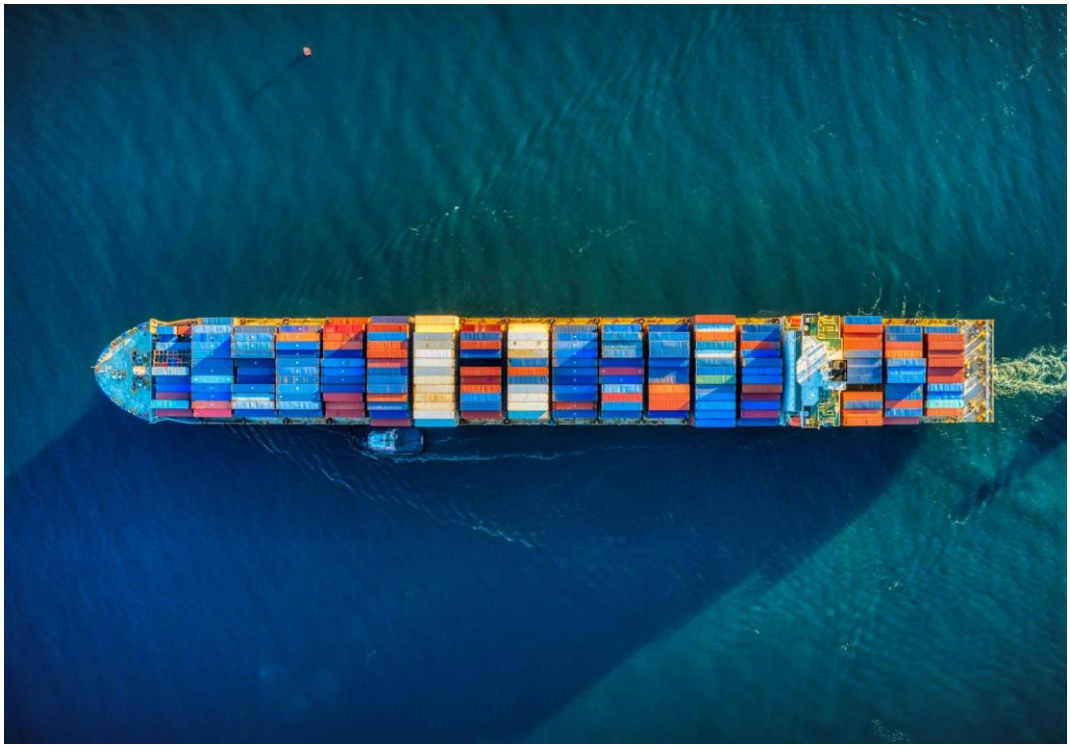

Climate change and shipping: Implications of the decarbonization of global energy supplies for the global shipping industry

Mentored and Supervised by:

Alex Zymnis, BSc Economics & Political Science Davidson College, MSc Finance Imperial

Research and Writing by CLC's students:

Gabriel Stavrakas / Angelis Kokkosioulis /
Andreas Papandreou / Panagiotis Tsouparis

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Abstract

The Covid-19 pandemic highlighted two increasingly important issues for international markets: Climate change and global supply chains. If the Paris Agreement goals are met, global shipping markets would have to undergo a radical transformation in order to secure their survival in the future. The aim of this paper is to explore how the decarbonization of global energy supplies will affect different sectors of the shipping industry.

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Introduction

Roughly eighty percent of global primary energy supply consists of hydrocarbons such as oil, gas and coal. The Paris Agreement and mounting international pressure to reduce global warming render this position clearly unsustainable. The energy industry is closely related to the shipping industry as the latter is responsible for transporting manufactured goods, commodities and energy such as oil. As the world steadily moves towards cleaner energy supplies the reduction in hydrocarbon emissions due to come will have strong implications not only for the energy sector but also the shipping sector. This paper draws heavily from the 2019 "Carbon Carriers" MSI report as well as other sources to focus on the implications of climate change on the shipping sector.

Oil tankers

Global Oil Demand

Oil tanker demand is closely linked to the global demand for oil which is in turn closely correlated to the production and consumption of demand. Oil can be shipped both as crude or unrefined, but also, as refined products such as gasoline and diesel.

