Annexures

Decarbonising Shipping Vessels in Indian Waterways through Clean Fuel

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Annexure 1: Vessel projection

Inland waterways

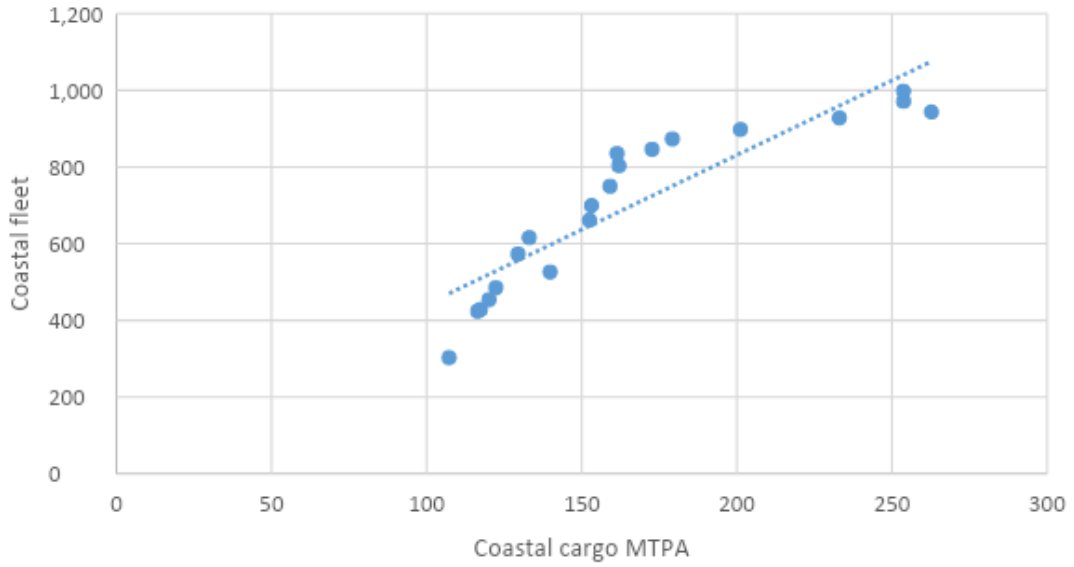
We use the coefficient of MTPA per vessel derived from the 2019 figures on cargo traffic and number of operating vessels, i.e., 0.042 MTPA/vessel, to estimate the number of cargo vessels in 2030 (MoPSW 2021c). We multiply this co-efficient with the projected cargo traffic of 200 MTPA by 2030 to arrive at an estimated vessel requirement of 4,811 by 2030.

We employ the same method in the estimation of passenger ferries in 2030. We derive a coefficient of passengers/vessel from the 2019 data, i.e., 1,09,499 passengers/vessels (MoPSW 2021c). The product of projected passenger traffic for 2030 and this coefficient gives us 6,393 passenger ferries for 2030.

Coastal shipping

We draw a linear correlation between the historical coastal fleet trends and the coastal cargo transported on these vessels annually (see Figure 29). We find a correlation co-efficient of 0.81 between these two variables and use the line equation to project the number of vessels in 2030 in two scenarios of increase in coastal cargo – 259 MTPA and 286 MTPA. This results in the 1,060 to 1,165 coastal vessels in 2030.

Figure A1: Correlation between coastal cargo and fleet over the years



Source: Authors' analysis

Annexure 2: Market size

Table A1: Costs of different kinds of vessels

Vessel type	Cost per vessel (INR)	Source
IWT diesel cargo vessel General cargo Oil tanker Self-propelled vessel of 2000 T	 INR 2,96,50,000 INR 2,96,50,000 INR 10,87,20,000	(IWAI 2021b)
IWT diesel passenger ferry	INR 2,25,00,000	(Thandasherry 2021)
IWT solar passenger ferry	INR 3,00,00,000	(Thandasherry 2021)
Coastal cargo vessel	INR 9,17,83,333	Stakeholder discussions

The cost of retrofitting the cargo vessels to LNG have been taken 30% as that of the conventional fuel technology vessel (Moirangthem 2016).

Annexure 3: Fuel consumption and CO_2 emissions

Inland waterways

We use the vessel and tonne-km data for the year 2019 to create a coefficient 26.95 lakh tonne-km/vessel, to estimate the tonne-kms of freight transported on coastal ships in 2030. The product of tonne-km/vessel and number of vessels estimated for 2030, gives 1,29,647 lakh tonne-kms of freight demand from coastal shipping in 2030. We then use the fuel index factor for diesel vessels as 2.2 g/tkm (Sui et al. 2020). We use the CO_2 emission factor of diesel – 3.206 gCO_2 per litre – to estimate the CO_2 emissions in 2030.

In order to calculate the fuel consumption in the alternate fuel scenario – LNG – we use a fuel index of 1.863 g/tkm (Sui et al. 2020) and multiplying it with the total . We use a CO_2 emission factor of 2.75 g CO_2/g of fuel to estimate the total CO_2 emissions from IWT cargo vessels.

We assume a passenger ferry consuming 15 litres per hour running 2,520 hours annually to estimate the diesel consumption (Thandasherry 2021). The product of fuel consumption factor (litres per hour), hours of operation and number of passenger ferries gives us the diesel fuel demand of 2,416 lakh litres. Using a CO_2 emission factor of diesel, we estimate the total CO_2 emissions in 2030. In an alternate fuel scenario, we assume that all the passenger ferries are replaced by solar electric boats. We assume a solar electric boat with a 23.5 kW_P solar power array attached on the roof generating 72.8 kWh during the operating hours per day. The ferry has a battery of 80 kWh and 30 kW motor power. The total energy required per day by the ferry boat is 90 kWh of which only 17.2 kWh is consumed from the grid (Thandasherry 2021). Smaller boats (20-30 passenger) have a higher potential for electrification. The number of small boats are estimated as 52% (Inland Waterways Authority of India 2019). Assuming that the smaller operational boats are solar-electric by 2030, we estimate the total electricity consumption as the product of 17.2 kWh, and 350 days of the year. Using the CO_2 emission factor of 0.671 gCO_2/kWh in 2030, we estimate CO_2 emissions from electricity consumption.

Coastal shipping

The CO_2 emissions of the vessels have been taken as 5.1 million tonnes based on the Annual Fuel Consumption report 2019-20 from the Directorate General of Shipping. Accounting for the growth in the vessels, the CO_2 emission has been calculated for BAU growth and LNG scenarios in 2030. The emission factors considered are listed in Table A2.

Table A2 Fuel consumption and CO_2 emission factor of marine fuels

Fuel	Fuel consumption factor (tonnes/hour)	CO_2 emissions factor (gCO_2/g of fuel)
Residual	7.41	3.11
Distillate	0.47	3.21
LNG	6.17	2.75

Source: Olmer et al. 2017. “Greenhouse Gas Emissions from Global Shipping, 2013–2015: Detailed Methodology.”; Mohseni et al. 2019. “Economic Evaluation of Alternative Technologies to Mitigate Sulphur Emissions in Maritime Container Transport from Both the Vessel Owner and Shipper Perspective.”