Technologies and Operational Measures for improving Vessel Efficiency

Kunal Sharma and Megha Sharma
Ships and Technical Services
Indian Register of Shipping
52A, Adi Shankaracharya Marg, Opposite Powai Lake, Mumbai, India
Corresponding author's email: kunal.sharma@irclass.org

Abstract - The 2023 IMO GHG Strategy has set up the future vision for international shipping by providing the levels of ambition to reduce GHG emissions. It aims for a reduction in carbon intensity of international shipping, by at least 40% by 2030 and to reach net-zero GHG emissions by 2050. A new level of ambition relating to the uptake of zero or near-zero GHG emission technologies, fuels / energy sources which are to represent at least 5%, striving for 10%, of the energy used by international shipping by 2030.

IRS is an accredited verifier for EU MRV and EU ETS as well as Recognised Organisation for 51 Flag Administrations for IMO DCS. Using the first year of CII data and ratings now available, an attempt has been made through this paper to analyse the various measures and their impacts. A description of various technologies by grouping them into machinery, propulsion/hull improvement, energy recovery and technical solutions for optimising operations has been put forth in the paper along with their applicability and energy saving potential. Our involvement in few ongoing decarbonisation projects including approval of hydrogen fuel cell, batteries for propulsion, Shaft Power Limitation (SHAPOLI) system and use of biofuels have also been discussed in this paper.

Technological innovation, upscaling of alternative fuels for international shipping and operational measures built on digitalisation will be integral to achieve the overall ambition.

Keywords: Decarbonisation; Net Zero Emissions, Energy Efficiency; Alternative Fuels; Operational Carbon Intensity Indicator

INTRODUCTION

International policies and regulations are providing a framework for the maritime industry's transition towards decarbonization by setting standards, providing incentives, and creating market conditions favourable to transition to cleaner technologies and practices.

In 2018, IMO adopted an Initial Strategy on the reduction of GHG emissions from ships, setting out a vision for reducing GHG emissions from international shipping and to phasing them out as soon as possible.

This was further revised in July 2023 at MEPC 80 IMO adopted the 2023 IMO Strategy on Reduction of GHG Emissions from Ships in accordance with the agreed programme of follow-up actions.

The 2023 IMO GHG Strategy [1] envisages, in particular, a reduction in carbon intensity of international shipping (to reduce CO2 emissions per transport work), as an average across international shipping, by at least 40% by 2030. It also includes a new level of ambition relating to the uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources which are to represent at least 5%, striving for 10%, of the energy used by international shipping by 2030.

Most importantly revising its level of ambition to peak GHG emissions from international shipping as soon as possible and to reach net-zero GHG emissions by or around 2050.

The effective implementation of 2023 IMO GHG Strategy will require all ships to implement mandatory measures. A basket of candidate measure(s), delivering on the reduction targets, are being discussed which comprise of both:

.1 a technical element, namely a goal-based marine fuel standard regulating the phased reduction of the marine fuel's GHG intensity; and

.2 an economic element, on the basis of a maritime GHG emissions pricing mechanism.

Furthermore, from 1 January 2024, CO2 emissions from ships of and above 5000 gross tonnage, calling at or departing from ports in the European Economic Area (EEA), are included in the EU's Emissions Trading System (ETS).

The Fuel EU Maritime Regulation is a complementary regulation to the EU ETS, ensuring that the GHG intensity of fuels used by the shipping sector will gradually decrease over time. The regulation aims to reduce greenhouse gas emissions from shipping by setting maximum limits on the yearly greenhouse gas intensity of the energy used by a ship. The limits will become more ambitious over time, from a decrease of 2% in 2025 to as much as 80% by 2050, to stimulate developments in technology and increased production of renewable and low-carbon fuels.

The new rules also introduce an additional zero-emission requirement at berth, mandating the use of onshore power supply (OPS) or alternative zero-emission technologies in ports by passenger ships and containerships as of 2030.

Indian Register of Shipping as a verifier in energy efficiency, GHG emissions, EU MRV, EU ETS and Fuel EU Maritime

IRS is an accredited verifier for EU MRV and EU ETS as well as Recognised Organisation for 51 Flag Administrations for IMO DCS. We undertake review of Energy Efficiency Design Index (EEDI) for new construction ships and Energy Efficiency Existing Ships Index (EEXI).

