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THE ACTUAL TRENDS IN REDUCING THE MARITIME TRANSPORT ASSOCIATED EMISSIONS

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Abstract: *The maritime transport is facing a new and complex environment, which is launching both challenges and opportunities. Among all these existing challenges, the climate change is one of the most important and it's coutermeasures are rising most of the problems, both on a political level and in the day by day life. Due to the obvious developing trends of the marine technology, the ships are rapidly becoming one of the biggest pollution source; the air pollutants generated by maritime transport activities are signifincantly contributing to the increased concentration of the air pollutants.The international bodies are defining the following piers in regulating the emissions level in the maritime transport which comprises several sets of rules and regulations in the field, identifying the funding sources for the required activities, research and development activities in the field of the green techologies and energy efficiency, developing a safety culture towards the marine environment. The companies which are activating in the maritime transport industry will have to align to these trends.*
Key words: *Pollution, Emissions, Marpol, Sustainable, Eco-ship.*

Trends in the development of maritime transport

Since ancient times, maritime transport represented the most cost-effective mode of transport for international trade of goods and raw materials in mass due to reduced costs of transport in terms of the volume of goods transported. Thus, in the year 2013, approximately 90 percent of world trade in terms of volume of freight was carried by sea. (LNG Bunkering Summit, 2014)

Therefore, international shipping, being in a direct connection to trade, developed gradually with the economy. As shown in figure1, the volume of cargo shipped by water evolves according to industrial production, as measured by the index of industrial production of the Organisation for economic cooperation and development (OECD), world trade in goods and world GDP. The figure shows an increase of world trade in goods nearly twice as much in relation to world GDP, which is due to the multiplier effect resulting from globalisation: production processes, increase trade in intermediate goods and components, as well as deepening and extending the supply chain worldwide.

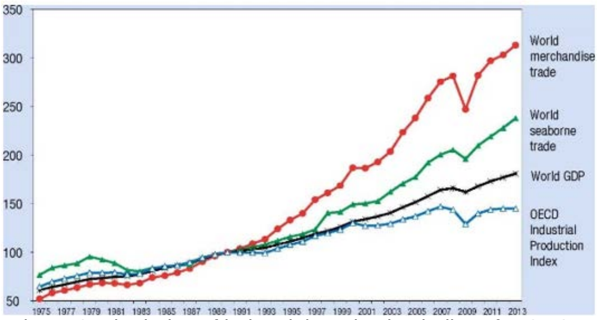


Figure 3. The index of industrial production indices for OECD and gross world product, domestic trade of goods and shipping(1975-2013), (1990=100) source:UNCTAD 2013

Therefore, according to UNCTAD, world maritime trade increased by an average annual rate of 4.3 percent, rising for the first time in the year 2012, to over 9 billion tons. However, in the year 2012, due to the effects of the global financial crisis, economic growth in tonne-miles of shipping has experienced a setback for growth, from 4.9 percent in 2011 to 4.2 percent. The increase in the maritime trade during the crisis is due, in particular, to the increase in domestic demand in China and to the increase in intra-Asian demand, as well as in South-South trade (figure 2). (UNCTAD, 2013)

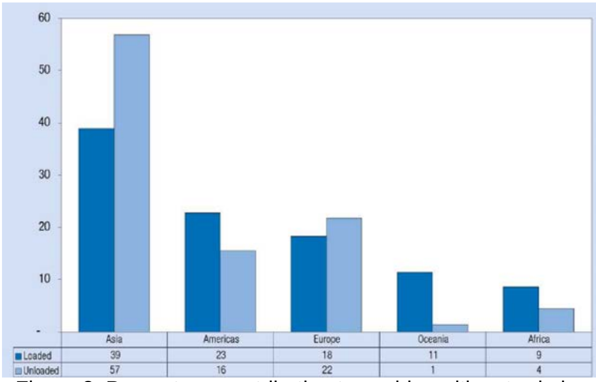


Figure 2. Percentage contribution to world maritime trade by geographic regions in the year 2012 (source: UNCTAD, 2013)

Although trade at sea has performed better than the world economy during the crisis, however, it is still subject to risks due to the persistent decline in facing the world economy and trade.(RMT, 2013)

