scrubber market is reportedly expanding. In 2011, DuPont, through Belco, agreed to supply Maersk with a scrubber system. Alfa Laval has a scrubber system in successful operation for the DFDS Ficaria Seaways and has the Spliethoff Group as another client. The company is also involved in a public-private partnership with the aim to develop solutions for cleaner shipping. Wärtsilä claims to have received 20 orders in the first quarter of 2013. The price for installing a scrubber in a ship typically ranges from EUR 1 million to EUR 5 million per ship, depending on the size of the vessel. Given the prospect of equipping every large vessel in the world with this technology, there is a strong interest from scrubber makers to lobby for a regulatory requirement that such equipment be installed. Wärtsilä predicts that the market size will consist of 2,000 vessels over a five years period. As the average turnover value is minimum EUR 2 million per ship, this represents a market size of EUR 4 billion. Alfa Laval predicts a similar market size. However, it might be that not all vessels are suitable for the addition of scrubbers; factors such as the age of a vessel can make the adoption of the technology unfeasible. SWECO estimates the market for scrubbers more conservatively, projecting that 350 ships will have adopted the technology by January 2015. Nonetheless, SWECO predicts a rise of the market as of 2015. The table below compares the three major players in the scrubber market.

<table>
<thead>
<tr>
<th>Scrubber Manufacturers: Comparison Table</th>
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<tbody>
<tr>
<td><strong>Source:</strong> Sustainalytics, Companies</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>DuPont</th>
<th>Wärtsilä</th>
<th>Alfa Laval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total R&amp;D expenditures</strong></td>
<td>USD 2.01 billion in 2011&lt;sup&gt;49&lt;/sup&gt;</td>
<td>USD 248 million in 2012&lt;sup&gt;50&lt;/sup&gt;</td>
<td>USD 110.7 million in 2012&lt;sup&gt;51&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>% of sales invested in R&amp;D</strong></td>
<td>5.3%, in 2011&lt;sup&gt;36&lt;/sup&gt;</td>
<td>4.0%, in 2012&lt;sup&gt;37&lt;/sup&gt;</td>
<td>2.4%, in 2012&lt;sup&gt;38&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Scrubber price range</strong></td>
<td>Total price is not disclosed&lt;sup&gt;52&lt;/sup&gt;</td>
<td>USD 1.32 million to USD 6.6 million&lt;sup&gt;56&lt;/sup&gt;</td>
<td>USD 2.64 million to USD 9 million&lt;sup&gt;36;34&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Collaboration with other organizations on scrubbers</strong></td>
<td>Clients: Maersk&lt;sup&gt;53&lt;/sup&gt;</td>
<td>Clients: Algoma Central Corporation, Ignazio Messina &amp; Co, Meyer Weft (Royal Caribbean), and Wilh. Wilhelmsen ASA&lt;sup&gt;54;55;56;57&lt;/sup&gt;</td>
<td>Clients: DFDS, Spliethoff Group&lt;sup&gt;59&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge partner: Ecospec&lt;sup&gt;58&lt;/sup&gt;</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Verification partner: Norwegian Marine Technology Research Institute&lt;sup&gt;44&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

*Total R&D expenditures, so not only on scrubbers.
Engine Manufacturers
In general, for engines to remain competitive they will need to comply with the new regulations and consequently remain certified with the Engine International Air Pollution Prevention (EIAPP) certification standard. Engine makers that are ahead of technological shifts are likely to gain a competitive advantage.

Ship Engine
Source: Wärtsilä

Beyond reducing GHG emissions, engines can also help reduce non-GHG emissions. For example, LNG-fuelled engines release very little SO\textsubscript{x} and NO\textsubscript{x} emissions.

Rolls-Royce, for whom ship engines represent approximately 4% of its total sales, predicts that regulations will stimulate the search for more efficient and technologically advanced engines. The company sees LNG-fuelled engines as an opportunity. In June 2012 the company sold its first gas-powered engines to Island Offshore.

MAN, which is also in the process of commercializing engines that run on LNG, launched a new engine that can run on a mix of natural gas and diesel. MAN is very well-positioned because of its ME-GI engines that can help reduce SO\textsubscript{x} emissions by 95%.

