# Emissions from Ships & Use of LNG as fuel

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Emissions from the maritime transport sector represent a significant and increasing source of air pollution. Furthermore, emissions from ships are transported in the atmosphere over several hundreds of kilometers, and thus can contribute to air quality problems on land even if they are emitted at sea. This pathway is especially relevant for the deposition of sulphur and nitrogen compounds. It should also be taken into account that, for economic reasons, many vessels use Internal Combustion engines burning heavy fuel oil with high sulphur content (The sulphur content of standard marine fuel is 2700 times higher than that of conventional diesel for cars). The main air emissions resulting from burning this type of fuel include Sulphur Dioxide (SO2), Nitrogen Oxides (NOX); Volatile Organic Compounds (VOCs); Particulate matter (PM); Carbon Dioxide (CO2) and other GHGs. The amount of gases emitted from marine engines into the atmosphere is directly related to total fuel oil consumption and the quality of fuel used which in turn depends on different factors such as hull shape, loading condition, roughness of hull and engine operating condition. The presence of these pollutants has local and global impacts. Impacts on local (or regional) air quality are mainly linked to pollutants such as PM, NOx and sulphur, while the GHGs (*e.g.* CO2) have a global impact on climate. For many years, shipping has prided itself in the efficiency of its cargo carriage, and there is no doubt that ships are still the most efficient means of carriage, at least measured in terms of CO2 emission per ton*mile of cargo moved. Irrespective of this, shipping has to contribute in global effort to fight climate change by reducing GHG emission further given that these emissions presently are not subject to any regulation, that ships are responsible for some 3.3% of global $CO_2$ emissions (2.7% from ships on international trade and 0.6% from Domestic and fishing vessels) and that emissions are expected to increase with increased demand for sea transportation.

The regulations governing Air pollution are contained in Annex VI of MARPOL convention adopted at IMO. There are limits imposed with timelines for achieving these limits governing the primary pollutants from combustion of fuels i.e. SOx, NOx and CO2. There are certain areas which are designated as Emission Control Areas (ECA) such as Baltic Sea, North America etc and more areas are going to be designated in the future as well. The ships plying in the ECA zones will need to comply with stricter regulations governing SOx and NOx. The SOx is entirely dependent on the quantity of sulphur content in the fuel while NOX is primarily dependent on the combustion process within the engine. While there is skepticism prevailing on the availability very low sulphur content of fuel as required by the regulations as well as the possible failures in engine operation especially at the time of fuel switching along with availability of engines for Tier III NOx compliance, one of the methods to comply with the regulations is to switch to uni-

fuel such as LNG which meets the SOx and NOx requirements for ECA's without having the need to fit any after treatment methods required to burn other liquid fossil fuels. Also new vessels will further need to comply with Energy Efficiency Design Index (EEDI) requirements, which is a measure of the GHG (CO2) (or fuel) efficiency of the ship as adopted by IMO. Incidentally LNG as a fuel has a higher energy content compared to HFO or Light Diesel Oils and also emits less CO2 per tonne of other liquid fossil fuels. The reduction in CO2 emissions by using LNG is around 12% per tonne of fuel or 30% per MJ of energy generated when compared with heavy fuel oil.

There are many new ship designs emerging from various ship designers/shipyards which have incorporated the use of LNG. For reasons indicated earlier, these designs are presently being adopted primarily in ships plying or intending to ply in ECA's where considerable investment has been put in place for the establishment of a robust supply chain to cater for refueling. Recently, Rolls Royce, the global power systems company has received the "Next Generation Ship Award" for its Enviro Ship Concept. Rolls Royce have, in their design of a short sea general cargo vessel, have utilized the inherent strengths of LNG along with improvements to hull form and propulsors to be able to produce a design claiming to achieve an overall reduction of 40% in CO2 emissions.

In terms of fleet size the Indian shipping tonnage stands currently at 10.11 million GT consisting of 1,135 vessels and ranks 16$^{th}$ in the world shipping Tonnage. The Indian flagged vessels are carrying presently around 8.4% of Indian export - import cargo and forms a marginal share of just above 1% of the global fleet. Based on data published by International Transport Forum In association with OECD, Indian Shipping has a contribution of less than 2% of total CO2 emissions from transport sector in India in the year 2007 (Fig-1).

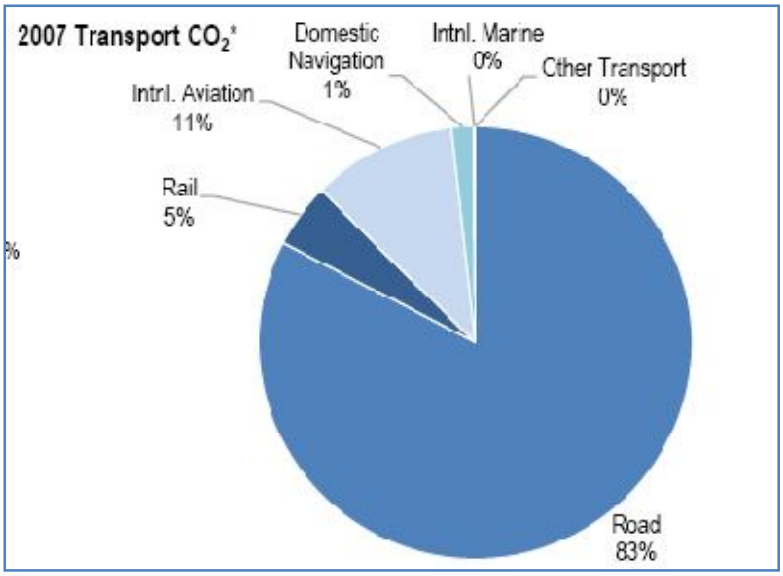


Fig-1: Distribution of CO2 Emissions from Indian Transport Sector in 2007

While the maritime emissions are currently low, the total Indian Tonnage is expected to increase to 30 Million tons by the year 2020 as per the Maritime Agenda released by Ministry of Shipping. This would increase the emissions substantially.