The Carbon Intensity Indicator (CII) is an operational measure and will be applicable to ships currently required to report fuel consumption data under IMO DCS, i.e., ships of 5000 GT & above engaged in international voyages. Based on the annual data collected, the attained annual operational CII is to be calculated, documented, and verified against the required annual operational CII to determine operational carbon intensity rating A, B, C, D or E (A being the most superior).

This is the first year of CII reporting. Based on the data submitted we have analysed the performance of the ships based on Attained CII and CII Ratings. IRS has undertaken IMO DCS verification of around 400 vessels and an analysis of CII ratings is presented in the below section

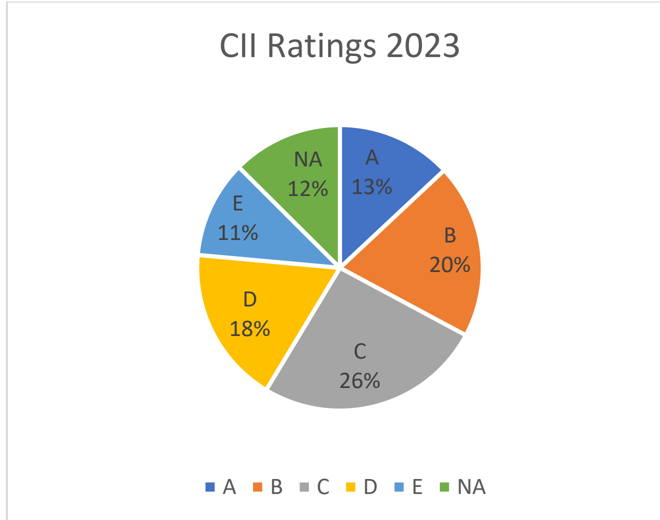

Fig.1 – 2023 CII Ratings for ships verified by IRS

Analysis of CII Ratings

Attained CII is required to be calculated for ships of 5000 GT and above of specific ship types such as bulk carrier, tanker, containerships, general cargo, gas carriers, LNG carriers

For the year 2023, around 11% of ships were determined as E rated.

Amongst the E rated vessels verified by IRS, the ship types tankers and bulkers account for around 93% of the vessels. Containerships owing to their lower waiting time and faster turnaround at ports fare comparatively better.

As the required CII value becomes more stringent every year, it is likely that more ships could fall into E rating in subsequent years. Moreover, a D rating in 3 consecutive years also considered as a violation and SOC cannot be issued to ship unless it submits a corrective action plan by revising SEEMP-III

A poor CII (Carbon Intensity Indicator) rating for ships can be influenced by several factors related to the efficiency and emissions of the vessel. The key factors are listed below

Fuel Inefficiency: Ships that use older, less efficient engines or consume higher amounts of fuel per distance travelled will have higher emissions per unit of cargo transported, leading to a poorer CII rating.

Short voyages, long anchorage times and waiting at port: Distance travelled over a year has an impact on CII rating of the vessel. If the vessel has not made significant distance in a year, its CII rating is adversely impacted.

Size and Type of Vessel: Larger vessels generally have lower emissions per unit of cargo transported due to economies of scale. Small or specialized vessels might have higher emissions relative to their cargo capacity, affecting their CII rating negatively.

Maintenance and Operational Practices: Poor maintenance practices and suboptimal operational procedures can lead to increased fuel consumption and emissions.

Speed and Route Optimization: Inefficient route planning and unnecessary speed can increase fuel consumption and emissions.

Fuel Type: Ships not utilizing cleaner alternatives like biofuels will have higher carbon emissions, contributing to a lower CII rating.

Improving a ship's CII rating involves adopting cleaner technologies, optimizing operations, using low-carbon fuels, and adhering to best practices in ship management and maintenance.

