MARITIME ENERGY MANAGEMENT SYSTEM (MARIEMS) ONLINE DELIVERY PLATFORM

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Abstract: Maritime accounts for approximately 90% of trade in the world today. The maritime transport emits around 1000 Mt of CO_2 per year about 2,5% of global GHG emissions (3rd IMO GHG study).The forecast of new scenarios about the shipping emissions predict an increase between 50% and 250% by 2050, depending on future economic and energy development. The Industry has taken steps to reduce its Air Pollution and Carbon footprint. IMO introduced several new regulations such as the Ship Energy Efficiency Management Plan (SEEMP), Energy Efficiency Design Index (EEDI), & Energy Efficiency Operational Index (EEOI), while the MARPOL Convention new regulations have imposed strict emissions caps in emission control areas. Ship owners have reacted to fulfill these requirements meeting the future environmental requirements set for 2025.

Maritime Energy Management Specification (MariEMS) is an industry-academia collaboration project funded by the EU under the Erasmus+ programme. The project started in October 2015 and the duration is 30 months. The purpose of this Partnership is the development of an energy management job requirements as well as a training specification, and the development and implementation of an online learning and assessment system for the

proposed training programme so that current cadets, as well as existing seafarers, can up-skill themselves to the new regulatory requirements and good practice.

The paper presentation includes the handouts of the proposed job specification and training programme for the ship energy management as well as a demonstration of the MariEMS online e-learning platform.

Keywords: maritime energy management, energy efficiency, online, e-learning,

Introduction

It is generally accepted that around 90% of world trade happens by sea. Indeed the IMO's own International Shipping Facts and Figures report in 2012 stated that the number of propelled sea going vessels across the globe of at least 100 Gross Tonnage was 104,304 ships, with cargo carrying vessels being 55,138 ships (Ziarati, 2016).

With awareness and understanding increasing around the world about the effects of pollution on the Global Environment the International Maritime Organisation (IMO) has tried to tackle the level and type of emissions produced by the Maritime Industry through new regulations. The majority of the IMO requirements on ship emissions are contained within MARPOL, with Air Pollution being the focus of Annex VI. The MARPOL regulations impose strict emissions caps in two emissions control areas (ECA) which are (partly or completely) inside the EU - The North Sea and the Baltic Sea. These emissions caps are intended to control the main air pollutants contained in ships exhaust gas, including, CO_2, sulphur oxides (SO_x) and nitrous oxides (NO_x), and prohibits deliberate emissions of ozone depleting substances (ODS).

As the regulations and technologies governing Energy Efficiency on board ships become ever more complex it has been recognised by the IMO and the shipping industry that seafarers themselves need to be trained to a much higher level in these fields. To this end the IMO (IMO Train The Trainer Course, 2016) has created in a sense a new position on board ship of viz., Energy Trainee/Officer/ Manager; a position that whether collective or given to an individual will play a crucial role in making ships and ports energy conscious and more efficient.

While the efforts by IMO and the many maritime communities particularly in Europe have been commendable the recent US reports to forego the outcomes of recent climate treaties is a

cause for concern particularly considering that US and China are the biggest maritime polluters in the world (Oceana report cited in Sahayam, 2014).

IMO Regulations

The IMO has also introduced regulations (DNV, 2014) such as the **Energy Efficiency Design Index (**EEDI), **Ship Energy Efficiency Management Plan** (SSEMP) and **Energy Efficiency Operational Index (**EEOI**)** which all entered in force on January 1st 2013. SEEMP is an operational measure that establishes a cost-effective mechanism in improving the ship's energy efficiency. This measure also assists the shipping companies in providing an approach for managing ship and fleet efficiency performance over time with the help of the EEOI as a monitoring tool. The assistance on the development of the SEEMP operational measure for new and existing ships includes best practices for efficient ship's operation, as well as procedures for deliberate use of the EEOI in new and already existing ships (MEPC.1/Circ.684). SEEMP therefore is a plan to improve the energy efficiency implementation in a ship's operation, reported to provide cost savings of about 5 to 15% and help to bring down GHG emissions; A plan to reduce fuel cost (prediction of 35-65% reduction of operational costs have been reported (Ziarati and Akdemir, 2015; Sahayam, 2014)) with a range of environmental impact based port fees and so forth.