Looking ahead, there are at present two scenarios concerning the maritime trade of goods worldwide, namely:

- Some analysts predict that the volume of world trade in goods will be more than double between 2010 and 2020, and that China's exports will be evaluated as nearly double in relation to exports from Europe and the United States of America. Also, it is expected that the volume of intraregional trade in Asia will grow rapidly to reach 5,000 billion dollars, and exports to Europe, Africa and West Asia will be about 50 percent higher than its exports to the United States of America (Ernst and Young, 2011).
- Other analysts say that, there are several reasons why trade could decrease: increase "in closed loop economies", in which resources are reused; a greater virtualization of trade based on information technology; and a crisis of critical resources, such as oil and natural gas (see the crisis in Ukraine, Asia minor), geopolitical tensions, which will lead to instability, protectionism and a reduced demand for the transport of goods (DNV Shipping Report, 2012; UNCTAD, 2013).

As a concluding remark, the international shipping is experiencing a new and complex environment, involving both challenges and opportunities. Of all the existing problems, the interconnected challenges of energy security and costs, climate change and environmental sustainability are probably the most important. Climate change, in particular, continues to occupy an important place on the agenda of international policy, starting with the Kyoto Protocol, in 1997. Despite the positive developments on a number of fronts, the world is not yet on track to limit the global average temperature increase to 2°C (over pre-industrial levels), which would provide an easier management of climate change. (The International Energy Agency, 2013).

With the effects of climate change already felt worldwide and in the absence of measures of adaptation and mitigation of climate change, the ports and the international maritime trade are likely to be severely affected by the potentially devastating effects of this change (e.g., extreme weather events and sea level rise).

Therefore, shipping should adapt both to the economic constraints to which it is subject, and to the requirements regarding the protection of the marine environment.

Atmospheric pollution

In recent years, international statistics show that ships are fast becoming one of the biggest sources of air pollution, while emissions from maritime transport contribute significantly to increased concentration of harmful air pollutants.

Ships are the biggest sources of pollution in burning fuel. Because, more than 50% of the running costs of a ship are, in general, represented by the cost of fuel, most ship operators in the world use heavy residue fuel (fuel oil and diesel-MGO, with high content of sulfur-MDO) for ship propulsion and in marine power plants, for their benefits in fuel economy. These fuels contain high levels of asphalt, carbon residue, sulphur and metallic compounds and properties of high viscosity (up to 700 cSt), cetane, and low volatility. During the combustion process in marine diesel engines, in boilers and incinerators, these fuels can produce significant amounts of black smoke, particulate matter (PM), nitrogen oxides (NOx), unburnthydrocarbons (UHC), sulphur oxides (SOx), carbon monoxide (CO), carbon dioxide (CO) etc. (Chul-hwan HAN, 2010) In total, the exhaust gases from diesel engines contain an estimated total amount of 450 different compounds, and nearly 40 of them are toxic contaminants, which have adverse effects on human health and the environment.

Of all these compounds, SOx, NOx, CO2 and PM are the most harmful, because CO2 contributes essentially to the formation of greenhouse gases that affect the natural environment, while particles in suspension of NOx, SOx and PM affect human health, particularly those living in coastal areas and near ports.

There is anincreased concern related to emissions from ships, because of their significant growth as a result of the increase in the volume of goods transported worldwide.

At EU level, by 2020, emissions from the international maritime transport in Europe is expected to equal or even exceed the total of all land-based sources in the 27 EU Member States combined.

Shipping is responsible for about 13% of all global emissions of greenhouse gases. Thus, the current level of CO2 is estimated at 1,050 million metric tons (mmt), of which 870 mmt are due to shipping and 180 mmt transport by inland waterway. Over the long term, the amount of CO2 will reach values up to 2500-3650 mmt.(IMO, 2009)

Givenan annual growth rate of the World economy of 2-4%, by the year 2050, the amount of greenhouse gasescoming from shipping will increase two or three times (figure 4). (DNV, 2010)