Wärtsilä, through its Hamworthy Gas Systems division, is co-operating with Rolls-Royce to supply LNG engines for ships. In January 2013, Wärtsilä delivered a LNG-powered passenger ferry to Viking Line. Mitsubishi plans to deliver a LNG-powered marine engine to Mitsui Engineering & Shipbuilding Co., Ltd. and to market the technology aggressively. In addition, Caterpillar Inc. is also focused on developing LNG for the marine industry.
In January 2016, NO\textsubscript{x} regulations will become more stringent and could result in new developments in marine engines. As an answer to the NO\textsubscript{x} requirements, companies such as Wärtsilä, Wilh. Wilhelmsen, and Hitachi Zosen are offering solutions based on Selective Catalytic Reduction (SCR) technology, which reduces NO\textsubscript{x} emissions to a level compliant with IMO regulations.\textsuperscript{65,66,67}

**Infrastructure**

The implementation of solutions to reduce emissions from shipping will in some cases require the development of new infrastructure. Onshore power and improvements in the LNG and low-sulphur fuel supply chains are examples of potential modifications in current infrastructure that can result from a search for more emission solutions. Note that voluntary initiatives in some parts of the world (e.g. in Hong Kong) only looks at the performance of ships at berth.

To comply with regulations relevant to ships at berth and lower CO\textsubscript{2} emissions, onshore power presents itself as an interesting alternative. Instead of burning fuel, onshore power offers the option of ships using inland electricity; therefore, assisting in reducing shipping emissions at berth. The World Ports Climate Initiative lists 18 ports that have installed such infrastructure.\textsuperscript{58} In 2008, Siemens installed the first system to supply shore-side power in Germany in the port of Lubeck.\textsuperscript{69} Furthermore, Schneider Electric has installed shore-side power solutions for ports in California, La Coruna, Shanghai, and Goteborg.\textsuperscript{70} Companies with experience installing onshore power systems have a competitive advantage if the technology proves to be an efficient method of reducing emissions.

Increase in demand for low-sulphur fuel could require Europe to import from abroad due to continental constraints in low-sulphur fuel production. Some experts predict port authorities will be required to invest in distribution infrastructure for low-sulphur fuel.\textsuperscript{71} Although LNG is predicted by Lloyd’s Register to become the long-term choice of fuel, most stakeholders agree that infrastructure to support the supply of LNG is currently lacking. Therefore, further investments in supporting infrastructure will be required to guarantee its supply.\textsuperscript{24} Gasnor, a Shell subsidiary, is the pioneer provider of LNG in Norway and is planning to build a LNG bunker station together with the Brunsbüttel Port in Germany.\textsuperscript{72} The Linde Group, through AGA, also supplies LNG at its terminal in Nynäshamn.\textsuperscript{73} In addition, the EU Commission is committed to invest EUR 2.1 billion with the objective of installing LNG bunker stations in 139 seaports and inland ports by 2025.\textsuperscript{74} Singapore is also in the initial stages of developing its own infrastructure for LNG. A consortium comprised of 21 industry leaders is investigating the feasibility of LNG bunkering in the country.\textsuperscript{75}

**Designers and Shipbuilders**

For the solutions involving the use of the LNG and scrubber technologies, retrofitting the vessels is required, which will have an impact on designers and shipbuilders. In order for vessels to be equipped with scrubbers, certain modifications must be made.\textsuperscript{29} Shipyards could derive competitive advantage from having the experience of retrofitting vessels to include scrubbers. In January 2012, Hyundai Heavy Industries agreed to install a scrubber manufactured by Hamworthy Krystallon, a Wärtsilä subsidiary.\textsuperscript{76} Hamworthy will also supply a scrubber for a container vessel built by STX Offshore & Shipbuilding.\textsuperscript{77}

So far, LNG has been used in niche sector vessels instead of deep sea carriers. However, COSCO recently designed a potential LNG-fueled bulk carrier.\textsuperscript{78} Furthermore, in December 2012, General Dynamics NASSCO agreed to construct two LNG-powered container ships for Totem Ocean Trailer Express.\textsuperscript{79}
**Others**

The new regulations on shipping emissions could also trigger an increase in demand for some companies not categorized in the previous sections. Fuel and lubricant providers are examples of the types of companies that could benefit.

