Evolution of Global Maritime Freight Energy Demand and CO_2 Emissions: A Business as Usual and 2 Degree Scenario

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Abstract

Global shipping lanes are responsible for transporting 80% of global freight by volume. In 2012, the maritime freight sector emitted 615 million tonnes of CO_2, accounting for 2.0% of global CO_2 emissions. Projections from the European Parliament indicate that the share of CO_2 emissions from international shipping may increase to account for up to 17% of the global total by 2050. This study firstly seeks to explain the evolution of final energy demand and CO_2 emissions from the global maritime freight sector up to 2050. This is explored using a bottom-up sectoral simulation model, using exogenous inputs for long-term activity projections to determine a BAU pathway and a 2DS pathway. Secondly, it investigates the CO_2 abatement options available to the shipping sector to move from BAU to 2DS emissions trajectories. Results indicate that CO_2 emissions from international maritime freight will grow under a BAU scenario by a factor of 2.73 between 2010 and 2050, to a total of 1,937 million tonnes of CO_2 per annum in 2050[1]. In comparison, a 2DS requires a carbon budget for the maritime freight sector of 710 million tonnes of CO_2 by 2050. This is technically achievable, yet ambitious, through (i) a reduction of trade growth of oil, gas and coal (ii) shifting to larger ships (iii) improved operational and technical efficiency for new ships and retrofits (iv) switching to a 25% LNG fuel mix by 2050 and (v) switching to a 25% biofuel fuel mix by 2050. This study emphasizes the urgency of timely implementation of globally binding policy targeting GHG emissions from ships through intervention by international policy makers and the academic community to reduce CO_2 emissions, and to design a roadmap to moving from a BAU to a 2DS future where global temperature increase is limited to 2°C.

[1] The results of this analysis reflect projections that were made in the framework of a cooperation between the International Energy Agency (IEA) and Utrecht University that was finalized in June 2016. Projections have been further refined by the IEA after this date. The result of this refinement fed into an updated projection of shipping energy demand that has been incorporated in the IEA World Energy Outlook 2016. These results are under embargo until the date of publication of the World Energy Outlook 2016 (16 November 2016).

Introduction

Global shipping lanes are the arteries of international trade. In 2012, 49 trillion tonne-miles of freight and 80% of total global freight by volume were navigated along thousands of maritime routes (UNCTAD, 2015). In providing this service, the international maritime freight sector consumed 191 million tonnes of oil equivalent (Mtoe) of final energy (2.1% of global final energy consumption) and emitted 615 million tonnes of carbon dioxide (Mt CO_2) (2.0% of global CO_2 emissions) in 2012 (IEA, 2015a). Projections indicate that under business as usual (BAU) conditions, energy demand in this sector will continue to increase considerably (IMO, 2014; Cames et al., 2015; ITF, 2015). The European Parliament cautions:

"[if] the ambition of [the international shipping sector] continues to fall behind efforts in other sectors and if action to combat climate change is further postponed, their CO_2 emission shares in global CO_2 emissions may rise substantially to 17 % for maritime transport by 2050" (Cames et al., 2015).

However, projections from IEA (2016) show that in a scenario where global temperature increase is limited to 2°C (2DS) with a 50% probability rate of achievement, annual CO_2 emissions of the international maritime sector must not exceed 710 Mt CO_2.

With around 90% of international shipping fuel use being dedicated to freight purposes (IMO, 2014), this paper seeks to explain the evolution of global final energy demand and CO_2 emissions of the maritime freight sector from 2010-2050, according to a BAU and 2DS. In addition, it seeks to explore CO_2 abatement options available to the shipping sector to move from BAU to 2DS emissions trajectories.

Methodology

This study was undertaken at the International Energy Agency (IEA) in cooperation with Utrecht University, by constructing a bottom-up technical simulation model using an ASIF structure to approximate energy demand and CO_2 emissions according to the two scenarios (Fulton et al., 2009; IEA, 2015b). The ASIF equation, adapted for the use in this study, is as follows:

$$\boldsymbol{E} = \sum_{regions} \sum_{ship\ types} A_r * S_s * I_s * F_{r,s}$$

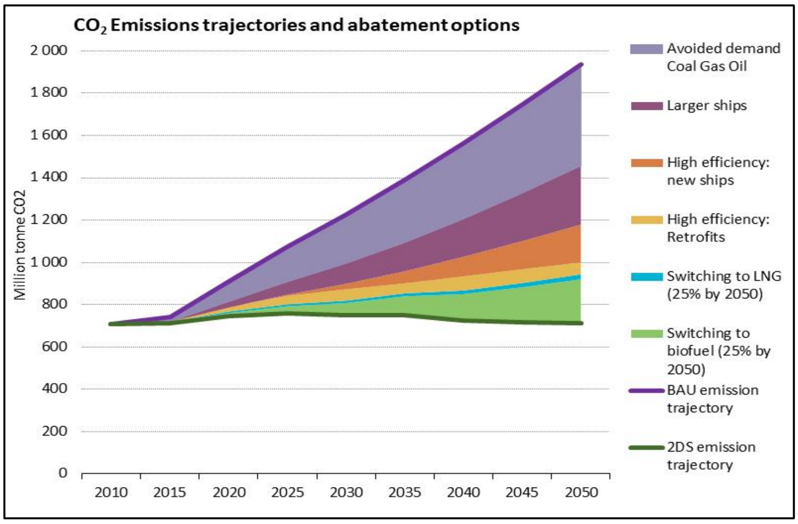
Where, *E* represents the total CO_2 emissions; *A* represents activity in tonne-kilometres of maritime trade for each region; *S* the structure variable that represents load factors, in tonne per ship per trip, for the various ship types; *I* measures the energy intensity in energy per vehicle kilometre (vkm) for each ship type; and *F* represents the emission factor in CO_2 per energy for each fuel type. The model considers 5 ship types - oil tankers, bulk carriers, general cargo, container ships and other types of ships – and maritime trade between 26 regions.