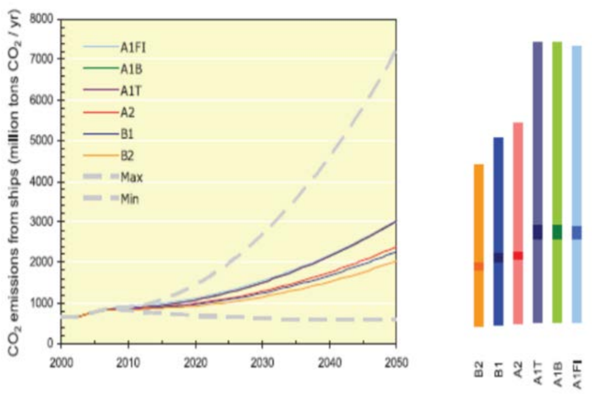
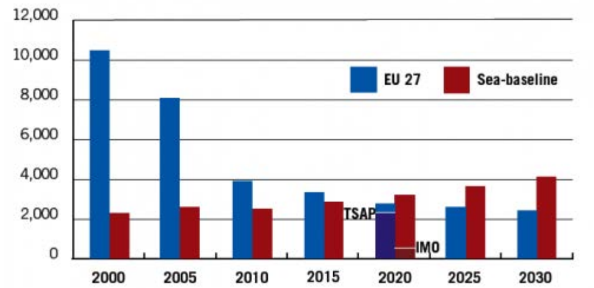


Figure 4. CO_2 emissions from shipping - 6 scenarios used by IMO for 6 scenarios of economic growth of the maritime industry(source: IMO 2009)

Major increases are forecast for other relevant substances: NOx, SOx, NMVOC, PM etc. (IMO 2009).

Emissions from ships engaged in international trade in the seas around Europe-Baltic Sea, the North Sea, in the North-East Atlantic, the Mediterranean and the Black Sea have been estimated to reach in 2020, 2.3 million tons of sulphur dioxide and 3.3 million tons of nitrogen oxides (figure 5 and figure 6). (Air Clim, 2011).



EU27 = Emissions from land-based sources in all EU countries (incl. domestic shipping).

Sea = Emissions from international shipping in European sea areas.

TSAP = Target in line with the EU Thematic Strategy on Air Pollution from September 2005.

IMO = Expected outcome from implementing MARRPOL Annex VI as revised in October 2008

Figure5. Development of scenarios of emissions SO_2

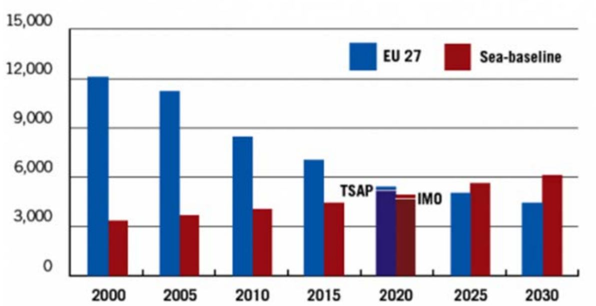


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Figure6. Development of scenarios of emissions NO_x

If developments would continue in the same manner, by the year 2020, sulphur emissions from transport in EU maritime areas would exceed those of all land-based sources.(Green report, 2012).

Emission reductions, taking into account the expected increase in transport volume, will be difficult to achieve.

International regulatory authorities in the field of naval and environmental protection have made efforts in recent years to impose a number of requirements, rules and standards of good practice which would lead, on a medium- and long-term basis, to reduce emissions of greenhouse gases and other air pollutants coming from vessels.

The objective of limiting the global temperature by 2°C lead to the signing of an ambitious agreement in 2014, at the European Union level, which stated that, by the year 2030, the level of greenhouse gas emissions would be reduced by 40% as compared to the reference level, reached in 1990.