Recommended Measures to improve Energy Efficiency of Ships

Energy efficiency and CII rating of the ships can be improved using technical and operational measures. Some of which are described below:

Operational measures:

There are a number of basic operational measures which should be implemented because such measures generally have a fuel-saving potential greater than that achievable by most EETs and are relatively inexpensive. The basic operational measures that should be considered are mentioned below:

Hull and propeller cleaning:

Biofouling accumulation on the hull and propeller is not only a source of invasive species, but also a major cause of poor energy efficiency. Fouling may easily increase fuel consumption by 10% to 20%, and even higher percentages are possible if the problem is not addressed, as can be seen from the following figure based on the preliminary results of a study on the "Impact of ships' biofouling on greenhouse gas emissions", undertaken by the Global Industry Alliance for Marine Biosafety as part of the Building Partnerships to Assist Developing Countries to Minimize the Impacts from Aquatic Biofouling

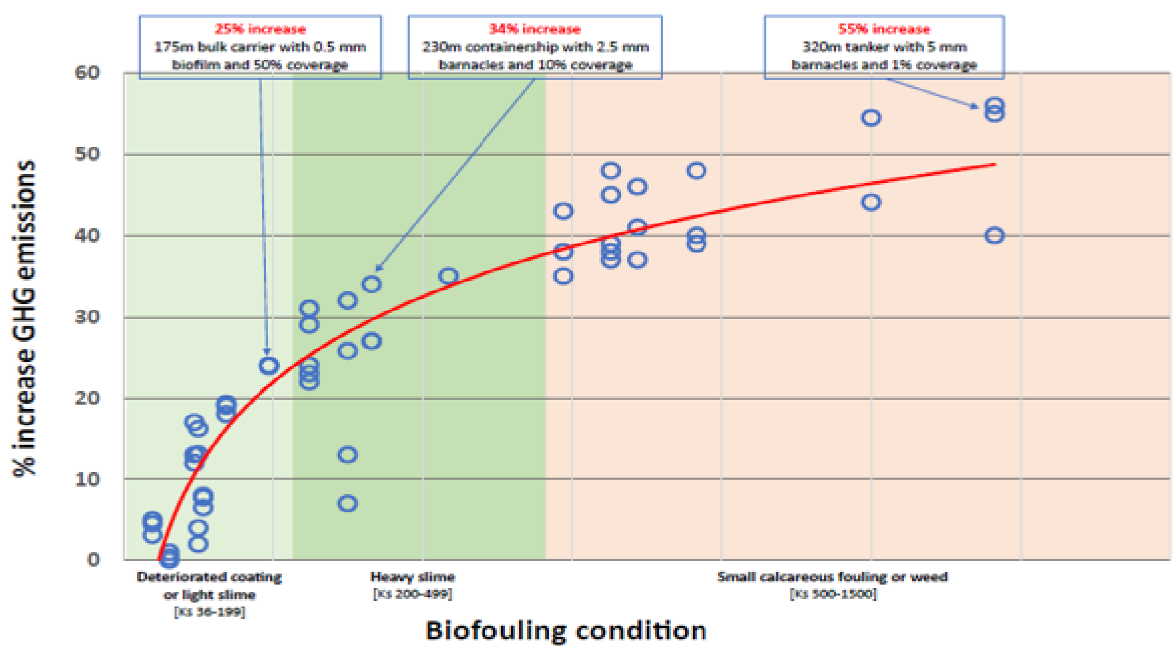

Fig.2.: Impact of ship hull biofouling on GHG emissions [2]

(GloFouling Partnerships) project, a joint project of the Global Environment Facility (GEF), the United Nations Development Programme (UNDP) and IMO.

Speed optimization

A rule of thumb is that ship power is proportional to the cube of the speed. Therefore, a small reduction in speed leads to a much larger reduction in power and associated fuel consumption. However, as speed is reduced away from the design speed range of a vessel, this cubic relationship begins to weaken as a result of decreasing propeller efficiency and the lower effectiveness of the bulbous bow. Running engines at a lower load also increases the specific fuel oil consumption. Hence the preferred approach is to aim for an optimal speed for a given set of considerations.

Weather routing

Weather routing is the practice of using weather forecasts to optimize a ship's route so as to minimize exposure to bad weather and/or to allow it to benefit from favourable wind and current directions or weather conditions.

Optimum trim

As indicated in the 2022 Guidelines for the development of a Ship Energy Efficiency Management Plan (SEEMP). Trim has a significant influence on the resistance of the ship and optimizing trim can deliver significant fuel savings. For any given draft there is a trim condition that gives minimum resistance. Design or safety factors may preclude full use of trim optimization.