As discussed earlier, demand for low-sulphur fuel is expected to rise, especially in the initial phase of compliance with the new sulphur regulations, leading to an increase in fuel prices. Fuel providers such as BP, Shell and Petrobras offer low-sulphur fuel for marine use and may benefit from the increase in demand. Singapore claims Petrobras will supply its low-sulphur fuel, while fuel in Panama will be supplied by OW Bunker.

One of the main issues in changing from high- to low-sulphur fuels is the lubrication. While high base number (BN) oils are preferred for the usual high-sulphur fuels, low-BN oils are better for a ship’s engine when low-sulphur fuel is used. In 2010, Total Lubmarine attributed a 90% increase in its sales to the fact that its oil worked well with low-sulphur fuels. An increase in the demand for low-sulphur fuel consequently triggers an increase in sales of companies offering low-BN oils.

Shell, through subsidiary Gasnor, could benefit if the shipping industry decides on LNG as its fuel. Gasnor is the market leader of small-scale LNG supply in Norway, which is the most developed LNG market in the world. Shell is followed by ExxonMobil as the largest LNG producing company in the world. Some predictions estimate that demand for LNG bunker fuel would increase by 25 million tonnes if 10% of the world’s shipping fleet were to adopt LNG fuel by 2025.

**Conclusion**

Among the six main solutions that we have outlined in this section, some are more sustainable than others and some require more capital expenditures. The table below lists the advantages and drawbacks of each solution and some examples of companies that can benefit from offering these solutions.

<table>
<thead>
<tr>
<th>Solution Type</th>
<th>Sustainability Assessment*</th>
<th>Investment Requirement</th>
<th>Examples of companies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GHG Emissions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel-Efficient Engines</td>
<td>3</td>
<td>Medium</td>
<td>Wärtsilä, Rolls-Royce, MAN</td>
</tr>
<tr>
<td>Ship Design/Building</td>
<td>3</td>
<td>High</td>
<td>Hyundai Heavy Industries, Daewoo</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Shipbuilding &amp; Marine Engineering,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sembcorp, Keppel</td>
</tr>
<tr>
<td>Coating/Kite</td>
<td>2</td>
<td>Limited</td>
<td>AkzoNobel, Chugoku, DSM</td>
</tr>
<tr>
<td><strong>Non-GHG Emissions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-sulphur fuel</td>
<td>2</td>
<td>Limited</td>
<td>ExxonMobil, Chevron, BP, Shell</td>
</tr>
<tr>
<td>Scrubbers</td>
<td>3</td>
<td>Medium</td>
<td>Wärtsilä, Alfa Laval, Ecospec</td>
</tr>
<tr>
<td>LNG</td>
<td>3</td>
<td>High</td>
<td>Wärtsilä, MAN, Linde, BG Group</td>
</tr>
</tbody>
</table>

*The Sustainability Assessment above is based on a scale of 1 to 3 and considers factors such as emissions-reduction efficiency and social and environmental constraints, with 3 representing more sustainable solutions and 1 representing less sustainable solutions.*
Implications for Investors

CO₂ and SOₓ emissions are viewed by major shipping companies as among the most material sustainability issues that they face, along with safety and oil spill prevention. As previously highlighted, new regulations will require companies to replace their fleets with more efficient vessels and equip their existing vessels with new equipment or fuel types. The new regulations on GHG emissions (SEEMP) will oblige companies to implement new procedures and set new goals to improve efficiency. The use of low-sulphur fuel (which seems to be the best short-term option to comply with SOₓ regulations) will result in additional costs for all companies that operate vessels. It is likely that penalties or non-monetary sanctions will also apply to companies who do not comply with regulations (especially SOₓ regulations in Emission Control Areas).

At the same time, however, these changes are generating new opportunities for companies that offer solutions – energy efficient engines, designs, coatings; low-sulphur fuel producers; scrubber manufacturers; and LNG producers – and therefore for investors as well. In order to pursue such opportunities investors should monitor these technologies and their market uptake, along with the companies that offer them, some of which have substantial involvement in the provision of environmentally friendly solutions. Wärtsilä, for example, offers several types of solutions including SOₓ/NOₓ scrubbers, dual-use LNG engines and ship propulsion systems. Investors should also keep in mind that these solutions involve a broad variety of industries: machinery and capital goods (engines, scrubbers), chemicals (coating), transportation infrastructure (LNG), oil and gas (low-sulphur fuel, LNG), energy equipment (LNG) and transportation (shipping). Note that there are still some uncertainties with respect to which solutions will benefit from non-GHG related regulations. Regulations such as MARPOL Annex VI and the EU Directive on SOₓ do not recommend one particular solution. Which solution providers will benefit the most will depend on several factors such as global economic recovery, government support, competition and innovation among providers, technological barriers, fuel price evolution, the development of infrastructure, and the role of customers.