Global demand for oil is affected by a broad array of macroeconomic factors. In recent years we have seen demand for oil plummet as it happened during the first year of the covid pandemic and then steeply rise again once the effects of the pandemic started dwindling off. In 2022 covid era supply shocks and the Russia-Ukraine conflict, along with worldwide inflationary pressure have caused prices to rise to unprecedented levels. Yet, as fears of an incoming recessions are accelerating, experts are expecting oil demand to ease off on the third quarter of 2022. All of this is to say that oil demand, in the short term, is hard to predict and is affected by a plethora of factors.

Nevertheless, the focus of this paper is on the longer-term horizon which might be easier to predict or forecast. In recent years, global oil demand has grown around 1-1.5% year on year, mostly driven by non-OECD regions with Asia being a major contributor. Long term demand, contrary to short term demand, will be driven by a plethora of factors such as the evolution of transportation technology and government regulation. According to the 2019 MSI report, global oil demand is

expected to halve by 2050 in their more aggressive estimates. This is mainly driven by the increase in engine efficiency (and less so on electric vehicle penetration. Declines are expected to be more severe for OECD countries and less severe for other Asian countries such as India.

Shipping Demand

Declining global demand and consumption will create increasing uncertainty about the sector and its future. According to the 2019 MSI report, by 2050 crude oil tanker demand is expected to drop by 34%, while oil product tanker demand is expected to decline by 38%.

The reason why tanker demand does not halve as does global oil consumption can be traced to the fact that changes in oil demand vary by regions. This means that trade flows will still be required. Additionally, as referenced by the MSI paper, trade fows are expected to increase in distance due to the increasing market share of the Amercias in oil flows. In other words, it is expected that more oil is going to flow from the Americas to Asia leading to longer routes and thus higher supportive demand.

Nevertheless, the drop in oil tanker demand by one-third is significant to say the least. The oil tanker market will be forced to make stark choices and carefully plan what might be one, if not the most, important threat in the sector's history.

Figure 1 & 2: Crude oil deadweight demand and oil products deadweight demand

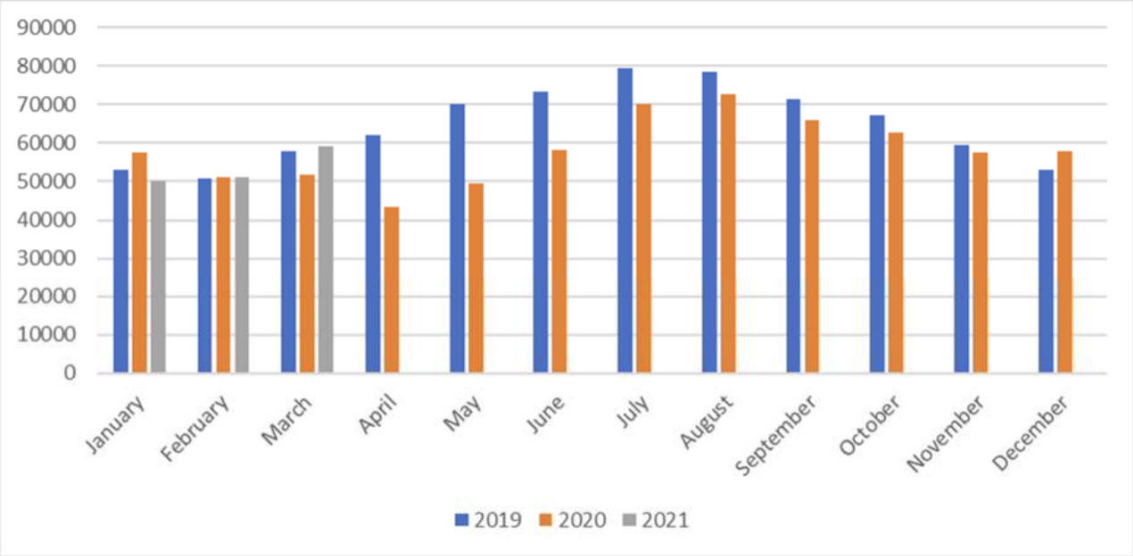
(MSI, "Carbon Carriers – The Impact of Raid Decarbonisation on the Shipping industry", 2019)

