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Ship Garbage – A Viable Source of Green Energy?

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Abstract

More than 90% of the cargo in international trade is transported by ships. Ocean transportation is considered to be the cheapest and the best mode of transport for bulk cargo. But there is also a flip side to it. Ships are supposed to be the most pollutant and every year, one billion metric tonnes of carbon dioxide are released into the atmosphere by container ships around the world, accounting for about 3% of global greenhouse gas emissions. The International Maritime Organization (IMO) has set strict targets to cut down CO2 emissions, following which several initiatives have been taken by the shipping industry to embrace new technologies that can make the industry greener. Significant investments have been made into R&D to develop alternative marine fuels. The feasibility of converting ships garbage into biofuel is also being tested. This article explores the options in generating and supplying biofuel to ships from garbage which can have twin benefits of disposing garbage effectively as well as running the ship on green fuel.

Key words: *Ship's garbage, biofuel, MARPOL, Port Reception Facility*

I. Introduction

Shipping is one of the most energy-efficient modes of transportation and plays a significant role in global trade. However, it is also a large and expanding source of carbon emissions. Around 940 million tonnes of CO2 are emitted annually by the shipping industry, or at least 2.5% of all CO2 emissions worldwide. A container ships is said to be as polluting as 50 million cars while the amount of emissions from all the cars in the world would be equal to only 15 of the biggest ships and according to the projections, this would keep increasing by 4% annually under a business-as-usual scenario. This means a growth of between 50% and 250% by 2050. In addition to CO2, cargo ships often discharge dangerous pollutants like sulphur oxide(SOx) and nitrous oxide (NOx). These have an impact on air quality and cause global warming. For all of the aforementioned reasons, mitigation strategies must be implemented as soon as possible. By the year 2050, the International Maritime Organization (IMO) wants to reduce these emissions by 50%. Under the IMO's pollution prevention convention (MARPOL), required measures have been adopted to minimise greenhouse gas emissions from international shipping. As per the convention new ships must comply with the Energy Efficiency Design Index (EEDI), and all ships must have a Ship Energy Efficiency Management Plan (SEEMP).

Reducing the CO2 emissions from vessels is possible in many ways:

- By optimizing route planning
- By switching over to renewables and cleaner sources of energy.
- By increasing efficiency of port operations
- By adopting slow steaming.
- By adopting measures to save energy on board
- By adopting battery technology

Of all the above methods transition to cleaner sources of fuel, offers scope for converting vessels garbage to clean fuel. This would give twin benefits of finding an efficient way to dispose garbage as well as running the ship on green fuel. It is evident from the researches going on that generating green fuel from the garbage generated by ships is not a myth. The most apparent method to reduce carbon emissions by the shipping industry in the short term is to consume fuels that release less greenhouse gases and other pollutants. To transport huge cargo over long distances, the cargo ships require massive energy, which is supplied to them from large fuel tanks. For instance, a medium-sized container ship could easily carry more than 2 million gallons of fuel and consume 63,000 gallons every day at sea. Almost all cargo ships were powered by "heavy fuel oil," often known as "bunker fuel," until recently. This fuel is of bad quality and lower cost

and has high sulphur content than diesel. Therefore cargo ships are not only extremely harmful to the environment but also consume enormous amounts of fuel.

At the beginning of 2020, the International Maritime Organization has put forth new bunker fuel regulations in place, lowering the maximum allowable sulphur level from 3.5% to just 0.5%. It is expected that this move will cut yearly sulphur emissions by 77%, or 8.5 million tonnes. Following this there has been an increasing demand for biofuel as it would help to significantly reduce ship CO2 emissions without expensive engine upgrades. Biomass-derived fuels are thus proving to be a potential choice for ships.

Objective of the study

Though the possibility of generating biofuel from garbage is proven and is also used in many industries, this article explores the feasibility of converting the garbage generated by a ship into biofuel which can be used to operate the vessel thereby making it self- reliant. The article also explores the possibility of ports becoming large scale producers and suppliers of bio fuel to vessels

Methodology

An exploratory research design was used for the study to investigate the possibility of supplying bio fuel to the ships generated out of their own garbage in order to make them self-sufficient. The study is qualitative in nature and used both primary and secondary sources of information. The existing MARPOL regulations on the disposal of wastes generated by ships have been reviewed. The researches happening in the field of converting garbage into bio fuel with particular reference to ships have been reviewed. The opinion of the people associated with the shipping industry on the feasibility of the concept was collected through a questionnaire.