Generator rationalization

Standard practice is typically to run two or more generators, often at a low load in order to provide a degree of redundancy in case of problems with a generator. However, operating two generators at a low load leads to a higher fuel consumption than if only one generator were operating at a higher load, because of the shape of the curve of specific fuel oil consumption of the engine. Therefore, the number of generators in operation should be reduced wherever it is safe and practicable to do so.

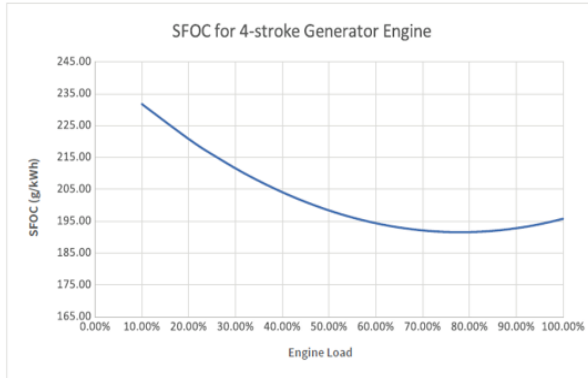

Figure 4: *Indicative specific fuel oil consumption (SFOC) for a four-stroke engine*

Fig.3.: Indicative specific fuel oil consumption (SFOC) for a four-stroke engine [2]

Technical Measures:

Hull Optimization (Design and coating)

Hull optimization involves designing the hull shape to minimize resistance through computational fluid dynamics (CFD) simulations and model testing. The design of bulbous bows with the further tuning of other pressure peaks by changes in the shoulder positions typically form part of the overall hull form design. [4] Several measures are recommended to avoid hull friction through lubrication, either by air or special paints or other hull/surface treatments.

Energy-Efficient Propellers

There are devices available which can improve the inflow into the propeller and so enhance the working of the propeller. Controllable pitch propellers, ducted propellers, contrarotating propellers, thrusters and podded propulsion systems have resulted in varying levels of efficiency improvement.

Digitalization and Smart Shipping

Digitalization in shipping, often referred to as maritime digitalization or smart shipping, involves the integration of digital technologies and data-driven solutions to enhance various aspects of the maritime industry. This can lead to improved efficiency in cargo handling, route planning, and logistics management. Digital platforms facilitate seamless integration and coordination across the supply chain, connecting shipyards, class societies, ports, shipping companies, freight forwarders, and customers.

Real-Time Data Analytics

Advanced sensors, IoT devices, and real-time data analytics contribute to better monitoring of vessel conditions, weather patterns, and potential hazards. Using real time conditions, weather forecasts and historical data, ship speeds can be calibrated to optimize fuel consumption. Also, the real time data on operating parameters of ships machinery enables condition-based maintenance ensuring their upkeep and optimal operation.

Autonomous and Semi-Autonomous Systems

Emerging technologies like AI, machine learning, and autonomous vessels are being explored for their potential to further transform the industry, although regulatory and ethical considerations remain significant and is a work in progress.

Decarbonization Projects at Indian Register of Shipping

Hydrogen Fuel Cell Powered Vessel

CSL and IRS are working towards end-to-end solutions system/ component compliance in marine certification, approval in principle, and validation of Hydrogen fuel cell powered vessels. The vessel is designed and constructed to IRS guidelines on “Vessels with Fuel Cell Power installations”. The fuel cell systems are supplied by Pune based Fuel cell manufacturer, M/s KPIT Ltd who has the expertise in the use of fuel cells in motor vehicles. IRS carried out gap analysis towards adapting the KPIT fuel cell technology for their suitability to marine application.

As part of technology development, IRS also carried out Gas Dispersion analysis study. The analysis is used to evaluate the risk and hazards associated with the dispersed gas from the potential leak source and vents to atmosphere, while considering various environmental parameters such as wind speed, wind direction, etc. The vessel successfully completed its initial trials and is being monitored for satisfactory operation of the fuel cell system during its technology demonstration period. India’s first hydrogen powered fuel cell vessel was inaugurated by Honourable Prime Minister, Shri Narendar Modi on 28 February 2024.