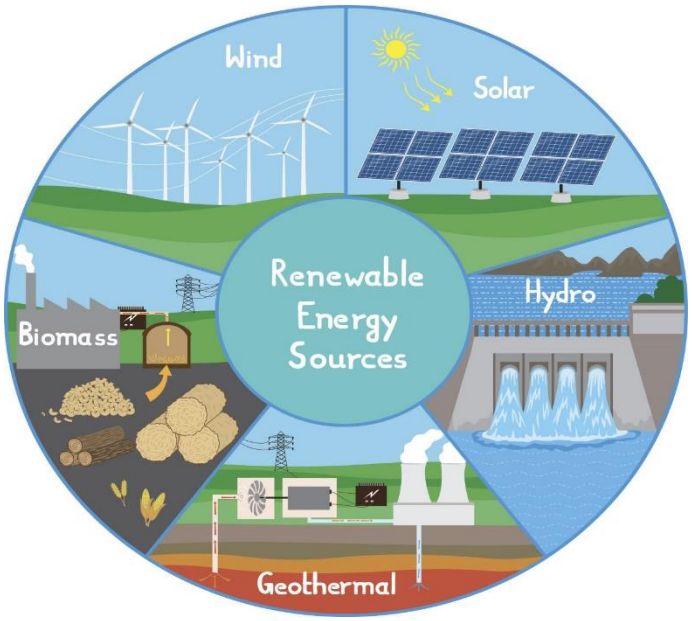
Containerships

Contrary to other sectors such as oil tankers and LNG carriers, containerships would witness no significant change in global demand as they carry almost zero energy related cargoes. Container box demand is analogous to consumer demand for manufactured and agricultural goods as well as business demand for semi-finished products, parts, and select raw materials. In hierarchical order, after container box demand comes that of vessels as it is primarily driven by the number of container boxes shipped. However, it may also be affected by the distance the boxes have to travel from the site of manufacture or assembly to the location of the final consumer. The reduction of vessel demand in Twenty-foot Equivalent Unit (TEU) terms could be achieved by moving to 're-' or 'near-shore' production, yet the number of container boxes moved would ultimately remain the same.

Overall, the carbon intensity of container shipping is very low. On the assumption that a 22 k TEU containership burns 140 tonnes of fuel every day on a 27-day sail from China to Europe, that would be equivalent to 0.3 tonnes of CO_2 per TEU, supposing that the vessel is 85% utilized. That would equal 0.63 tonnes of CO_2 per container. A t-shirt weighs an approximate 110 grams, so if 10 tonnes of t-shirts were to be loaded in each container with packaging that weighs an additional 90 grams, then each container can hold 50 k t-shirts. The CO_2 emissions of ocean transport are 0.000013 tonnes of CO_2 for every t-shirt, or otherwise 0.01 kg. In comparison to a t-shirts overall carbon footprint, ocean transportation produces only a fragment of that, while alternative transport methods would likely be more polluting after all.

Antithetical to mutual expectation, the COVID-19 outbreak actually lessened global shipping demand rather dramatically. Breaking everlasting records, container trade noticed a 10% decline in 2020 even though ports had remained operational. The notable decrease in the number of ship calls began 12 weeks after the identification of the virus (12-16 March 2020), shortly after the WHO declared the COVID-19 outbreak a pandemic. Containerships fell to a drastic 12% decrease in a span of just two years (January 2019 - January 2021), while other ship types witnessed even harsher of a decline. The impact on ship traffic was a direct consequence of the limitations in movements of passengers and crew members as well as the lockdown measures imposed in many Member States which reduced international trade.





Renewables

The shipping industry business heavily depends on how many hydrocarbons are consumed. If the consumption of hydrocarbons increases, then there will be more demand for them and more business for the shipping sector. One way hydrocarbon consumption is lessened is by using alternative sources of energy such as renewables or nuclear power. Renewable sources of energy are sources which provide clean energy, usually with little or no greenhouse gas emissions, which will not run out in the foreseeable future.