The Indian Maritime University has taken up the challenge of reduction of carbon footprint of ships seriously and is trying to address the problem in different ways

IMU(V) has taken up a study (sponsored by Ministry of Shipping) to assess the current emission levels of ships especially those vessels operating in the coastal, inland and harbour trades. The preliminary analysis of data (data from D.G.Shipping, LR Fairplay and IRS) indicates that the specific CO2 emissions (CO2 Emissions/hr per GT) are high for vessels operating in the Indian coast (Fig-2)

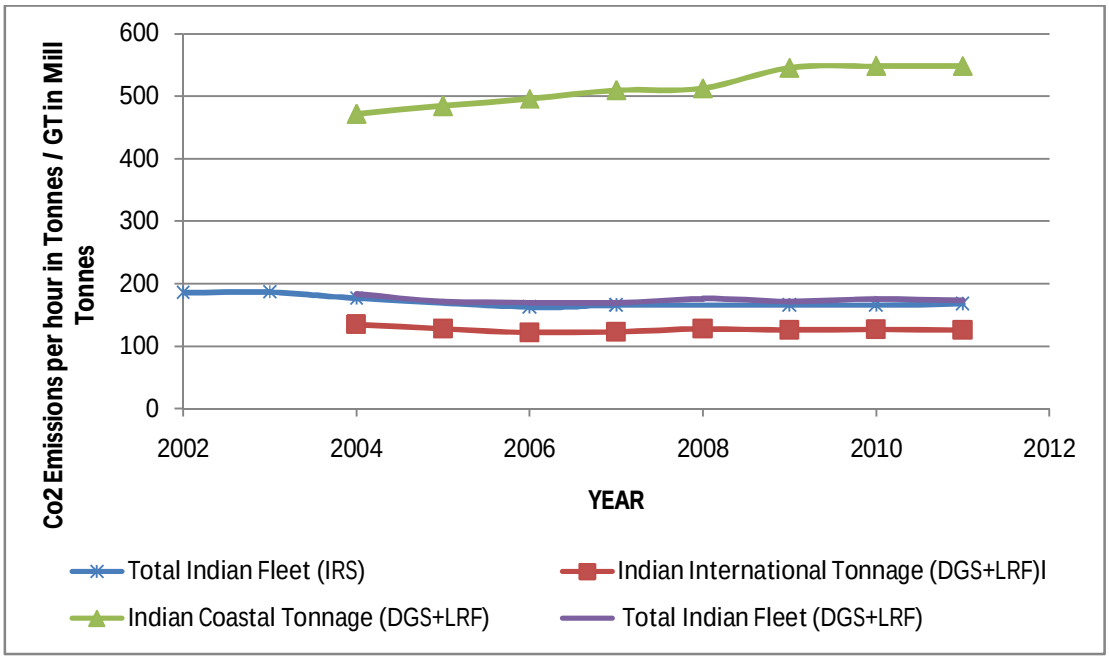


Fig-2: Variation of Specific CO2 Emissions over Time

The study is ongoing which will eventually lead to an assessment of the situation and will also lay the ground work for continuous monitoring.

This campus is also exploring possibility of using LNG as fuel in Tugs and coastal vessels. Standard designs for 40-60 ton bollard pull tugs for harbour and escort operations and a design of 10,000 Dwt bulk carrier / oil tanker/ heavy lift cargo vessel for coastal trade are under progress where one of the alternatives being explored is the use of LNG.

While LNG as fuel reduces the emissions by virtue of its properties, it is only considered as an alternative in the short term, as it is still a fossil fuel whose reserves are fast depleting. Also there is a concern about the availability of LNG to Indian coastal vessels and the establishment of the supply chain for supplying this fuel at all the ports at costs at least equivalent to diesel fuel. Therefore IMU (V) is also considering the possibility of use of other forms of renewable energy such as Bio Diesel, wind and solar power for their applications in Maritime sector.

In order to reduce the EEDI further, it would be necessary to also look at the overall Marine power plant efficiency and especially waste heat recovery systems to be able to extract as much energy as possible so as to able to get more work out of the input energy. IMU (V) is looking into this aspect and is exploring the use of Stirling engines with/without external combustion sources.

While Diesel engines as prime movers for propulsion has become a defacto standard so far, time has come to look into other forms of energy conversion mechanisms such as external combustion sources where it would be possible to have a better control over the combustion mechanism, fuel cells and even nuclear energy which incidentally has a zero CO2 emissions..

While work is ongoing into the mechanism of utilizing the energy produced, Academic and Research institutions in India are also looking into improving the hydrodynamic performance of vessels by improvements in the hull form and propulsors along with use of high performance materials leading to overall weight reduction and better paints for reducing the resistance and improved hydrodynamic performance, fouling and corrosion.

IMU (V) has proposed to the Ministry of shipping for setting up a national program on indigenous green ship development involving a large number of research and industrial organizations.