Kollamthodi et al (2008) claims from an interview with the Norwegian ship association that, the charterers (contractors) are ready to pay higher amounts for energy efficient ships when comparing with other normal vessels (Sustainable shipping, 2012). On the other hand, Faber et al. (2011) concludes that, the ship owners investing in ships that are fuel efficient will not be able to recoup their investments unless otherwise their own ships are being operated or by having a long term agreement with charterers. But an argument, on the other side is, investments in the energy efficiency vessels increase the rate of success for winning contracts and hence provides a better utilisation of ships.

Energy Management

The role of the person designated for energy management should therefore incorporate the improvements in both transformation and use of energy with a view to also reduce harmful pollutants. There are a number of related areas, such as new regulation on sulphur content which in itself is a full-time job as described below, for the Energy Manager on board a vessel, when sailing through Emission Control Areas (ECA) designated waters.

Authorities given responsibility to oversee the implementation of ECA such as USCG and EMSA are issuing safety alert on fuel switching as of recently. Many losses of propulsion have occurred in different ports and have been associated with changeover processes and procedures. At a recent meeting at EMSA it was clear that polluter can be spotted and brought to justice based on evidence gathered by the agency. A review of recent legislations Sahayam, 2014) clearly shows that in terms of legislation there are in reality only two efforts regarding the 2010 ECA Sulphur limit and the 2011 NO_x tier II so far of any significant value which is far short of what is required to make an effective inroad to reduce harmful pollutants as demonstrated in the following figure nº 1.

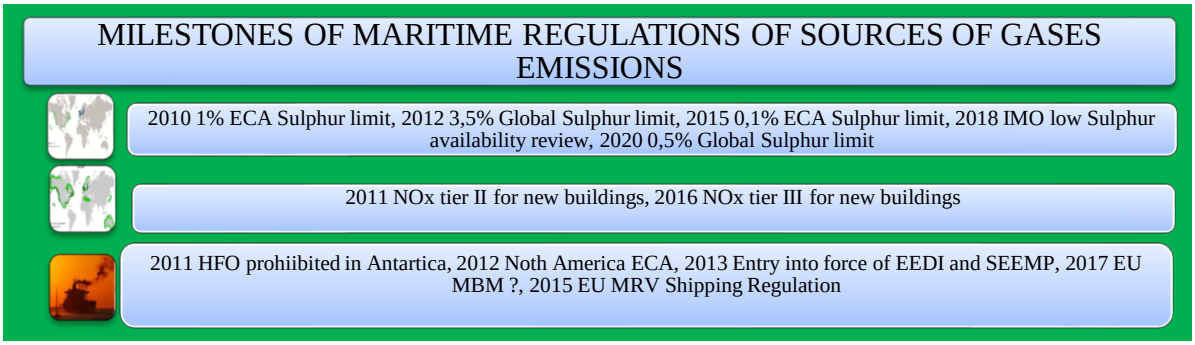

Figure nº 1; **Milestones of Maritime Regulations of Sources of Gases Emissions**

Ziarati and Akdemir (2015) have argued that to make a real impact on reducing engine emissions there needs to be a combined effort applying a range of options such i) Maximising thermal efficiency, ii) considering adaptation of hybrid propulsion, iii) using alternative fuels and or fuel cells/batteries, iv) integration of novel catalysts, exhaust recirculation systems and exhaust treatment, v) including multi-Stage inter-cooling, vi) using variable Geometry turbochargers, vii) considering use of lighter materials, viii) using more efficient bearings, ix) Injecting water after end of combustion to reduce NO_x formation and for cooling the engine hence reducing heat losses through primarily conduction, x) using novel injectors with high injection pressures as part of the common rail systems.

Maritime Record Verification, MRV

The management and oversight of any fuel oil mixing that may be part of a changeover process including, proper control and reduction of the operating temperature of fuel supplied, varying ratios of the mixed fuels and control of mixed fuel viscosity to the engines must take place before the vessel enters the ECAs or after the vessel leaves the ECAs.

The EU has the aim to reduce the emissions of CO_2 from shipping and has created a system called Monitoring Record Verification, MRV, to control the CO_2 emissions from vessels larger than 5000 GT and which call at any EU port.

The shipping companies must prepare a monitoring plan for each of their vessels that has to comply with the MRV Regulation. The MRV Regulation was adopted in April 2015 and entered in force on July 2015; by August 2017 the shipping companies must have submitted the monitoring plans to the administration or accredited verifier. In January 2018 each vessel will start to voyage reporting till December of that year, that will be completed a period. In the next year the EC will publish the data of MRV.