There are five main types of renewable energy:

1. Solar energy
   Energy taken directly from the sun. This usually involves photovoltaic cells which convert light energy into electricity.

2. Wind energy
   This is energy harvested from moving air currents caused by differences in pressure between two locations. The moving air collides with the blades of the turbine and pushes them around, turning a generator and producing electricity.

3. Hydroelectric power
   Energy taken from rivers and lakes. To harvest this energy, dams are usually built and the water flow from rivers is used to turn turbines producing electricity. Hydroelectric power currently provides most of the electricity from renewables.

4. Biomass and Biofuels
   This is fuel made by harvesting organic matter, usually from plants, and then processing it in specific ways.

5. Geothermal power
   This is energy taken from heat which exists far underground. This heat is used to boil water, resulting in steam being produced which turns a turbine.

General overview

Renewables have long been considered to be the main rival of fossil fuels and they have been growing quickly over the past few years. The bar graphs and charts below show the worldwide increase in total renewable power capacity and a few major countries' power capacity over several years.

Fig.1

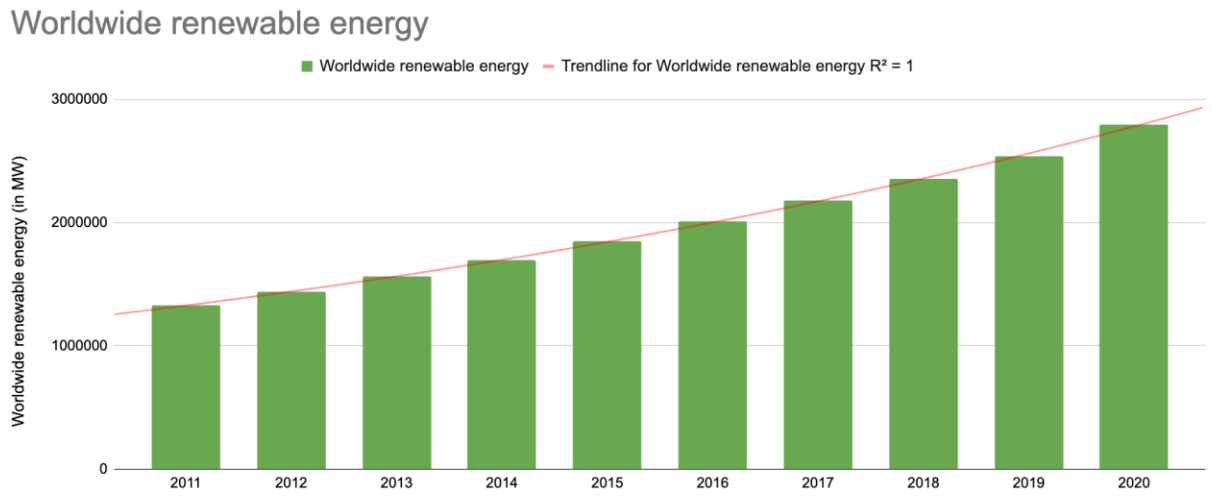
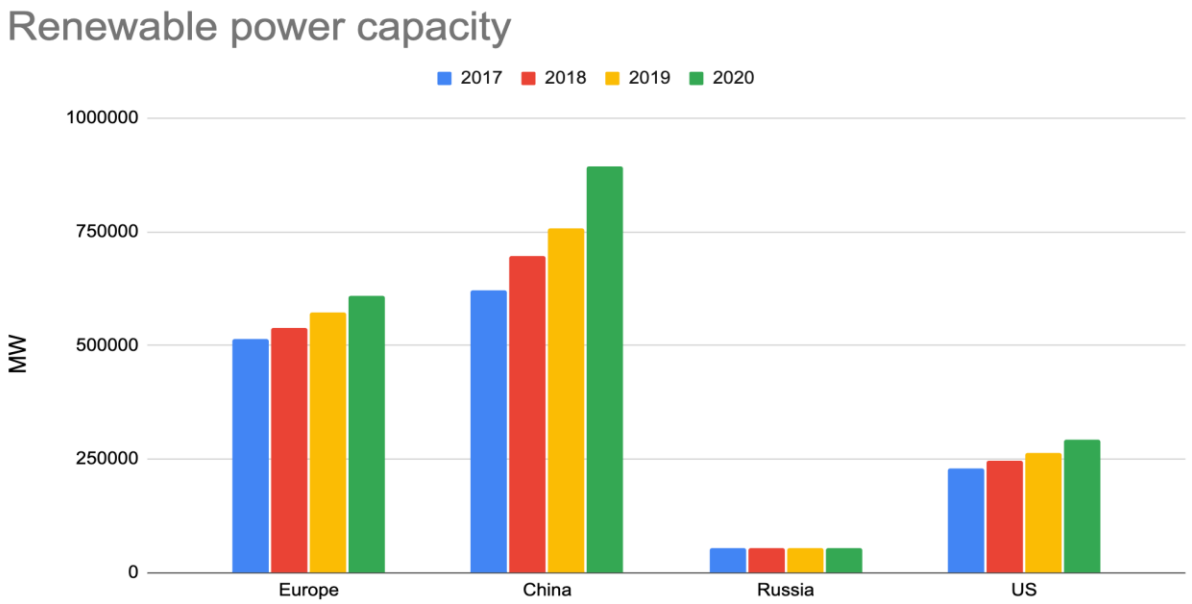