Investors can also play a key role by engaging ship builders, ship owners, equipment providers, fuel providers and the financial companies that support them. In recent years shareholder resolutions addressing these issues have been filed with a number of ship owners. At Maersk’s 2011 and 2012 AGMs, shareholder resolutions proposed that the company adopt more environmentally friendly technologies by installing windmills on vessels and allocating EUR 13 million toward the research and development of propulsion-based technologies. Below are a number of questions that investors might ask during the engagement process.

Questions for Engagement

**Ship builders**
- Has the ship builder integrated the new EEDI requirements?
- Are the vessels commercialized by the ship builder ahead of competitors in terms of CO₂ reduction?
- Has the ship builder set any targets in line with EEDI (e.g., a 10% reduction in CO₂ emissions by 2015 from a 2000-2010 baseline)?

**Ship owners**
- Is there a board committee in place that oversees CO₂, SOₓ and NOₓ issues?
- Does the ship owner publish data on GHG and non-GHG emissions (SO\textsubscript{x}, NO\textsubscript{x}, and PM) per region and per business unit?
- Has the ship owner implemented a Ship Energy Efficiency Management Plan (SEEMP)? Have EEOI-based targets been set?
- Does the ship owner report data on the percentage of total fuel that is low sulphur fuel?
- Does the ship owner disclose the number of fuel switch programs in place and their status?
- Has the ship owner considered all three options (low-sulphur fuel, scrubbers and LNG) to comply with SO\textsubscript{x} regulations?

**Equipment providers**
- What are the economic and sustainability-related challenges posed by the solutions offered by the company?
- Scrubbers: What is the net order book until 2020?

**Fuel providers**
- What are the economic and sustainability-related challenges posed by the solutions that the company offers?
- Is the company well-positioned to benefit from a growing demand for low-sulphur fuel and LNG?

**Financials**
- Does the bank integrate social and environmental standards in its credit and loan business and its asset management activities?
- Does the bank engage with ship builders and ship owners on the issue of shipping emissions?
- Is the bank a member of the Sustainable Shipping Initiative?
Appendix I

International Maritime Organization (IMO)

The International Maritime Organization (IMO) is a United Nations-backed agency created in 1948. The IMO’s main role is to establish international conventions to improve the shipping industry in terms of safety, security and efficiency. The IMO currently has 170 member states. The process for an IMO convention to be transposed into national law and implemented involves six phases, as illustrated in the chart below.

**IMO Conventions: Stages Towards Enforcement**

*Source: International Maritime Organization, Sustainalytics*

<table>
<thead>
<tr>
<th>Adoption</th>
<th>Acceptance</th>
<th>Entry Into Force</th>
<th>Amendment</th>
<th>Enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 5 years</td>
<td>1 - 2 years</td>
<td>4 - 5 years</td>
<td>1 - 3 years</td>
<td>2 - 10 years</td>
</tr>
</tbody>
</table>

**Adoption**

The IMO is responsible for adopting new conventions. Member states discuss new conventions and amendments within one of the following six bodies; the Assembly, Council, Maritime Safety Committee, Marine Environment Protection Committee, Legal Committee and the Facilitation Committee. So far, a comprehensive set of international conventions has been adopted by the IMO. Key conventions include the International Convention for the Prevention of Pollution From Ships (MARPOL) designed to minimize pollution of the seas, including dumping, oil and exhaust pollution, and the International Convention for the Safety of Life at Sea (SOLAS) focusing on health and safety.

*MARPOL Annex VI: MARPOL Annex VI has been first adopted by the IMO in 1997 and was amended several times since then.*

**Acceptance**

Once a convention is adopted, it first needs to be accepted formally by states. There are several methods through which a state can accept a convention, but signature, ratification and approval are the methods that are often used.