The parameters that must be monitored per voyage are: Port departure and arrival, including date and hour of departure and arrival, type of fuel consumed and the quantity and emission factors of each one, CO_2 emitted, distance travelled, transport carried and transport work.

Energy Efficient Ship Operation Training The Trainer course (EESO-TTT) and the MariEMS Project

IMO in recent years has produced an Energy Efficient Ship Operation Training The Trainer course (EESO-TTT). The MariEMS Project was initiated for the intended trainees of this course and also for use by all ship crew particularly those with direct responsibility for energy management and efficient ship operation. MariEMS is primarily an online course and has several intellectual outputs. The first key output is the design of a specification for the role that the trainees of the IMO EESO-TTT course are anticipated to play and the second key output is the specification for the trainees training programme in a similar way that EESO-TTT was for the trainers. To this end, care has been exercised in ensuring the full use of the IMO EESO-TTT content so that the trainers and trainees would use a common teaching/learning material.

Currently there are no job specifications, and no training specifications for the intended trainees/energy efficiency team members and so existing crew members are learning 'on the job' how to implement these new regulations as best they can, which is not an effective method of applying these regulations and will of course mean that the best results are not currently being achieved.

The purpose of this Strategic Partnership is the development of an energy management job and training specifications, and the development and implementation of an online leaning and

assessment system for the new training programme so that current Cadets, as well as existing seafarers, can up-skill themselves to the new IMO regulatory requirements. The needs that this proposal will fulfil are as follows:

1. The need for qualified personnel to be implementing the new regulations and technologies.
2. The need for Energy Efficiency to be embraced by Shipping Companies in order to achieve the best results through cost savings gained through more efficient use of fuels etc.
3. Enhanced employability and mobility in a global labour market for EU seafarers and cadets who take the qualification either as part of their initial studies or as part of a continuing VET.
4. METs continuing to offer courses that are relevant and comply with latest regulations and requirements of the industry.
5. Integrating and developing e-learning and digital skills into the EU MET's so that they can design and deliver e-learning materials and an online learning platform. In the 2010 STCW amendments the IMO officially recognised the validity of e-learning for the maritime sector.

The partners are anticipating to bring together a unique blend of industrial, academic and industrial partners who can bring to the table valuable and necessary experience in ship types, ship propulsion, ship navigation, energy transformation, electrical and mechanical parts and circuitry, safety issues, national certification, accreditation and validation of learning materials, pedagogical aspects of learning and last but by no means least online application. The partners have developed a sustainability plan and the activities contained in this plan are expected to invite as many ship companies, ports and other key stakeholders including maritime institutions into the project team. Within their sustainability plan several areas have been identified which could help to reduce ship fuel consumptions as well as reducing harmful emissions both due to reduction in fuel consumption and due to other measures being introduced to filter or re-circulate/burn some of the more vicious pollutants using now novel systems as are the following: slow steaming**,** weather routing**,** green energy wind and sun (Flettner rotor & sun panels)**,** use of sea currents**,** e-navigation**,** ballast water management**,** hull and trim optimisation**,** ship-port and port-ship system integration**,** port-road-train-airport system integration**,** on-board ship management and Artificial Intelligence and Virtual Reality applications such as virtual arrival and departure, advanced satellite and drone communications, Just-In-Time data using neural network predictive techniques.

Innovative aspects of the Project

The innovative characteristic of the project is to develop the first European specifications for the Ship Energy Trainee/Officer/Manager position, as well as developing the standards and specifications for the training courses for that position, and the specifications and first online delivery platform for these training courses and materials. The skills shortage that is currently emerging between traditional education and the latest technologies, requirements and practices for maritime energy efficiency needs to be addressed urgently in order for cadets and seafarers to have the skills necessary to implement the latest regulation and technologies to their best effect and thus secure the energy efficiency and pollutant reduction needed to help the EU meet its 20% reduction target by 2020.

Another innovative characteristic of this project is the involvement of the shipping industry in the formation of training course right from the specification stage. The Maritime Energy Manager Role is entirely new. The team of project partners has the opportunity to embed the industry's requirements into the training courses right from their development stage. Also with industry involvement in the design and development stage of the training courses comes the ability to accurately tailor the training programme to the current skill and knowledge level of seafarers working in the industry.