Fig.2



As their total power capacity grows, more fuel powered stations are rendered obsolete, cutting the demand for oil. Thus, they, indirectly, can have a negative impact on the shipping sector. This is because fewer power stations means less feedstock is required. Therefore, the shipping sector loses part of their reliable source of business, as fuel carriers usually have to supply a constant stream of fuel to the power stations. Of course, the shipping industry will gain more business for a while due to shipping components needed to build the renewable, but this will be a one off event and promises no long term profit.

However, there are two potential saviors for the shipping sector. The most obvious one is biofuel as it has net zero emissions* and still provides constant feedstock. Moreover, it provides the option to reuse old oil tankers which have been decommissioned due to the decline of this part of the shipping sector. There are, however, difficulties in using biofuels: biodiesel generally costs more than conventional fossil fuels to produce, is less energy dense, and uses a large amount of land for the biomass to be grown and harvested.

The second savior is offshore wind power. Because offshore wind turbines frequently require maintenance vessels during their operational time they can provide a significant amount of business for the shipping sector. On the other hand, these offshore wind generators need very specialized vessels, meaning that it is unlikely that old tankers will be reused.

Future of Renewables

Efficiency improvements

Along with the introduction of electrification, many machines have been made much more energy efficient. This means that machines, overall, use less energy to run. This can heavily impact the oil industry as less fuel or energy will be used, therefore demand will fall further. This effect is amplified by electrification mentioned below.

Electrification

Electrification is the process of converting machinery which works with fuel to machinery that can work with electricity. Eventually, this is the process that will deliver the death blow to the oil industry by making it obsolete, given enough time. Renewables provide energy mostly in the form of electricity. In fact, four out of the five types mentioned above output solely electricity, and biofuels are economically and practically outmatched by fossil fuels. This presents one of the biggest problems the renewable industry has to face, because a lot of our machinery requires gasoline and other fuels to operate. Therefore, unless we can convert the majority of our machines into using electricity, renewables will always be restricted and unable to completely take over the energy industry. There is another side effect of this process that will catalyze the downfall of fossil fuels even more. Electric engines are, by nature, much more efficient than conventional fuel engines, meaning that they will reduce the energy needed to run them, and, as mentioned above, efficiency is a crucial factor to take into account when looking at the decline of the oil industry.