Thus, the IMO annex VI of Marpol 73/78: "Rules for preventing air pollution with exhaust emissions from ships", reviewed in 2011, with the amendments regarding the implementation of "technical and operational measures on board vessels for energy efficiency", imposes requirements and standards on board ships in order to reduce air pollution.
NOx emission limits (regulation 13-Marpol Annex IV) are set out for diesel engines, depending on the maximum speed of engine operation (n, k). The limits of grade I and grade II are global, while Tier III standards only applyto EU-emissions control area (figure 7).(International: Marine: Emissions)
The Annex VI Regulations (Regulation 14), include limits on the sulphur content of heavy fuel oil as a measure to control the emission of SOx and, indirectly, emissions of PM (there are no explicit limits on emissions of PM). There are special provisions relating to fuel quality for the control of emissions of SOx. (International: Marine: Emissions)

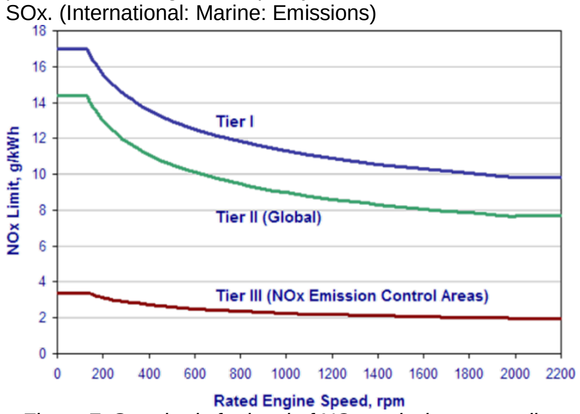


Figure 7. Standards for level of NOx emissions according to engine speed

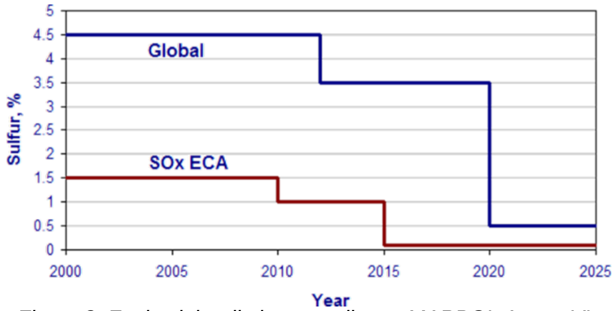


Figure 8. Fuel sulphur limits according to MARPOL Annex VI

In order to limit the CO2emissions, in 2011, through the amendment to Annex VI, Chapter 4 (Resolution MEPC. 203 (62)) was introduced to design index (EEDI) energy efficiency expressed in grams per mile of vessel capacity.
The reduction of CO_2 (grams CO_2 per tonne-mile) in the first phase will have an energy efficiency of 10 percent at the beggining of 2015, and will increase every five years (20%-30% by 2020-2030) in order to keep pace with the technological developments and with the measures to reduce CO_2 pollution. (International: Marine: Emissions)
Although the implementation of MARPOL Annex VI is a start, the problem is far from being resolved. Given the increasing naval activities without strict control, shipping emissions were likely to become a growing problem in the near future.
All of these legislative measures will affect shipping, therefore their implementation is a continuous topic of debate.

Sustainable development

In the context of booming business opportunities in the developing economies and emerging markets, and also taking into account the existing risks and uncertainties, as well as the requirements of the increasingly stringent environmental protection requirements, the shipping industry will have to adapt to the changes in world economy, but also to implement measures for the protection of the environment.

The changing context in which shipping must operate is summarized in seven global trends that we believe will profoundly affect the maritime industry over the next 30 years (figure 9). Each of these will have direct effects, which will be at least as important as the way these trends will combine and interact to create change and significant challenges.