The ship energy manager is primarily responsible for managing all aspects of energy management and efficiency on board vessels. The manager should have knowledge, understanding and application of IMO Energy Requirements/Regulations and is expected that the manager should be familiar with application of EEOI and EEDI with a specific knowledge of energy transformation on board of vessels, with skills in energy saving practices including engine propulsion, heating cooling and so forth. The manager should be familiar with the ISM practices, and company specific measures including aspects relating to any quality standards which may relate to ISO 9000/EN 29000 or ship specific standards such as ISO 50001 and ISO 14000. The manager must be aware of IMO's MARPOL, SOLAS, and other related standards including aspects concerning maritime environment protection.

The training programme has four parts; the first part has seven sections: Knowledge, Understanding and Application of IMO Energy Management Requirements/Regulations, EEDI Reference lines – significance, Company Specific Measures, Energy Saving System – Internal and Existing Environmental Protection Requirements. The second part is about Skills, Experience and Qualifications. The third part is about Personal Characteristics and the fourth part is about the term of the contract along with the points discussed and agreed at the point of interview. At the end of course the learners are able to: identify, implement, assess,

evaluate the energy efficiency measures of all kind of propulsion and systems on board, and provide guidance to the crew and compliance with the international legislations and requirements

Expected Impact

At the national level the impact of the MariEMS project is to increase the capacity of the partner METs through developing the e-learning infrastructure and capabilities of these institutions and their staff to use and run the MariEMS e-learning platform and training courses to help METs deliver the brand new Energy Manager field of training, to both their cadets and to already qualified seafarers resulting is a more skilled, competent and mobile Maritime labour force educated to the latest regulatory requirements.

Another national impact is that cadets and seafarers who complete the MariEMS course and become qualified Energy Managers will be heavily in demand by the industry as they seek to appoint and Energy Manager on each ship.

The exchange of good practices and knowledge between the partner METs, and also between the partnership and international shipping companies and ports, as well as with the IMO (170 member states and growing) and international awarding, accrediting and licensing bodies will be a truly international impact of the project as it will allow for industry, academia and policymakers to exchange knowledge and best practices right at the birth of a new educational field so that the MariEMS outputs developed as a result of the project will reflect all parties involved.

International impact is expected to be a decline in emissions from ships and countries that train and employ truly qualified and effective Energy Managers. It is believed that the Maritime Industry currently account for some 50% of CO_2-emissions at ports with substantial level of other dangerous pollutant particularly outside the ECA zones, and so the energy saving measures that are intended by the IMO to be employed by the Energy Managers, such as reductions in fuel consumption, will result in emissions drops of by at least 20 to 30% (Sahayam, 2013). The environment is a global issue and so such a reduction in emissions by the shipping Industry will also have a global impact.

Another–international impact of the project will be the designing of the first full training specification, course, e-learning delivery platform and sample training materials for the new Energy Manager position, and then submitting this to the IMO as a possible basis for a new model course. The impact of having a single standardised model course for the Energy Manager position would be tremendous because many METs in the IMOs 170 member states

prefer to use IMO model curses rather than design their own courses from scratch. Currently almost all METs make use of IMO Model Courses and so the level of uptake and impact that the Energy Manger Model Course would have can be judged to be substantial.. By providing a possibility of a Model Course being developed MariEMS would be speeding up the global timetable of the implementation of the Energy Management training courses complementing the IMO's EESO-TTT course.

Conclusions

The job specification and training programme content and learning material so far developed are in hand and have been validated by two multiplier events in Finland and in the UK. The feedbacks from these events have been very helpful. A meeting was also organised at EMSA to seek comments on the project from the Agency. There several other opportunities to present the outputs from the MariEMS project to participants of national and international professional networks and seek further feedback.