Research Questions

The study addresses the following research questions

1. Is it a viable option to generate bio fuel from ship's garbage ?
2. Is it a viable option to install recycling plants on the vessel to make them self –reliant?
3. What can be the challenges in implementing the process?
4. What other alternatives are available to supply green fuel to ships?

II. MARPOL regulations on disposal of wastes generated by ships

Garbage is one of the numerous things that has led to marine pollution. As per MARPOL Annex V, the garbage generated on board a ship includes domestic, operational, and all other types of victual waste. This excludes fresh fish and parts thereof, produced during the normal operation of the ship and subjected to continuous or periodic disposal. This comes with an exception to those substances which are defined or listed in other Annexes to the current convention.

This waste legislation of MARPOL applies to all ships operating including merchant ships, fixed or floating platforms, non-commercial ships like yachts, pleasure vessels, ferries, etc.

Every ship must carry a visible signs and instructions informing the crew and passengers on the rules governing garbage disposal. Additionally, every ship with 400 GWT or more which is authorised to transport 15 persons or more must carry a Garbage Management Plan (GMP) and a Garbage Record Book [1].

Classes of Garbage on Ships

To make management and disposal of waste on ships easier, trash is divided into a number of types [2]

On board garbage is divided into the following categories

- Plastics: Plastics have got a range of applications in maritime industry. They are used in packaging vapour-proof barriers, bottles, containers, and liners, they are used as a raw material in ship construction to manufacture fibreglass and laminated structures, siding, piping, insulation, flooring, carpets, and fabrics, they are also used in

disposable eating utensils and cups, bags, sheeting, floats, strapping bands, rope, line, and incinerator ashes from plastic production.

- Food wastes: On board a ship, particularly in the galley or dining room, food wastes include any rotten or intact items, such as fruits, vegetables, dairy products, poultry, meat, food scraps, food particles, and any other items adulterated by such wastes.
- Domestic wastes: These are any food wastes or wastes generated in a ship's living quarters that are excluded from other waste categories like paper goods, rags, glass, metal, bottles, or dishes and other flatware. Domestic wastes also include any dishes and other flatware that are not considered to be hazardous waste.
- Cooking oil: Any legal oil or animal fat that is consumed or intended to be utilised in the preparation of food for consumption is referred to as "cooking oil."
- Incinerator Ashes: Shipboard incinerators produce ash and clinkers, which are referred to as incinerator ashes.
- Operational Wastes: These are all solid wastes, including slurries, that don't fit into any other waste categories. Operational wastes are those produced during cargo handling and stowing which includes pallets, dunnage, shoring, lining and packing materials, plywood, paper, cardboard, wire, and steel strapping. They also include those wastes generated during maintenance such as the residues collected from the engine and deck departments while maintaining the operating vessel, soot, machinery deposits, scraped paint, deck sweeping, wiping wastes, rags and oily rags etc.
- Animal corpses: Any animal that is transported on board as cargo and dies or is put to death while in transit.
- Fishing equipment: This includes any tangible object used to catch, manage, or harvest marine or freshwater animals that is submerged in water or placed on the ocean floor.
- Electronic waste: This includes cards, devices, tools, computers, printer cartridges, and other electronic items.
- Non- Harmful to Marine Environment (HME) cargo residues: Residues remaining on deck or in the holds after the cargo has been loaded or unloaded or after the holds have been cleaned in preparation for the incoming cargo
- Remaining Cargo - Harmful to Marine Environment (HME): Cargoes that meet particular requirements and are deemed harmful to the marine environment are referred to as HME.

The goal of MARPOL Annex V is to prevent and reduce the amount of rubbish that ships discharge into the ocean. Except as specifically stated in MARPOL Annex V regulations 4, 5, and 6, which deal with food waste, cargo residues, cleaning agents and additives, and animal corpses, Annex V applies to all ships of any kind operating in the marine environment. Discharging any trash into the sea is typically prohibited.