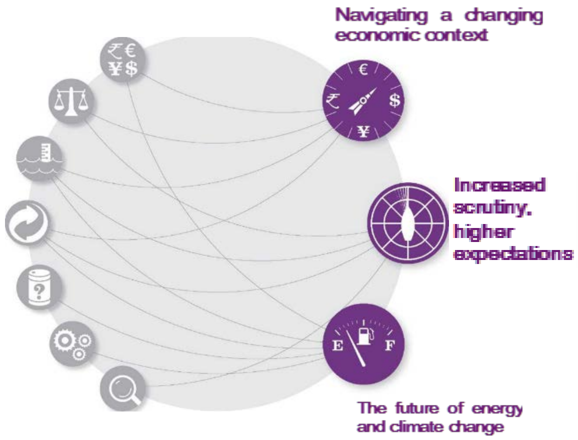


Figure 9. Global trends facing maritime transport *(source: SSI, 2014)*

These trends are: 1. modifying the transport routes due to relocation of trade goods to Asia and to the developing countries of Latin America and Africa; and the global economy change due to new trade patterns and a changing demand for goods in transit; 2.the differentiated competition conditions imposed by regional legislations; 3. transparency demands imposed by technological developments in the field of IT, through which the companies'performance can be monitored in real time and at affordable prices;4.the climate change requiring the conformation tostricter laws in the field of protection of the marine environment; 5.the rising fuel prices require switching to alternative fuels and to more efficient technologies for ship propulsion and auxiliary aggregates on board; 6. the emergence of legislation on energy efficiency of ships and the alternative energy technologies that reduce fuel consumption and bring radical improvements in the sustainability of transport requires major investment, and last but not least, the international law imposed by the IMO; 7.Higher requirements of standards: the rules of sustainability - due to increasing pressure on global resources, these rulesare likely to lead to higher standards of sustainability.
To cope with these developments, under the initiative of a sustainable transport, „Sustainable Shipping Initiative" (SSI), major companies across the industry and around the world are reunited in two top NGOs Forum for the Future, and WWF, to plan the mode of transport which to thrive and contribute to a sustainable future(SSI, 2014). Therefore, the development in the future of shipping must be based on the principles of a sustainable development, to which are added all the forms and methods of development, whose main objective is focused on ensuring a balance between the social, economic and ecological and the natural capital elements. The goal of global development strategies aimed at transforming the system of shipping and port activity into a high-performance system, to ensure increased mobility, to support growth and facilitate the creation of new jobs, in compliance with environmental regulations.
International bodies highlight the following pillars to support the development in the field: the creation of a regulatory framework according to the principles of sustainable development, strengthening the mechanisms for financing and insurance activities, research and innovation in clean technologies and energy efficiency, the development of a culture of safety and protection of the marine environment.
Therefore, the future strategy for the development of the shipbuilding industry can only be achieved on the basis of a dynamic model of aneconologic type, which takes into account

three components: ecological, economic and technological, figure10.(Nicolae F. et al, 2013).
This pattern represents a complex method of further study of the economic and ecological phenomena in a close interdependence, which is an easy means of forecasting the future economic growth and development of shipping and of the shipping industry in general. (SSI, 2014).

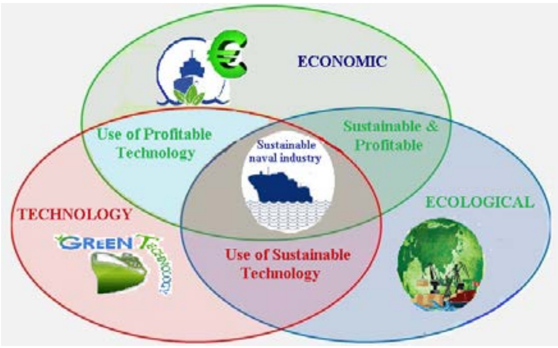


Figure10.The econologic approach to the problem of shipping/shipping industry

In terms of the implementation of the concept of sustainable development in maritime transport, the European Union, through the European Commission's report with regard to research and innovation for European mobility of the future, has developed a strategy which highlights, inter alia, three directions of research and innovation for shipping. (C.E., 2012):

- the ship, the implementation of components, materials, technologies, alternative propulsion systems and fuels, which will facilitate the achievement of smart, safe, less polutting ships, as well as a more effective interface with the port infrastructure.
- at the level of the shipping infrastructure progress is needed concerning the achievement of an intelligent, ecological, resistant to climate change and reduced maintenance costs. The aims in this area provide port facilities for: using alternative fuels, development of information systems and modal traffic management and developing solutions related to infrastructure optimization.
- the level of service and shipping operations are aimed at: increasing efficiency, avoiding discontinuities for freight, the integration of transport modes, designing a suitable approach to achieve the adequate conception of transshipment nodes and equipment, integrated multimodal information management, traffic and demand.