The BAU projections include the evolution of trade flows and technical characteristics of the global fleet towards 2050 and embody the effects of the globally binding Energy Efficiency Design Index (EEDI) policy issued by the

International Maritime Organization (IMO). The 2DS follows a CO_2 emission trajectory resulting from the combination of technical and operational innovations aiming to attain stabilization of CO_2 emissions by 2050; which is optimized according to a 'What-if' approach.

Data on the driving variable of the model, tonne-kilometres of maritime trade, is derived from the International Transport Forum (ITF). It represents global physical flows of maritime trade by origin-destination point between 26 regions and by 19 commodity types, which was aggregated to account for 5 different ship types. This data was available for this research for the years 2010-2050 in 5 year time steps, and therefore implies projections on trade and shifting of trade patterns. The data used are an output of the ITF transport model (Martinez et al., 2014) relying on value to weight conversion data from Eurostat and ECLAC databases, as well as trade projections (in monetary units) that were derived using a general equilibrium model for international trade developed by the Economic Department of the OECD. Data on the remaining ASIF parameters were mostly derived from IEA, IMO and UNCTAD.

Results



The results indicate that, according to the BAU scenario, global maritime freight (represented in tonnes) will grow by a factor 3.75 between 2010 and 2050, while the activity (in tonne-kilometre) is projected to grow with a factor 4.4 over the same period - due to an increase of relative distance over time. By 2050, the total final energy demand from international maritime freight is projected to be 625 million of 2010 tonne fuel equivalent, which corresponds to 1937 Mt CO_2.

In the 2DS, global CO_2 emissions from maritime freight are reduced to 714 Mt CO_2 emitted in 2050 through a combination of measures. The figure above shows results brought about by the subsequent application of (i) a reduction in trade growth of fossil energy carriers (ii) shifting to larger ships (iii) improved operational and technical efficiency for new ships and retrofits (iv) increased LNG use in the fuel mix and (v) increased biofuel use. Reduced trade growth results from a reduced global demand for oil, gas and coal from global decarbonisation, avoiding 480 Mt CO_2 in 2050. In the BAU scenario demand for these commodity types is projected to increase. The more optimistic assumptions on growth of average ship sizes compared to BAU are mostly triggered by growth of container ships and bulk carriers. This increases fuel efficiency per tonne-kilometre, and overall results in 278 MtCO_2 avoided in 2050. The CO_2 abatement from improved efficiency of ships in 2DS is significant: avoiding 56 MtCO_2 from retrofits and 178 MtCO_2 from new ships in 2050. This requires the optimistic assumption that all new ships are 34%-56% more efficient by 2035 compared to 2010, and all existing ships that are still in the fleet by 2050 are retrofitted, improving their efficiency by 17%-27%. The fuel mix is composed by 25% LNG and 25% advanced biofuels by 2050, leading to 24 $MtCO_2$ and 206 $MtCO_2$ of abatement respectively. This clearly emphasizes that the decarbonisation potential of (second generation) biofuel is larger than that of LNG. Above all, it is important to note that achieving stabilization of CO_2 emissions in the 2DS required highly optimistic assumptions, which cannot be achieved without immediate action from international policymakers. Increasingly delaying action in pursuing a 2DS will require increasingly stringent measures and even faster deployment rates of efficiency improvement technologies and fuel switching in the future.

Conclusions

The EEDI is a start towards decarbonizing the shipping sector, but in its current form will be easily outpaced by the projected growth in demand, and it still allows for an increasing share of global CO_2 emissions from international shipping. Additional policy measures are required to guide the decarbonisation of the sector in line with a 2DS. Secondly, although shipping is currently known for offering a cheap solution to freight transport, it is unambiguous that pursuing a 2DS will increase costs for the sector, from the use of cleaner fuels and investing in efficiency improvements. Thirdly, although LNG has gained popularity as a “clean technology” solution to the shipping sector, results of this study indicate that its carbon reduction potential is limited. Given the large investments required for worldwide LNG availability it is worth it to (re)evaluate its added value for the global community when pursuing a 2DS.

The BAU CO_2 emissions projections discussed here have been further refined by the IEA after finalization of the communal study between IEA and Utrecht University presented in this article. The result of this refinement fed into an updated projection of shipping energy demand that has been incorporated in the IEA World Energy Outlook 2016. These results are under embargo until the date of publication (16 November 2016). The selection of abatement options in the 2DS outlined in this analysis are also the result of discretionary choices that could be further improved. Further research in this field is required. Also, this analysis could be further enriched by a better assessment of relative costs involved in the different decarbonization options available to the shipping sector.

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