It should be mentioned that the Annex V of MARPOL prohibits the discharge of plastic near bodies of water. Additionally, it forbids the dumping of any form of rubbish in "special zones" and along the coast.

Special zone under MARPOL Annex V includes

- Mediterranean Sea
- The Baltic Sea
- The Black Sea
- The Gulf Areas
- Antarctic Area
- The Red Sea Area
- The North Sea
- The Wider Caribbean Region
- Garbage Disposal Inside Special Areas

Garbage disposal inside special zone is totally restricted apart from

- Disposal of food waste at distances more than 12 nautical miles
- Food wastes have travelled more than three nautical miles in the greater Caribbean region.

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- According to MARPOL, ships are not permitted to enter the Antarctic region unless they have the ability to store all waste on board and have plans in place for discharging the waste at a reception site after leaving the region. No waste of any kind, not even food scraps, should be dumped in the Antarctic region.

Simplified overview of the discharge provisions of the revised MARPOL Annex V which entered into force on 1 March 2018

Garbage type[1]	All ships except platforms[4]		Regulation 5 Offshore platforms located more than 12 nm from nearest land and ships when alongside or within 500 metres of such platforms[4]
	Regulation 4 Outside special areas and Arctic waters (Distances are from the nearest land)	Regulation 6 Within special areas and Arctic waters (Distances are from nearest land, nearest ice-shelf or nearest fast ice)	
Food waste comminuted or ground[2]	≥3 nm, en route and as far as practicable	≥12 nm, en route and as far as practicable[3]	Discharge permitted
Food waste not comminuted or ground	≥12 nm, en route and as far as practicable	Discharge prohibited	Discharge prohibited
Cargo residues[5, 6] not contained in washwater	≥ 12 nm, en route and as far as practicable	Discharge prohibited	Discharge prohibited
Cargo residues[5, 6] contained in washwater		≥ 12 nm, en route and as far as practicable (subject to conditions in regulation 6.1.2 and paragraph 5.2.1.5 of part II-A of the Polar Code)	
Cleaning agents and additives[6] contained in cargo hold washwater	Discharge permitted	≥ 12 nm, en route and as far as practicable (subject to conditions in regulation 6.1.2 and paragraph 5.2.1.5 of part II-A of the Polar Code)	Discharge prohibited
Cleaning agents and additives[6] in deck and external surfaces washwater		Discharge permitted	
Animal Carcasses (should be split or otherwise treated to ensure the carcasses will sink immediately)	Must be en route and as far from the nearest land as possible. Should be >100 nm and maximum water depth	Discharge prohibited	Discharge prohibited
All other garbage including plastics, synthetic ropes, fishing gear, plastic garbage bags, incinerator ashes, clinkers, cooking oil, floating dunnage, lining and packing materials, paper, rags, glass, metal, bottles, crockery and similar refuse	Discharge prohibited	Discharge prohibited	Discharge prohibited

Source:https://www.imo.org/en/OurWork/Environment/Pages/Garbage-Default.aspx#:~:text=All%20ships%20of%20100%20gross,the%20use%20of%20the%20equipment

1. More stringent standards must be followed when rubbish is combined with or polluted by other dangerous substances that are not permitted to be discharged or that have different discharge requirements.
2. Food waste that has been comminuted must be able to pass through a screen with a mesh size of no more than 25 mm.
3. Avian products may not be released in the Antarctic region unless they have been sterilised through incineration, autoclaving, or another method. Discharge from ice concentrations more than 1/10 must be avoided as much as possible in polar waters; in any event, food waste must not be released onto the ice.
4. All fixed or floating platforms involved in the exploration, exploitation, or associated processing of seabed mineral resources, as well as all ships anchored next to or within 500 metres of such platforms, are considered offshore platforms and are to be positioned 12 nautical miles from the nearest land.

5. Only those cargo remnants that cannot be collected utilising widely used methods for unloading are referred to be cargo residues.
6. The marine ecosystem must not be harmed by these pollutants.