**Entry into force**

Depending on the convention, there are provisions stipulating conditions which have to be met before it enters into force. In general, an IMO convention enters into force once a number of member states whose merchant fleets comprise a certain percentage of global gross tonnage (usually 50%) have accepted it. However, conditions may vary depending on the complexity of the convention being passed.

*MARPOL Annex VI: As of April 2013, 72 of the 170 IMO member states, 72 states, representing 94.3% of the gross tonnage of the world’s fleet, have ratified Annex VI.*
Amendment

As technology is rapidly evolving, there is a need to amend existing conventions. Amending an existing convention usually takes less time than establishing a new convention because of the “tacit acceptance” rule. Following this rule, an amendment can enter into force at any time unless objections to the amendment are received from a specified number of member states. Hence, there is no need to have a certain percentage of member states (usually above 50%) accepting the convention.

MARPOL Annex VI: Since its entry into force in 2005, MARPOL Annex VI has been amended five times, with the most recent amendment being the introduction of the EEDI and the SEEMP in 2011 (see Appendix 2).

Enforcement

The IMO does not have power to enforce the conventions. Instead, enforcement relies on the member parties. Each government is free to decide how to enforce the regulation upon its own ships. Some states choose to set penalties or non-monetary sanctions in case of non-compliance. To make sure that enforcement is effective, the IMO is considering the introduction of a Voluntary IMO Member State Audit Scheme. Audits were already conducted at the end of 2006 and the IMO wishes to make this scheme mandatory by 2015.

MARPOL Annex VI: Countries around the world have started to enforce MARPOL Annex VI:

- **United States:** In June 2011, the US Environmental Protection Agency and the US Coast Guard entered into a Memorandum of Understanding (MOU) to enforce MARPOL Annex VI. Examples of measures include investigations and the setting of penalties in case of non-compliance.\(^{90}\)

- **European Union:** EU member states are required to establish a system of penalties for non-compliance. Fines must be high enough to ensure there is no economic benefits from infringement, and should increase gradually for repeated infringements.

- **Canada:** Transport Canada checks compliance of Canadian vessels through periodic inspections. Penalties can also apply. Canadian authorities can exchange information with US authorities. \(^{91}\)
Appendix 2

New MARPOL Annex VI Regulation (EEDI & SEEMP)

In July 2011, the IMO added a new chapter to its MARPOL Annex VI regulations making an Energy Efficiency Design Index (EEDI) and a Ship Energy Efficiency Management Plan (SEEMP) mandatory for new ships, as described below. The new regulations came into effect 1 January 2013 and apply to ships of 400 gross tonnage and above.¹⁴

Energy Efficiency Design Index (EEDI)

The EEDI is an index that measures a ship’s CO₂ emissions per capacity mile. It is therefore a theoretical measure of energy efficiency that has implications for design. The EEDI requires that ship engines and equipment attain certain energy efficiency levels regardless of the solution used to achieve compliance. The choice of the technology used for specific ship designs is left up to the industry to determine. More specifically, CO₂ emissions per capacity mile, such as tonne mile, will be determined for different ship types and size segments. Furthermore, the efficiency level will be tightened every five years. The aim is to stimulate the continual improvement of ships’ energy efficiency and consequently reduce greenhouse gases. The current EEDI formula can be accurately used for large and energy-intensive ships such as “new oil and gas tankers, bulk carriers, general cargo, refrigerated cargo and container ships as well as combination carriers (wet/dry bulk).”⁷ New formulas will be calculated to fit ships that are not listed.¹⁴

The IMO will allow flag states to be exempt from complying with the EEDI until 1 January 2017.³¹ The EEDI is expected to result in a 10% reduction in energy consumption between 1 January 2015 and 31 December 2019; a further reduction of 30% is expected by 2024.⁹²

Ship Energy Efficiency Management Plan (SEEMP)

The SEEMP is a management plan to be used as a mechanism to improve the energy efficiency of existing ships. The plan will allow ship operators to improve fuel efficiency by monitoring the ships performance over time, consequently making the most informed and optimal decisions to improve efficiency. The SEEMP also forces ship operators to look for new technologies and practices to improve the performance of the ship.⁹³ Although the SEEMP may form part of existing management systems such as environmental management systems and safety management systems, Sustainalytics recommends that companies publicly report on the SEEMP specifically.