Battery Operated Vessels:

Cochin Shipyard Limited (CSL), the premier shipbuilding and ship repair company in India, recently delivered series of Electric Hybrid 100 Pax Water Metro ferries to Kochi Water Metro. With a focus on sustainability and environmental responsibility, this ferry is equipped with electric hybrid technology, ensuring reduced emissions and minimized environmental impact.[3]

IRS has developed Guidelines for Battery powered vessels and the vessel was assigned with Notation “BATTERY PROP” . It is assigned to vessels where the battery systems are used for ship propulsion and are in accordance with the requirements specified in our Guidelines. The project has also helped in validating IRS Classification Notes for Approval of Li ion Battery systems while undertaking project specific certification of Li ion battery systems.

With the growing trend in use of battery power for vessel propulsion /Auxiliaries the experience gained through this project has helped to develop greater understanding and challenges in use of battery systems for domestic ferries . IRS is now fully geared up to provide a holistic solution to industry on battery powered vessels both for new builds and retrofits.

New Generation Electric Ferry

Indian Register of Shipping (IRS) was associated with the successful launch of ‘Dheu’, a New Generation Electric Ferry at M/s Garden Reach Shipbuilders & Engineers Ltd (GRSE) Kolkata. Being constructed under IRS class, the Battery-powered Electric Ferry has an Aluminium Hull and a FRP superstructure. 'Dheu' is a 24-metre long twin-hulled vessel equipped with a 246 kW capacity liquid-cooled battery system which can be charged from a shore-based source or through deck-mounted solar panels that generate 18 kW per hour. In addition, the vessel incorporates an efficient Energy Management System, which maximizes the use of solar power to achieve speeds of up to 10 knots through two 50 kW electric propulsion motors. Built to IRS Guidelines for Battery Powered Vessels, 'Dheu' marks the advent of green energy in maritime transportation, eliminating carbon emissions associated with diesel engines. For added safety, the ship is equipped with a 50 kW Emergency DG set, ensuring lighting and power during emergencies.

Biofuels:

Trials have been successfully carried out on vessels operating on coast. The type of fuel used during sea trials were Fatty Acid Methyl Easter (FAME) biodiesel obtained from filtered soya extract and blended with Low Sulphur High Speed Diesel (LSHSD) to get a blend of B20 (20% biodiesel and 80% LSHSD). Biodiesel (B100) samples tested to meet the criteria mentioned in the ASTM D6751 Standard and B20 was analysed for sample testing as per ASTM D7467 Standard. Special care was exercised to ensure the acid number, water content, copper strip corrosion, cold filter plugging point (CFPP) and oxidation stability of the product is within the required limits as mentioned in the standard.

IRS has been involved in witnessing and verification of initial trials, measurements of NOx and vibration as well as full examination of engines after a trial period of 3 months. The CO2 emission was found to be reduced by approximately 7% while running on blend fuel oil. No impact was observed on NOx and SOx.

Conclusion:

Environmental performance of shipping continues to be an area of intensive scrutiny, which has driven governments, ports and shipping operators to focus on ways of improving the sustainability of the shipping. There is no one silver bullet and a hybrid approach of technologies and regulatory policies could be the solution. Digitalisation must be on the agenda for shipping companies to 'future-proof' business. In order to turn barriers into opportunities, it is important that targets imposed to the industry may be accompanied by incentives and supporting policies if they are to be effective and widely accepted by all stakeholders.

When facing a technological transformation, we depend fundamentally on people and the organizational culture. The benefits of technological transformation are limited if our professionals, are not trained and prepared for it. So, training and upskilling of seafarers will be paramount.

Overall, the future of decarbonisation in shipping hinges on technological advancements, regulatory frameworks, collaborative efforts, and supportive policies. While challenges remain, there is growing momentum towards achieving a more sustainable maritime industry that aligns with global climate goals.

References:

[1] International Maritime Organisation (IMO) - MEPC 377(80) – 2023 IMO Strategy on Reduction of GHG Emissions from Ships

[2] IMO, A Practical Guide to the Selection of Energy Efficiency Technologies for Ships

[3] Cochin Shipyard Website - https://cochinshipyard.in/news-release

[4] Ship Efficiency the Guide, Fathom Consultants, 2011

[5] Yuki Ichimura, Dimitrios Dalaklis, Momoko Kitada, Anastasia Christodoulou - Shipping in the era of digitalization: Mapping the future strategic plans of major maritime commercial actors, 2022