III. Research initiatives on the feasibility of biofuels in shipping

Several research projects are ongoing to test the feasibility of using biofuels to run the ship. A gist of a few researches that are very promising and are relevant for this article are given below

- The Mediterranean Shipping Company (MSC), one of the world's leading container shipping lines, has begun experimenting with biofuel blends. The company after successfully testing a 10% mix, before increasing the proportion to 30%, has seen some favourable results. The executive vice president of maritime policy and government affairs at MSC estimates that usage of such blended fuel will result in CO2 emissions falling by 15% to 20%, and the bio component of these fuels may even result in CO2 reductions of up to 80% or 90%. [3]
- Tradebe Environmental Services a pioneer in environmental services since 1983, was established with the goal of assisting chemical industries to manage the complexity of their waste in order to safeguard both people and the environment. A vessel produces a variety of pollutants during its regular operations, including trash from the cargo, residential waste, wastewater, and even oily combinations. The potential to convert ship hydrocarbon waste into a high-quality, reusable product with several advantages opens up new and significant avenues for minimising the environmental impact of fuel use. Since 2015 Tradebe has been looking into ways to turn hydrocarbon waste in order to utilise them as fuel in the future. Results obtained by them show that a circular process is feasible and may produce high-quality products with performance on par with that of the original fuel while also meeting the requirements set forth by the International Maritime Organization for any maritime fuel. This research process has culminated in the invention of a new technology which allows for the production of TGF (Tradebe Green Fuel), a cutting-edge, high-quality marine fuel made from combinations of waste heterogeneous oil, which uses 50% [4] less energy than conventional recovery processes, while assisting in reducing CO2 emissions through the use of conventional fossil fuels. The Tradebe treatment offers an innovative replacement for conventional techniques of recovery, resolving the potential marine fuel production shortage and minimising waste formation.
- A yacht that collects ocean plastic trash and utilises it as fuel is being developed by French ocean explorer Yvan Bourgon and his team. He claims the boat can collect plastic trash to prevent it from polluting the waters and turns that trash into fuel to help power the boat. Waste would be gathered by conveyor belts as the boat wades through the water, the wastes thus collected would be then categorised and fed into a burner. This process would melt the plastic, eventually producing gas that will power a turbine and generate electricity for the boat's systems. According to Bourgnon, this electricity will boost the boat's energy independence by 70% [5] when combined with the solar panels and wind turbines on the deck.

- In the first quarter of 2024, A.P. Moller-Maersk intends to launch the first of an innovative series of eight big high sea container ships that can operate on methanol which is a carbon-neutral fuel. These ships which are to be built by Hyundai Heavy Industries (HHI), would have an approximate 16,000 container capacity (Twenty Foot Equivalent - TEU). The contract with HHI includes a 2025 option for 4 more boats also [6]. A million tonnes of CO2 will be saved annually thanks to the replacement of outdated boats. The vessels will set a new benchmark for the industry by offering the clients of Maersk, a scaled-up and completely carbon-neutral shipping on the high seas.

- Every year, up to 12.7 [7] million tonnes of plastic are dumped into the oceans. They eventually break down into microscopic fragments that can penetrate into the food chain. At the moment, ships that are used in the clean up efforts collect and store plastic which they unload after returning to port, that are located thousands of miles away. Both time and fuel are needed for this. However, Michael Timko and his colleagues at Worcester Polytechnic Institute in Massachusetts believe that by employing hydrothermal liquefaction, this plastic might be converted into fuel on a ship while at sea. At pressures of 27,500 kPa and temperatures of up to 550 °C, the substance must be broken down into its constituent polymers [8]. They think plastic can be converted into

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enough fuel to facilitate the conversion process, power the ship, and even stock extra. According to Timko team's modelling, big booms put in the Great Pacific Garbage Patch (GPGP), an area where waste naturally accumulates may collect enough plastic to allow one ship to convert 11,500[9] tonnes annually. The estimated size of this area is about 1.6 million square kilometres. Timko adds that there is a lack of information on the density of plastic in the GPGP. However, he is of the opinion that a ship could become completely self-reliant and can even produce enough extra fuel to go between booms and eventually return to the port at the very lowest density estimates.