According to the IMO, the process of managing a SEEMP follows five steps:

- **Planning:** Planning will help ship owners understand how energy efficient their fleet is and how they can improve energy efficiency. Factors to take into account include the vessel types (container vessels, tug boats, etc.), the status of the different energy-saving measures that can be adopted and the level of engagement with stakeholders (e.g., how long until suppliers are ready for the change).

- **Goal setting:** Setting goals is a necessary step mobilizing resources efficiently and creating incentives. The goal should be measurable and time-bound. Examples of indicators that can be used as goals include average annual fuel consumption and average annual GHG emissions. However, Sustainalytics recommends companies measure progress against the Energy Efficiency Operational Indicator (EEOI), which represents the actual transport-efficiency of a ship in service. Contrary to the EEDI which is a theoretical measure at the design stage, the EEOI is an operational indicator that is universally recognized by the shipping industry.
• **Implementation:** The ship owner should then assign tasks and responsibilities to the qualified personnel. It is important to maintain records of all measures taken.

• **Monitoring/Reporting:** The ship owner should then implement a new system to monitor progress against the goals. Ideally, a ship owner should have a database that keeps track of measurable indicators such as the EEOI. Although the IMO does not oblige ship owners to report on progress in their public documents, Sustainalytics recommends doing so in order to anticipate any future reporting requirements and to keep stakeholders informed.

• **Review:** Like every project, this process should end with a self-evaluation and review phase in which initiatives to improve the current monitoring system can be undertaken.
Appendix 3

Scrubbers

Scrubbers are one of the solutions shipping companies can use to comply with current and upcoming non-GHG regulations. The table below lists the different scrubbers that are currently on the market and the emissions reduction percentages. Results show that all scrubbers deliver significant SO\textsubscript{x} emissions reductions (95%-99.9%) as well as PM reductions (65%-80%). In contrast, levels of NO\textsubscript{x} reduction vary significantly from one manufacturer to another.

<table>
<thead>
<tr>
<th>Scrubber Type</th>
<th>Wärtsilä (Hamworthy)</th>
<th>DuPont (Belco)</th>
<th>Alfa Laval (Aalborg)</th>
<th>Ecospec</th>
<th>Marine Exhaust Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Closed loop\textsuperscript{28}</td>
<td>Hybrid (open or closed)\textsuperscript{34}</td>
<td>Hybrid (open or closed)\textsuperscript{35}</td>
<td>Open CSNO\textsubscript{x}\textsuperscript{28}</td>
<td>Open\textsuperscript{96}</td>
</tr>
<tr>
<td>SO\textsubscript{x} reduction</td>
<td>99.9%\textsuperscript{29}</td>
<td>&lt;97.7%\textsuperscript{77}</td>
<td>98%\textsuperscript{78}</td>
<td>99%\textsuperscript{28}</td>
<td>95%\textsuperscript{28}</td>
</tr>
<tr>
<td>NO\textsubscript{x} reduction</td>
<td>90%\textsuperscript{29}</td>
<td>n/d</td>
<td>n/d</td>
<td>66%\textsuperscript{28}</td>
<td>15%\textsuperscript{28}</td>
</tr>
<tr>
<td>PM reduction</td>
<td>65%\textsuperscript{29}</td>
<td>n/d</td>
<td>&gt;80%\textsuperscript{78}</td>
<td>n/d</td>
<td>&gt;80%\textsuperscript{28}</td>
</tr>
</tbody>
</table>

