Oceanic Solutions – Ships and Shipping

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1. Introduction

Much of the world's goods travel by container ships, the primary subject of this paper. A current challenge is modifying these vessels such that they operate sustainably. As I was researching this paper, I found that there are many similarities between this, and another paper I recently posted. Which is described and linked below.

A Circular Jet Fuel: *This paper will explore three interrelated issues. The first is the circular economy model. The second issue is greenhouse gas emissions, more specifically carbon dioxide (CO_2) emissions. The third and main issue is sustainable aviation fuel.*

https://energycentral.com/c/ec/circular-jet-fuel

2. The Problem

Container ships transport just about everything. The world wants more of all of it. So the ships are getting bigger, as are the shipping channels, port complexes, and loading cranes. "All over the world they're expanding and expanding, and building more and more terminals to accommodate more and more vessels;' says Captain Erduan Murtaza, speaking on the bridge of his nearly 10 million cu. ft. container ship, the Gerda Maersk. Outside the windscreens, thousands of containers, painted in dull primary colors, are stacked nine levels high on the deck. Onshore, in an Elizabeth, N.J., container terminal, many more of these steel boxes spread into the distance like disassembled pieces of a giant's play set.[1]

When it was built in 2009, the Gerda Maersk was one of the largest container ships in the world. It's nearly a quarter-mile long, with a hold seven stories deep. See figure on next page. *But even this monster has been dwarfed by the industry's expansion it's able to carry only half the cargo of some recently launched ships. Murtaza says the growth is only accelerating. "During this pandemic, people went crazy because they were closed inside their homes. So what do you do? You go online and start shopping;' he says. "[All that stuff] has to come through these boxes!'*

Proponents of maritime shipping are fond of referring to growth in the sector as a gauge of global economic well-being. They also trumpet shipping's environmental bona fides, citing statistics showing that oceangoing vessels are one of the most energy-efficient ways to move goods around the world. But though those ships may be less carbon intensive than, say, cargo airplanes, they still account for almost 3% of global $C0_2$ emissions. And it's unclear how that might change. Where sectors like automobiles and electricity grids are relatively straightforward to convert to renewable power, the constraints of physics mean there's currently no simple way to move millions of tons of cargo across the oceans without fossil fuels. And despite ships getting more energy-efficient in recent decades, overall emissions continue to rise as the industry expands. Last year alone, the industry's $C0_2$ emissions jumped nearly 5%.

[1] Alejandro de la Garza, Time (hardcopy), July 4 / 11 Issue, Page 57, "Waiting for the Green Ship to come in," To order a copy of a Time issue, call 800-843-8463.

3. Short-Term Solution?

Today, facilities around the world produce about 100 million tons of methanol annually, almost all of which is derived from fossil fuels, and much of which is used as industrial feedstock for things like plastic production. Using fossil-fuel based methanol to power ships, as some pilot projects have done, is not much different climate-wise from simply burning the natural gas or coal it's made from. So instead, Maersk is trying to power its ships with green methanol.

There are two versions Maersk and others in the industry are working with. The first is bio-methanol, which entails extracting the molecule from biomass like crop waste. The second is electro-methanol, or e-methanol, created by combining $C0_2$ with hydrogen produced from water using renewable electricity. These "green" forms of methanol still release $C0_2$ when they're burned-but in both cases, it's the same $C0_2$ that had already been sucked out of the atmosphere, either by plants or machines, when the methanol was produced. That means their overall contribution to a ship's carbon footprint is far lower than using new fossil fuels pulled up out of the ground.

Between mid-2021 and early 2022, Maersk ordered 12 new cargo vessels able to run on methanol to be delivered from Hyundai Heavy Industries in Korea in 2024 and 2025. (In a pinch, they can also run on conventional fuels.) Soon after, Maersk signed deals to secure enough green methanol to start sailing them. The new vessels account for only about 2% of Maersk's global fleet, but it's a first step toward decarbonizing the world's second biggest shipping company, says Morten Bo Christiansen, who leads Maersk's climate efforts. This will mean continually replacing ships that age out of service with ones able to sail on methanol or other fossil fuel alternatives. "It was really a chicken-and-egg type situation," Christiansen says. "No one was building green vessels because there was no green fuel, but no one produced green fuel because there were no vessels to burn it. This for us has been an attempt to break that."