- The Japanese shipping corporation NYK has investing in Sustainable Energy Co Ltd, a business that specialises in biomass power generation from garbage collection. Sustainable Energy has created an integrated subcritical-water organic waste power production system (ISOP)[10], which uses subcritical-water treatment technology to break down organic materials and creates green energy products like biofuels as a result. Through this investment, NYK intends to launch joint investigations on using the ISOP system to turn organic waste produced aboard ships, such as rubbish and sludge, into biofuel.

Overview of the ISOP system

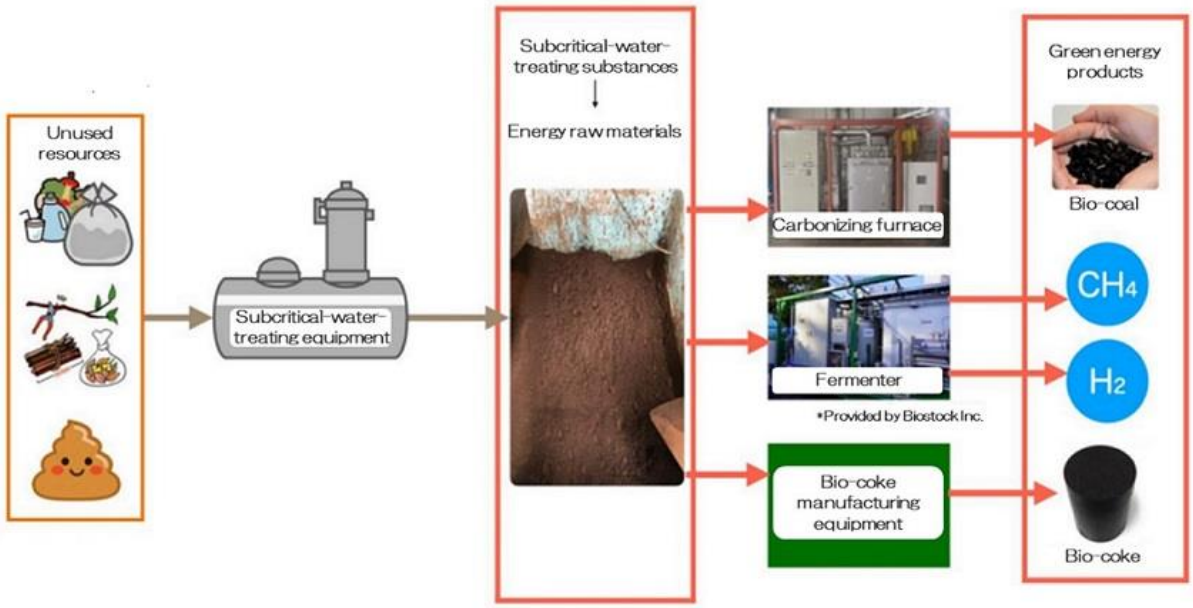

Image source: https://www.nyk.com/english/news/2022/20220826_01.html

The ISOP system consists of machinery that uses subcritical water treatment technology to break down organic materials like combustible garbage into low-molecular-weight compounds in a sealed environment, producing dry and powdery energy raw materials. The raw materials used to generate energy can be recycled to create green energy products like bio-coal, biogas (including methane and hydrogen), bio-coke, and similar ones. Contrary to current incinerators, the system does not produce dangerous compounds like dioxins.

The objective, according to NYK, is to get this ground-breaking technology closer to commercialisation. The duo plans to promote the application of the energy generated out of the raw material as fuel for vessels as part of the global mission to decarbonize ships through research and development.

IV. Results and Discussion

It is evident from MARPOL regulations that sooner or later all the ships would have to be driven by cleaner fuel. The primary data collected point out the fact that ships have in fact started using Very Low Sulphur Fuel oil (VLSFO) and the demand is increasing for it. 50% of the respondents felt that there is growing demand for VLSFO.