An example of the implementation of new technologies aboard ships is the Hercules project, sponsored by the European Union, which aims to develop technologies to significantly reduce the emissions of gases and particules from marine engines with increased efficiency and reliability. This project, which began in 2002, has spurred unprecedented cooperation between the rival naval engineering firms, and is currently in the third phase of development. This phase of the project aims at improving the production and sustainability in energy savings through systemic integration of technologies to optimize thermal processes in marine engines, developed in phases I and II, taking into account the reliability and the service life of the engine, as well as a significant reduction in exhaust emissions. (Doug Woodyard,2009; www. Hercules-c.com).
Therefore, sustainable development of the shipping industry and the shipping involves a new approach to environmental issues and promoting eco-navigation-concepts: Green Shipping and eco-friendly ship - Green Ship or Eco-ship (Nicolae F. et al, 2013). The two concepts can be implemented only through an integrated approach geared towards supporting water transport through reduction/limitation of the pollutant vectors and of the negative impact on the environment.
Eco-ships must implement technical solutions that can contribute to reducing fuel consumption and pollutant emissions, redesigning the bridgeand deck systems, optimizing the managerial and technical conditions for sailing, harnessing energy from renewable sources.
Redesigning the bridge and deck systems provides: thruster operation optimization, propulsion machinery and auxiliary equipment optimization, high quality lighting systems, high efficiency, innovative propulsion systems.
Managerial and technical optimization of navigation conditions is achieved by cleaning the hull, by updating the autopilot system, by optimizing the hydrodynamic shapes, the special coatings, by the determination of the optimum route in terms of hydro-meteorological conditions of navigation etc.

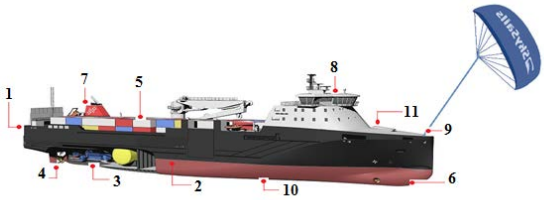


Figure11. Technologies that reduce exhaust emissions(Green Technologies)
source: The Norvegian Trade Portal,2012

1- Ashore electricity supply; 2- Hull optimization; 3- Propulsion system optimization; 4- Steering gear Optimization; 5- Ship loading optimization; 6- Hydrodynamics optimization; 7- System for adjusting the vapor content in flue gases; 8- ATC system; 9- Sky Sail System and Fletner rotors; 10- Anti-fouling paint. 11. Solar/thermal solutions.(The Norvegian Trade Portal, 2012)
Application of the full range of solutions presented in figure11. could result in lower exhaust emissions in a percentage of 69%. (CIMAC, 2010).
The first generation of ecologic ships that are already in use are influenced by the standards indicated by the energy efficiency design index (EEDI), adopted in July, 2011, under the
auspices of IMO-which became mandatory from 1 January 2013 for all new ship constructions with gross tonnage of more than 400 tonnes (GT). They rely on the redesign of the bridge and deck systems, on hull redesign, on using LNG as fuel and on optimizing the technical managerial conditions for sailing.

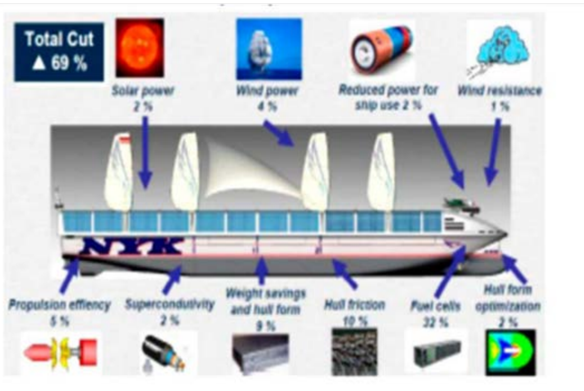
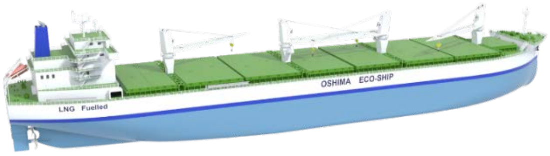


Figure 12. Ecologic vessels for an environmentally friendly shipping. source: CIMAC 2010