Source: Company annual reports and websites
## Appendix 4
### Solutions SWOT

<table>
<thead>
<tr>
<th>Scrubbers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength</strong></td>
<td><strong>Weakness</strong></td>
</tr>
<tr>
<td>1. Comply with EU regulations</td>
<td>1. Prices can range from USD 1.3 million to USD 9 million</td>
</tr>
<tr>
<td>2. Continue using cheap high-sulphur fuel</td>
<td>2. USD 395,000 to USD 6.59 million loss of revenue</td>
</tr>
<tr>
<td></td>
<td>3. Insufficiently proven technology</td>
</tr>
<tr>
<td></td>
<td>4. Not applicable for all vessels due to age or availability of space</td>
</tr>
<tr>
<td></td>
<td>5. Stability of vessel compromised</td>
</tr>
<tr>
<td><strong>Opportunity</strong></td>
<td><strong>Threat</strong></td>
</tr>
<tr>
<td>1. Scrubbers fare better than other technologies economically or technically</td>
<td>1. Price spread between high-and low-sulphur fuel</td>
</tr>
<tr>
<td>2. Price spread between high-and low-sulphur fuel</td>
<td>2. Transport shift towards road or rail</td>
</tr>
<tr>
<td></td>
<td>3. Difficulty forecasting maintenance costs</td>
</tr>
<tr>
<td></td>
<td>4. Tightening of regulations making technology not compliant</td>
</tr>
<tr>
<td></td>
<td>5. Scrubbers fares worse than other technologies economically or technically</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liquified Natural Gas</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength</strong></td>
<td><strong>Weakness</strong></td>
</tr>
<tr>
<td>1. Comply with EU regulations</td>
<td>1. Lack of available supply chain and infrastructure</td>
</tr>
<tr>
<td>2. Least harmful to the environment</td>
<td>2. High flammability and toxicity</td>
</tr>
<tr>
<td>3. Most economically feasible in the long term</td>
<td>3. Additional investment of 10-50% for new vessels</td>
</tr>
<tr>
<td><strong>Opportunity</strong></td>
<td><strong>Threat</strong></td>
</tr>
<tr>
<td>1. LNG fares better than other technologies economically or technically</td>
<td>1. Transport shift towards road or rail</td>
</tr>
<tr>
<td>2. Stricter regulations come in place</td>
<td>2. Infrastructure does not develop</td>
</tr>
<tr>
<td></td>
<td>3. LNG fares worse than other technologies economically or technically</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Low-Sulphur Fuel</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength</strong></td>
<td><strong>Weakness</strong></td>
</tr>
<tr>
<td>1. Comply with EU regulations</td>
<td>1. High price for low-sulphur fuel</td>
</tr>
<tr>
<td>2. Investment costs are considered negligible</td>
<td></td>
</tr>
<tr>
<td>3. Already technically feasible</td>
<td></td>
</tr>
<tr>
<td><strong>Opportunity</strong></td>
<td><strong>Threat</strong></td>
</tr>
<tr>
<td>1. Low-sulphur fuel fares better than other technologies economically or technically</td>
<td>1. Insufficient supply of low-sulphur fuel</td>
</tr>
<tr>
<td></td>
<td>2. Transport shift towards road or rail</td>
</tr>
<tr>
<td></td>
<td>3. Low-sulphur fuel fares worse than other technologies economically or technically</td>
</tr>
</tbody>
</table>
Appendix 5
Summary Table – 10 Selected Companies

The table below lists the 10 companies selected for this report and summarizes their exposure to the issue of shipping emissions.