It is obvious that the concept of generating bio fuel from ship's garbage holds huge potential for shipping industry. Large Shipping companies like MSC, AP Moller- Maersk and NYK are on the verge of floating their carbon neutral vessels. The primary data also supports it, 75% of the respondents did agree that ship's garbage is a viable source for generating biofuel and the remaining 25% cited reasons such as engine compatibility, complications in the installation of fuel generating plants on board and regulatory compliance for not considering it as a viable option

While the feasibility is quite high, 87% of the respondents agreed that the bio fuel generated out of a ships garbage would be too less to operate the vessel and therefore it cannot be made self - reliant. But 23% of the respondents did agree that ships can be made partly self-reliant by utilising the energy generated towards lighting and other such purposes. Installing bio fuel conversion plants on board the vessel is a pre requisite to make the vessel self relient, but 75% of the respondents agreed that ships would have space crunch as they are primarily designed to carry cargo. Recycling plants need to be designed in such a way taking into account the available space. Some ships do have MARPOL certified waste shredding plants installed on board but installing full fledged bio fuel plants would require redesigning of the vessel.

The technology developed by French ocean explorer Yvan Bourgon and Michael Timko from Worcester Polytechnic Institute in Massachusetts also focus on utilising the plastics dumped into the ocean as raw material for biofuel and not just the garbage generated by a single vessel, which means huge quantities of raw material is needed for the purpose.

In order to increase the quantity of garbage available for recycling a shipping company may pool all the garbage generated by all its vessels and recycle them at the plants installed for this purpose at ports. But 50% of the respondents agreed that that this may not be possible unless the shipping company owns the port also. 20% agreed that it may not be a viable option as there are many shipping companies that own only a few vessels. 30% cited regulatory compliances for not considering it as a viable option

To overcome the above challenges ports may invest into bio fuel plants at the Port Reception Facility (PRF). The Port Reception Facility can effectively engage in the generation of bio fuel as they have access to garbage from a number of ships. This would also provide sufficient quantities of garbage for generation of bio fuel. While 50% of the respondents agreed to it, the remaining 50% pointed out that port model, willingness of the port, space requirements at ports and regulatory measures would be the challenges in implementing this option. The availability of garbage can further be augmented through creation of buy back centres. With respect to creation of buy back centres the major challenge cited by the respondents was regulatory compliance. If garbage and wastes from other industries are going to be accepted at PRF it would call for more stringent regulations both at the national and international level

V. Suggestions

Huge quantities of bio fuel are needed to operate a vessel and the garbage generated by a single ship would in no way match the requirements. Therefore installing recycling plants on board the vessel may not be a viable option. The technology to scoop the plastics dumped in sea and converting that into bio fuel may be an option but cargo vessels are operated along particular routes and are bound to deliver cargo as per schedule. The scooping process might cause delay and deviation from scheduled routes. Besides there are other issues such as space and regulations. Based on the primary data it is suggested that ports may resort to production and supply of bio fuel by installing bio fuel generating plants at their port reception facilities. Depending on the port model investment into this can be made by either the government or private parties or both. In countries like India it can be developed through PPP mode. These recycling plants may be installed at the Port Reception Facility. It is evident from researches that technological breakthrough is on the cards. After commercialisation and abiding the patenting regulations, feasible technology such as ISOP or tradebe Green Fuel (TGF) may be adopted to convert garbage to bio fuel. Buy back centre may be established to buy wastes generated by other industries too and this comes with no cost as industries pay to remove them. This would generate additional source of revenue for ports Bunkering is a profitable business and supply of green fuels can be even more lucrative going by

their increasing demand in future. The entire system would call for new regulatory measures both at the national and global level. A new regulatory framework needs to be created for production and supply of biofuel to vessels which might involve inspections, quality checks and certifications.

VI. Conclusion

With the tightening of IMO regulations on carbon emissions from ships, shipping companies have started investing into cleaner fuel technologies. But it is evident from the study that installing a biofuel plant on the vessel to make it self-reliant is not a viable option. But it is a viable option for ports to install biofuel plants and resort to large scale production and supply of biofuel to vessels. Ports already have port reception facilities for collecting garbage from vessels. These facilities may be further enhanced to facilitate production of bio fuels. Of course this might require new regulatory framework, particularly if buy back centres are to be established. But this would certainly be a viable option to make shipping greener, besides being a good source of revenue for ports

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