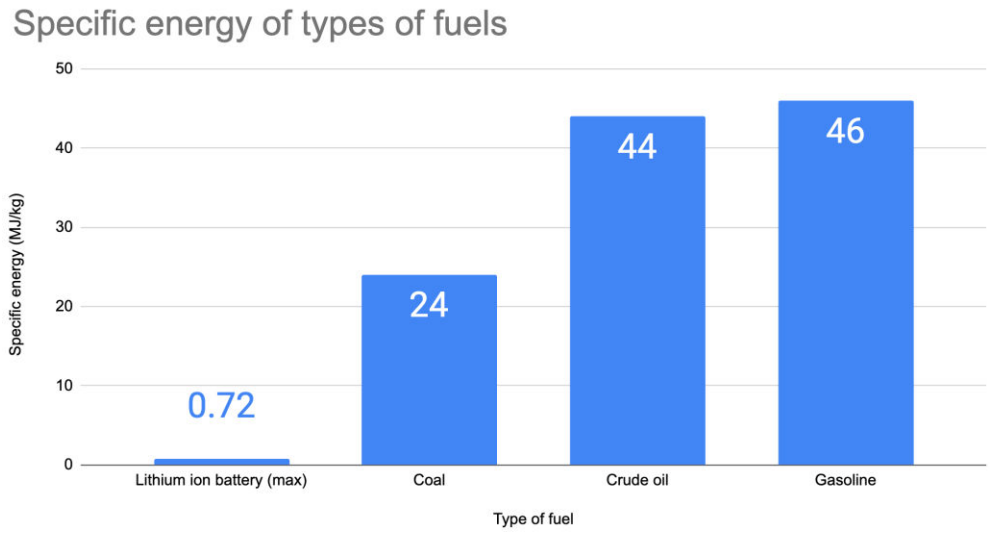
Various other Problems of the Renewable industry

Storage of energy

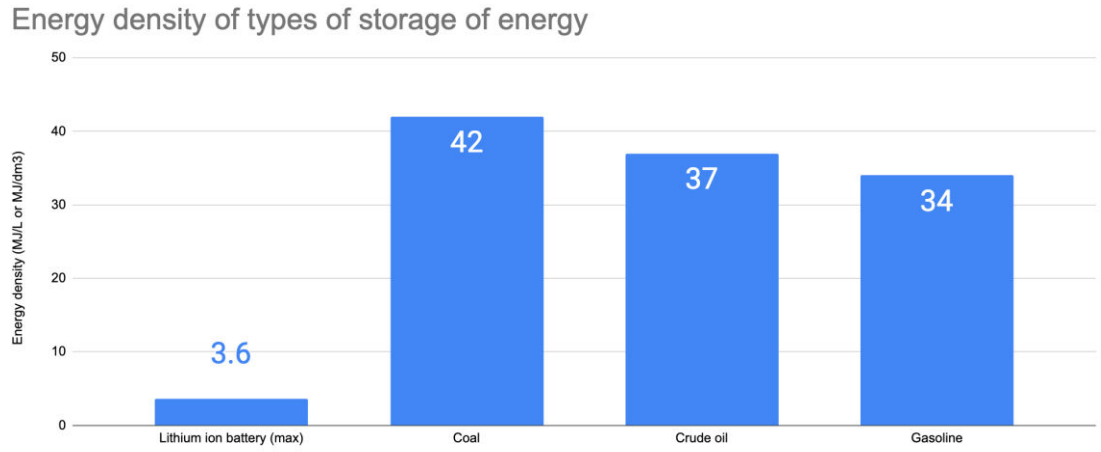
Renewables are frequently unreliable. Even the ones that are reliable -geothermal and biofuel- are expensive or need special locations. The sun does not always shine and the wind does not blow constantly. Even the flow of the river changes through the seasons. This means that if we were to base our society solely on electrical energy derived purely from renewable sources there would be an excess of power in some seasons and a dearth in others. In order to overcome this problem, many batteries may have to be installed in power ‘warehouses’ to store energy for the few ‘dry’ seasons when power production is at its nadir. Building this many batteries is not only expensive, but also environmentally unfriendly due to the numerous materials

required for the construction. Also, current batteries do not output enough voltage and are not energy dense enough for such a task. Therefore, new batteries have to be researched and made which will take a significant amount of time and money.

Batteries are also outmatched by fossil fuels because they are much less energy dense. What this means is that they store less energy per unit mass and volume and the difference is very large, as shown in the bar graph below.



Energy per unit mass (Fig.3)



Energy per unit volume (Fig.4)

Thus, unless batteries are improved, tonnes of batteries taking up many cubic metres will be required to match the energy trapped in a single barrel of oil. The only renewable that can compete with fossil fuels in terms of energy density is biofuel and even that needs a lot of land for cultivating plant material.