The most important impact of the project is expected to be the reduction of energy used on board vessels and as the MariEMS course also incorporates ISO 50001 will ensure saving are made. ISO processes will enable a continuous system of development to be in place which is expected to help ship operators and owners, to be more respectful with the environment reducing the uptake of fuel. The reduction of energy is expected also to reduce harmful emissions from ship propulsion systems. In a recent IMO WMU paper by the vice president of BIMCO (Kaptanoglu and Ziarati, 2015) it was stated that the key challenge facing the shipping industry is the competiveness and environmental issues. It emphasis that the IMO's own reports (Marine Environmental Protection Committee (MEPC), 64 session, Agenda item 4, 29th June 2012) and similar reports by learnt societies and classification societies and maritime organisations give a clear view of the roadmap for reducing the energy consumption and marine engine emissions. It was noted that the whole of Central and North America coastal areas are now almost an ECA (Emission Control Area) and it is expected that coasts of Mexico, Alaska and the Great lakes, Singapore, Hong Kong, Korea, Australia, Black Sea, Mediterranean Sea and Tokyo bay are currently considering becoming ECAs. What is significant is that these constitute 90% of shipping routes so the implications are serious. To this end, MariEMS project is anticipated to play a positive role in addressing the challenges before us at the source and by getting things right the first time.

The project will support the IMO efforts in ship energy efficient operations. IMO has devoted significant time and effort in order to regulate shipping energy efficiency and thereby control the marine emissions in addition to EEDI, EEOI and the SEEMP particularly considering IMO's work in devising a new Chapter 4 of MARPOL Annex VI.

Referring to what has been stated above the impact of this project is expected to be substantial both in terms of energy reduction on board vessels and in port as well as the resulting emission of harmful GHGs helping EU to realise its set goals for 2020 and beyond. The user-friendly e-leaning and e-assessment course will be available free of charge at any place and at any time provided there is access to-the-internet.

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For slides see attached.

Slides

In a recent study by MariEMS[1] project Team it has be demonstrated at the best there will be an increase of 5% in ship CO_2 emission by 2050 despite all recent efforts in improving ship energy efficiency.

It should be noted for any given ship a combination of potential benefits as reported in Wang and Lutsey (2013) [2] can lead to a substantial reduction both in energy use and in ship emissions as shown below.

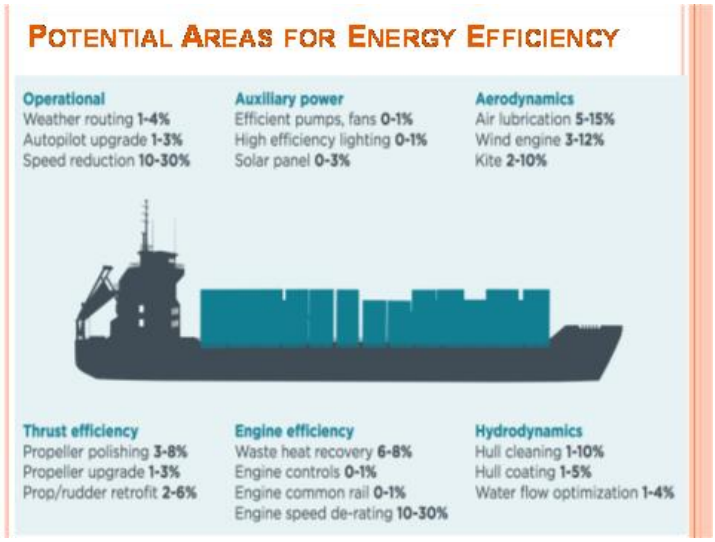


Figure 2 – Potential Areas for Improving Ship Energy Efficiency

C4FF in their studies[5] have shown that provided the government invests in local supply chains and provide funds for shipping companies to take advantage of energy savings as well as encouraging port electrifications through renewable energy; these could substantially reduce the level of CO_2 emissions by 25% by 2030 to counter the expected increase of possibly by 30% as shown in the above diagram (Figure 1). So, the best scenario indicates status quo hence no reduction of CO_2 is expected from the shipping industry. It has been reported that a combination of the above efficiency improvements (Figure 2) could lead to some 60% overall reduction of fuel requirements and hence in ship emissions for a given ship. However, ship lifecycle is over 30 years and many ships particularly in poorer countries will continue to operate as they are.

To overcome the level of CO_2 Emissions shipping industry has started to implement some of the potential areas for energy efficiency but let us assume that taking advantage of the above potential areas for energy efficiency would at best lead to marine ship CO_2 emissions to be kept at 2018 level in 2030. One way of achieving this is to use Ammonia and extend the use of Flettner cylinders and sails to assist in propelling the ships. Many ships have started using but since this leads to an unacceptable level of Methane as result of LNG combustion use of such fuels should be kept to minimum.