Eco-vessels are expected to be nearly 30 percent more numerous than the current generation of ships based on reducing fuel consumption.(RMT, 2013)
An example of first generation eco-vessel, is the Oshima ECO-Ship 2020 concept, a program developed by Oshima Shipbuildings and DNV Ltd, 2011.
Eco-Ship 2020 is a design concept regarding cost-efficiency, developed to assist owners and operators in improving

business performance while reducing fuel costs and increasing energy efficiency. The concept features a number of innovative solutions, such as:

- designing the shape of the hull to reduce resistance, by providing a smooth water and air flow during propulsion (figure13).
- the use of two four-stroke LNG-fuelled Diesel engines of 4100 HP, and the interplay of generators between the propulsion engine shaft and propeller shaft in order to employ propulsion engines as power generators to retrieve the power surplus and turn it into electricity during the ship's propulsion (figure14);
- using a rudder-propeller coupling system, called the Promas system, that ensures a better ship manoeuvrability (figure15);
- the use of a composite material for the construction of hatches and derricks, which reduced their weight by 50%, while the hatch covers handling hydraulic system was replaced by an electric one.



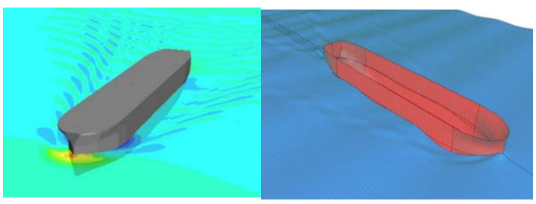


Figure13. Comparison between the current hull and the hull designed for Oshima. (source: DNV-GL)

Figure14.A comparison between the current thruster system and thePromas system

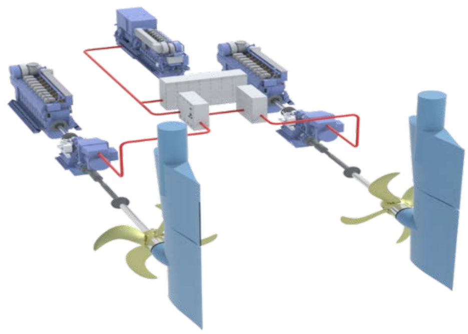


Figure 15.The Oshima propulsion system

The second generation of eco-ships will be based on the introduction of innovative technologies and services on board ships, which recover energy from renewable sources. The analysis of variants deployed aboard ships shows that harnessing renewable wind/solar energy decreases fuel consumption and thereby lowering operating expenses as well as reducingthe greenhouse gases produced by the naval equipment and systems.

The implementation of these technologies at present are pioneering. A project which encompasses solar,wind and waves power is that of the company Wallenius Wilhelmsen Logistics. The ship's design was done in 2005 at the request of Toyota and she is expected to enter service in 2025, figure16.(Solar Powered Eco-Concept Vessel)

Figure 16. The Orcelle concept:a- the ship; b- the solar/wind/ waves solution.

Detached from the technical solutions to exploit the potential of renewable energies, the analyzed technologies are strategiesof the "win-win-win" type, which aim to protect the environment, the human communities in the coastal areas and the crew. It is expected that through the implementation on board ships of solutions based on the potential of renewable energies, as well as through the reduction ofgreenhouse emissions,higher efficiency profitability and competitiveness of maritime transport will be attained, acting upon the principles of precaution, prevention, integration.

The implementation of sustainable development strategies is causing a serious dilemma for the ship owners, in particular, in the context of freight markets falling, lower wages, the existing excess capacity of vessels, the lack of financing, the stricter environmental regulations and the expanding practice of speed reduction.

At the moment, there is no immediate interest on the part of shipowners with regard to the implementation of "green" technologies, mainly due to major investments and the long term capital gain. Shipowners are struggling to determine whether to invest in eco-ships or to make the necessary adjustments and improvements to the existing vessels to ensure their optimization. These considerations divide industry and raise many questions which enhance the existing financial risks and uncertainties. What increases this dilemma further is the market's segmentation potential, which may appear, depending on the decisions that can be taken today.(RMT, 2013).

The actors in the world of shipping which will not adhere to these global emission reduction trends, will be inevitably removed from the shipping market.

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