Waste (Parts)

Parts of solar panels and wind turbines are very difficult to dispose of at the end of their lifetime. They have a large environmental impact and are much more expensive to recycle than normal garbage. The blades of wind turbines, for example, are very large and need special vehicles to carry them down and away from the mountain tops where they are usually positioned.

Renewables are indeed on the rise, as shown in the data above. However, this does not mean that they will completely replace hydrocarbons quickly as there are many major problems to overcome before they can dominate the energy sector.

Nuclear energy (Fusion & Fission)

Fission

Nuclear energy has not been considered a main adversary of fossil fuels and is not generally acknowledged as a green energy source, due to the waste it produces. However, it may play a major role in the downfall of fossil fuels. Nuclear energy is unlikely to help the shipping industry for more business if it grows. This is because building nuclear reactors is expensive and time consuming due to lack of know-how. Therefore, even if construction for new reactors was started now, it would take as long as a decade for the new reactors to become fully operational. Also, many countries are not too keen on supporting nuclear energy due to the disadvantages mentioned above and due to the general, hostile public stance against it, meaning it lacks the support. Moreover, while nuclear reactors require feedstock of fuel, they need much less than coal and oil plants due to the energy density of nuclear fuel. Thus, there is going to be a net decrease in shipping business if the nuclear energy sector grows and replaces coal and oil plants with nuclear ones.

Fusion (theoretical)

Fusion energy is a type of nuclear energy that is still under development and while it promises energy production off the charts many people are skeptical of its potential. Fusion is the act of putting together isotopes of hydrogen and forming heavier elements. One of the biggest experimental reactors built to test if fusion is possible is ITER. Many physicists claim that, theoretically, ITER can have a Q ratio of 10, meaning that the reactor will output 10 times the energy it consumes. If this is true, and fusion energy takes less time to be commercially available than predicted, then it will probably have a very large impact on the energy market, possibly

dominating it and catalyzing the removal of fossil fuels. However, this is extremely unlikely and many scientists have expressed doubts about whether ITER has the potential to generate a Q of 10. Optimistic sites have predicted that the first fusion reactors could be coming online in around 2040, assuming that the ITER project is successful. Realistically, it may take much longer, at least 3 decades or more, for fusion energy to be fully developed.

How does this all link to the Shipping Sector?

As explained above, with numerous graphs as evidence, renewables are vastly outclassed by their fossil fuel counterparts. This means that trade of the fossil fuels will continue as they are much more economically and practically viable for all purposes in life. However, the extensive discussion above occurred due to the nature of development of renewables. Many optimistic sources state that they are increasing at an increasing rate due to the progression of technology. If this is true, they may replace fossil fuels in the coming century. This will create a sudden decline in the containerships used, as demand for hydrocarbons drops sharply and the shipping sector dealing with the transportation of these fossil fuels will shrink rapidly.

On the other hand, renewables may never overtake fossil fuels due to their problems which were described under “Various Other Problems of the Renewable Industry” which prevent them from becoming more practically and economically viable options for providing electricity. Under this case, there may be a decline in fossil fuel usage which will be negligible compared to its annual increase, therefore not harming the Shipping industry involved in the fossil fuel trade.

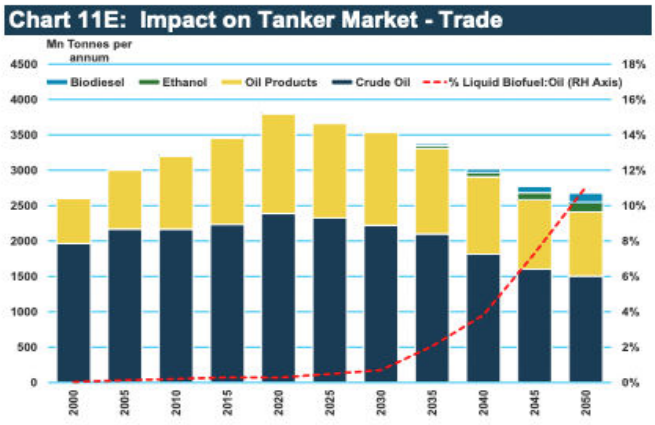
The electrification paragraph depicted how, as technology progresses, more and more of our machines are likely to use electricity, drastically increasing their efficiency. This means less overall fossil fuel usage because less energy is wasted and renewables become more viable. This leads to a decrease in demand for coal and other fuels which are needed to make power plants function. Less demand means less business for the transportation of these fuels, leading to a decline for the Shipping industry.