[1] www.mariems.com
[2] Wang and Lutsey (2013), International Council on Clean Transportation (ICCT), Long-term potential for increasing shipping efficiency through the adoption of industry-leading practices, 2013.

In a recent IMarEST sponsored Lecture serialised in Marifuture[3] it has been reported that starting with most effective to least effective the following methods could help to reduce fuel consumption hence emissions by ships:

- Slow steaming
- Weather routing and use of sea currents
- New fuels (Ammonia, LNG, etc.), Biofuel including Ethanol and Methanol
- Green energy – wind and sun (Flettner rotors/Cylinders; sails & solar panels)
- Engine efficiency
- Hull and trim optimisation and Propeller Polishing
- e-navigation
- Ballast water management
- Ship-port and port-ship system integration
- Port-road-train-airport system integration
- On-board ship management
- AI , VR and Quantum Physic applications – Virtual arrival, advanced communications, JIT, predictive requirements and use of quantum physics in fuel molecular restructuring

Key areas for engine optimisation are noted to be as follows:

- Thermal efficiency
- Hybrid propulsion
- Alternative fuels
- Fuel cells/batteries
- Catalysts
- Exhaust recirculation systems
- Exhaust treatment
- Multi-Stage inter-cooling
- Variable Geometry Diesels
- Lighter materials
- Efficient bearings
- Water injection
- Novel injectors
- High injection pressures
- Common rail systems

Figures 3 shows the current mitigating technologies, latest IMO limits set for SOx and NO_x and IMO recent efforts in making ships more energy efficient and less polluting.

[3] Examples from some 30 lectures: https://www.marifuture.org/Reports/Development-Papers/ADP_02_2018_MARIFUTURE.pdf ; https://www.marifuture.org/Reports/Development-Papers/ADP_05_2018_MARIFUTURE.pdf ; https://www.marifuture.org/Reports/Development-Papers/ADP_06_2018_MARIFUTURE.pdf - See full series at https://www.marifuture.org/Reports/Development-Papers.aspx. for a copy of the book contact info@c4ff.co.uk

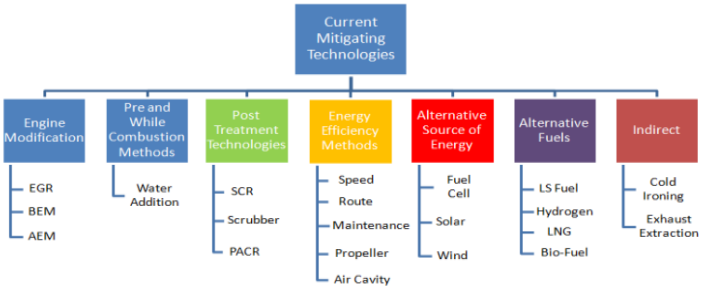
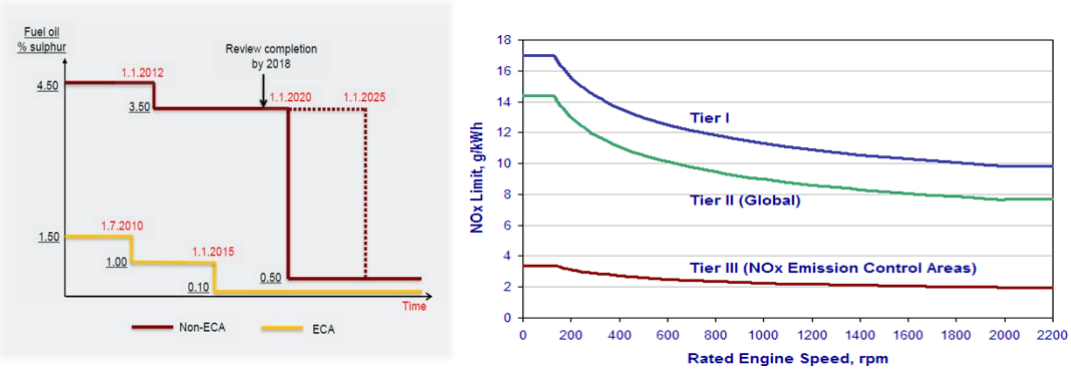


Figure 3 – Ship Energy Use and Emission Reduction Mitigating Technologies



Figures 4 and 5 - New IMO regulations for SO_x and on the right for NO_x

Figures 6 and 7 – IMO new Initiatives to address GHG Emissions and Ship energy Management