<table>
<thead>
<tr>
<th>Company Name (Solution type)</th>
<th>Country of Origin</th>
<th>Market Capitalization*</th>
<th>R&amp;D Expenditures** (% relative to revenues)</th>
<th>Description (incl. % of revenues derived from relevant activities)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AkzoNobel (Coating)</td>
<td>Netherlands</td>
<td>11,762</td>
<td>EUR 387 million (2.4%)</td>
<td>AkzoNobel is a chemical company that operates in three segments: performance coatings, specialty chemicals, and decorative paints. The company's performance coatings segment offers a number of marine coatings products (10% of the company's total revenues). AkzoNobel can benefit from potential growth in the marine coating market in which the company ranks first in terms of market shares. Nevertheless, this market is relatively limited in size (USD 5 billion in 2011).</td>
</tr>
<tr>
<td>A.P. Moller Maersk (Shipping/LNG)</td>
<td>Denmark</td>
<td>24,166</td>
<td>n/d</td>
<td>A.P. Moller Maersk is a transportation company operating in several segments: container shipping, retail, supply chain management services, infrastructure, and oil and gas. 37% of the company’s revenues are derived from container shipping via the subsidiary Maersk Lines and 17% from infrastructure via the subsidiary APM Terminals. Maersk’s fleet, which comprises over 600 vessels, is 8% more efficient than that of peers. Maersk has five voluntary fuel switch programs in place and it has recently started to test scrubbers. The company is well-positioned to benefit in the long term from a possible growth in the LNG market as some of its subsidiaries also engage in LNG-related services (8% of the company’s total revenues).</td>
</tr>
<tr>
<td>Chugoku Marine Paint (Coating)</td>
<td>Japan</td>
<td>237</td>
<td>EUR 18 million (2%)</td>
<td>Chugoku Marine Paint is a manufacturer producing and selling marine and industrial paints. 99% of its revenues are derived from coating. Chugoku Marine Paint is particularly well-positioned because of its presence in China, South Korea and Japan where demand for marine paints is growing.</td>
</tr>
<tr>
<td>DSM (Coating/Kite)</td>
<td>Netherlands</td>
<td>8,539</td>
<td>EUR 381 million (4.2%)</td>
<td>DSM is a life sciences and materials sciences company. The company’s Performance and Polymers segments (50% of the company’s revenues) offer a broad range of innovative solutions including marine coating solutions like BluCure™ Technology and the Dyneema® Max Technology DM20, which is a new fiber designed for the production of very strong ropes for the marine industry. The company is also a pioneer in wind-power engineering. One of the promising “soft” solutions to reduce fuel consumption shipping companies is its SkySail product, which is a towing kite that fly 100-300 metres above cargo ships.</td>
</tr>
<tr>
<td>Company</td>
<td>Country</td>
<td>Employees</td>
<td>Earnings</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------</td>
<td>-----------</td>
<td>----------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Great Eastern Shipping (Shipping)</td>
<td>India</td>
<td>528</td>
<td>n/d</td>
<td>Great Eastern Shipping Company provides shipping and oil production/exploration services with a particular focus on India. 60% of its revenues are derived from shipping activities. The company has a fleet of approximately 34, relatively young vessels (8.9 years). Great Eastern Shipping does not disclose any information on the use of scrubbers and the implementation of fuel switch programs.</td>
</tr>
<tr>
<td>Keppel Corp (Shipbuilding/design)</td>
<td>Singapore</td>
<td>11,816</td>
<td>n/d</td>
<td>Keppel Corporation is a conglomerate that operates in the offshore and marine, property, infrastructure, and investment industries. The offshore and marine segment represents 57% of its revenues. The company specializes in offshore rig design, ship repair, and specialized shipbuilding and is geared towards emerging markets.</td>
</tr>
<tr>
<td>Kuehne + Nagel (Shipping)</td>
<td>Switzerland</td>
<td>10,277</td>
<td>n/d</td>
<td>Kuehne + Nagel provides integrated logistics solutions including sea freights forwarding. The latter represents 43% of the company’s turnover. Kuehne + Nagel is leading the industry with IT-based solutions and has strong partnerships with global carriers. The company is well-positioned to benefit from a shift to more efficient IT solutions onboard (i.e., route and speed optimization).</td>
</tr>
<tr>
<td>Pacific Basin (Shipping)</td>
<td>Hong Kong</td>
<td>856</td>
<td>n/d</td>
<td>Pacific Basin offers shipping and supply services. 90% of its revenues are derived from shipping. The company’s fleet comprises approximately 261 vessels, and is relatively young (8.2 years). Pacific Basin is exploring the opportunity of using scrubbers onboard. It follows best practices by disclosing the percentage of low-sulphur fuel used relative to total fuel purchased. Results show that low-sulphur fuel represented 5.2% of total fuel used in 2012 (2011: 1.8%).</td>
</tr>
<tr>
<td>SembCorp Marine (Shipbuilding/design)</td>
<td>Singapore</td>
<td>5,566</td>
<td>n/d</td>
<td>Sembcorp Marine is a marine and utilities company. The company offers solutions such as ship maintenance, shipbuilding, and ship conversion. The marine segment represents 55% of the company’s revenues. SembCorp is geared towards emerging markets with a presence in Brazil and India.</td>
</tr>
<tr>
<td>Wärtsilä (Scrubbers/LNG/Engines)</td>
<td>Finland</td>
<td>7,387</td>
<td>EUR 188 million (4%)</td>
<td>Wärtsilä Corporation is a machinery company that offers a range of products to the shipping industry. Due to its strong market presence and its broad range of products, the company is one of the best positioned to benefit from the switch to more efficient shipping technologies. The company offers scrubbers, dual-use LNG engines and ship propulsion systems. Regarding engine manufacturing, the company ranks first in terms of market share (47%) for medium-speed engines and second for low-speed engines (18%).</td>
</tr>
</tbody>
</table>

*in EUR million, data as of May 29, 2013.
**in EUR million, FY 2012 data.
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