The last two paragraphs focus on two types of nuclear energy. Nuclear energy is not typically considered “green” or renewable energy but in some places - for example the European Union - it has been named a green energy source in order to encourage its development. It is very unlikely that nuclear energy becomes widespread, however if it does then there will be a sharp decrease in the demand of fossil fuels and the shipping sector will shrink. The Shipping sector will not be able to switch to transporting nuclear fuel or nuclear waste because that job is usually done by trains and much less nuclear fuel is used to produce the same amount of energy that fossil fuels would procure (higher specific energy and energy density). Less goods to transport means less business overall. The second type of nuclear energy, fusion, is yet to be developed. If nuclear fusion is achieved with promised results of multiplying the input energy by 10, then most of the world will rapidly switch to using fusion energy, as it is a cheap, environmentally friendly and extremely efficient source of energy. This would cause the Shipping sector dealing with fossil fuels to collapse as demand for such fuels dropped to a nadir. However, as explained in the paragraph discussing fusion, it is unlikely that the reactor will provide that much energy and will take a long time to come into operation.

Biofuels

Liquid biofuels could be seen as an area of potential support to the oil tanker market which is expected to drastically decrease as discussed above. In recent years, global consumption of bio-diesel and ethanol has seen important growth rising from less than 0.4 Mn b/d in 2001 to more than 2.5 Mn b/d in 2005. According to the 2019 MSI "Carbon Carriers" report global bioenergy demand could rise from roughly 60 Exajoules to roughly 150 Exajoules by 2050. It is expected however that most of the increase in consumption will be driven by biomass, which is typically consumed locally and, if shipped, uses dry bulk carriers and not oil tankers. As a result, despite the strong growth in liquid biofuel demand and trade, the proportion of traded liquid biofuels relative to trade in oil will still remain relatively low meaning that the oil tanker market will most likely not be salvaged by the increase in biofuel demand. Part of this lies on the fact that biofuels will gain more traction further in the future when the oil tanker market will have already seen a very significant decrease.

Figure



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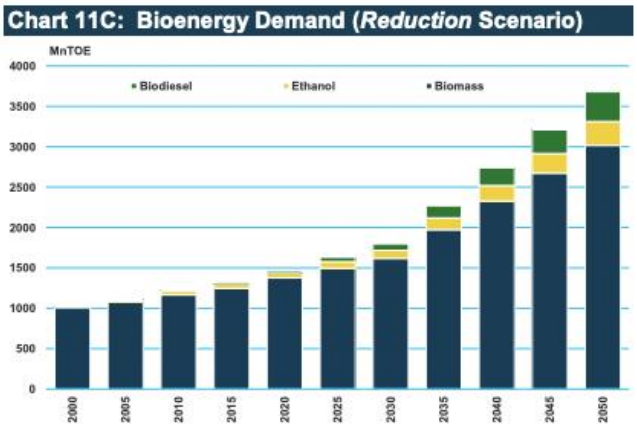

Conclusion

The Paris Agreement and mounting international pressure to reduce global warming have radical implications for the global shipping industry. According to a report published by MSI in 2019, by 2050 global consumption of oil would fall by 50%, coal consumption will fall by 80% and LNG demand will peak in the short term before declining. The tanker market is expected to be most exposed to such changes as it solely transports oil and other fossil fuels. According to MSI, tanker demand will fall by one third and demand for bulk carriers that transport coal will fall by 50% by 2035. Containerships and chemical tankers on the other hand are expected to see much smaller changes in their demand. Lastly, the renewables energy sector will play an increasingly important role going forward. Companies and governments alike should pay close attention to developments in the industry to capitalize on disruptive technology and avoid being disrupted themselves.

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