Danish wind and solar company European Energy is one of the players slated to produce that fuel. It is constructing what's billed as the world's first large-scale e-methanol plant in Kasso, Denmark; Maersk will be buying half its output when production starts in the second half of 2023. The plan was the brainchild of Soren Knudsen Krer, a former engineering professor at Aalborg University, who is working with European Energy on the new facility. The goal is to help solve a crucial challenge in decarbonizing shipping: how to store large amounts of energy, transport it, and have it ready when you need it most-like in the middle of the Pacific Ocean-without using fossil fuels, which are very energy-dense, meaning they take up relatively little space and weight compared with other possible sources of power…

Maersk isn't the only company that's eyeing methanol. CMA CGM, the world's third largest container shipper, ordered six new methanol-powered container ships in June, and Swedish shipper Stena Bulk is building methanol-powered tankers with Swiss chemical company Proman. "Go back even a year and a half ago, we'd go to a shipping conference and we'd get an opportunity to present on the·last panel of the final day;' says Greg Dolan, CEO of the Methanol Institute, an industry trade association "Now there's so much more interest in methanol. We're getting keynote slots."

Despite the current craze, green methanol has a long-term handicap: methanol is a carbon based fuel, so to make it, we need a lot of carbon…

Assuming we will not use petroleum to make methanol, we are limited to green methanol, but we still need carbon.

Taking $C0_2$ directly from the atmosphere might seem like a good idea, but such technology (usually referred to as "direct air capture") is expensive and energy-intensive, and some experts don't think it'll ever be cost-effective.

Instead, the best current option is to find sources of biogenic carbon that comes from plants or animals-either biomass that can be transformed into bio-methanol through chemical processes, or $C0_2$ released from burning or fermenting plants or other organic material that can be combined with hydrogen to make e-methanol. European Energy's e-methanol project, for instance, relies on agricultural waste like cow manure for its supply of $C0_2$. The problem is that there aren't enough sustainable sources of biogenic $C0_2$ to make more than a fraction of the methanol needed to decarbonize shipping…

Clearly current non-fossil-fuel CO_2 production is not adequate to produce enough fuel for large ships a decade or two in the future. However, like many other resources we will need to fight climate change, the manufacturing and supply chain will need to ramp up as demand increases, and demand will increase as penalties and/or incentives to strongly limit greenhouse gas emissions drives it.

For now, Christiansen[2] thinks there's plenty of biomass to start hauling cargo across the world's oceans on methanol-powered ships. And though he agrees that finding biogenic $C0_2$ in the future will be a struggle-perhaps requiring direct air capture, if the technology comes to fruition-he believes methanol is the best current option…

Ahead of this year's annual climate negotiations in Egypt, some countries are making a renewed push to green shipping. On June 17, the Biden Administration announced that the U.S. and Norway will be launching a green shipping challenge at COP27. The goal,

[2] Morten Bo Christiansen, who leads Maersk's climate efforts.

says the White House, is to encourage the industry "to come forward with concrete steps that will help put the international shipping sector on a credible pathway this decade toward full decarbonization no later than 2050:

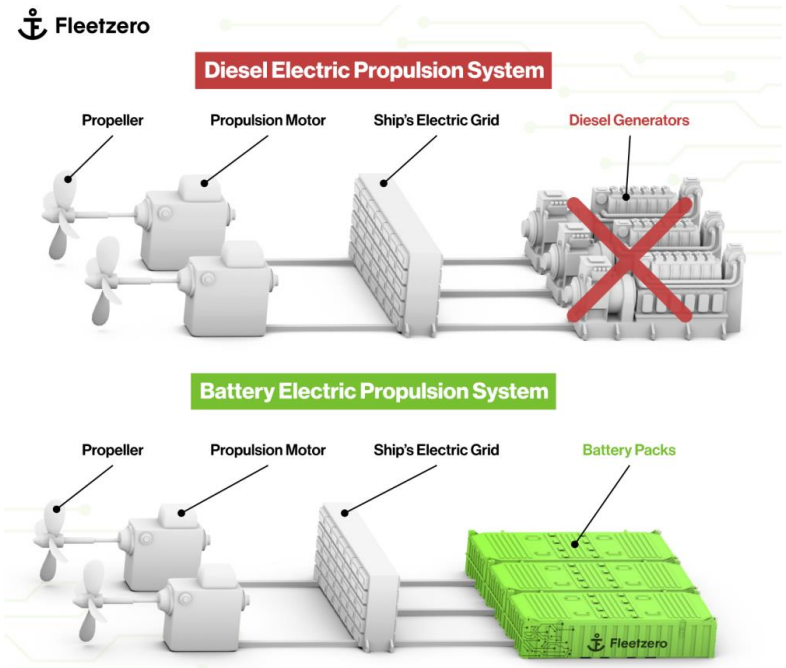
4. Limited Solution

Fleetzero has an ambitious goal: to compete with global shipping companies with its own boats, powered entirely by electricity. The company just secured $15.5 million in new funding and is looking for the first ship to convert to run on its shipping container-shaped batteries.[3]

The company's plan, described in detail here, is to convert existing ships to electric propulsion, replacing the diesel engine or generator with enormous batteries of the company's own design. These would be loaded and unloaded like any other cargo, swapped out at ports and charged between journeys. Done right (and it seems likely that's the way they're trying to do it) a ship doing this can handle some of the longest and most popular routes across the Pacific.

See figure below.

But though it all sounds good in theory, obviously at some point you need to put these theories on the water, and that's the next step for the company. Fortunately, co-founders Steven Henderson and Mike Carter have backgrounds in shipping and shipbuilding and are excited to jump in.



 www.fleetzero.com

[3] Devin Coldewey, TechCrunch, "Fleetzero begins its search for the first giant ship to convert to battery power," June 30, 2022, https://techcrunch.com/2022/06/30/fleetzero-begins-its-search-for-the-first-giant-ship-to-convert-to-battery-power/

While Fleetzero's tech could eventually power ships in the 700-foot range, it makes sense to start with something a little smaller but that also benefits from battery power.

"Companies across the spectrum have reached out to us across industries — not just container shipping," said Henderson. "So we've been going through the list of the biggest auxiliary ship companies, like supply vessels for oil and gas companies, and research vessels, and saying: All right, we've got this tech, and our goal is eventually to go do our own cargo, but we want to prove it out with a partner so we don't have to spend millions on the first ship."

Surprisingly, this "want to give us a boat?" pitch went over quite well. "People are so interested in our batteries that they're willing to pay us to test them," Henderson added. Ultimately Fleetzero plans to make their own boats, but that's a long-term goal.

It helps to understand that there's a real variety in ocean-going vessels and their operators. Some big companies own and operate, some only own, only operate, have fleets for short-term hire and so on. The possibility of electrifying their ships has a different charm to all these, though some are more likely to bite first.

One of those better prospects is the "auxiliary" category of ships mentioned earlier: These are things like research vessels, ships that go out and inspect offshore wind farms, and other tasks that take a serious boat and crew but aren't the hyper-specialized bulk movers of container ships. Many of these ships are already partially electrified — they use electric motors powered by diesel generators. It sounds like the worst of both worlds, but I'm sure they have their reasons — and more importantly, they're really easy to convert to Fleetzero's battery tech.

"It's minimum scope; the conversion itself takes a matter of weeks, and it doesn't involve a dry dock," said Henderson. "In the best case, a PSV [platform supply vessel] about 250 feet long, we put our batteries on the back deck and just wire them in."

The following figure is a Fleetzero shipping container based battery pack (from www.fleetzero.com).

I didn't find an energy capacity of one of their battery packs, and this was not unexpected. Standard shipping containers come in many sizes. Also it is assumed that they will be using lithium-chemistry batteries, and these keep increasing their capacity and vary depending on specific chemistry.

One side benefit of using standard shipping containers for their battery energy storage systems (BESS) is that these are frequently used for large grid and microgrid BESS. Thus Fleetzero can use manufacturers of these BESS to make their battery packs.

5. Other Vessels & Projects

The following link is for to a paper I wrote in 2019 where I covered the section-subject information on other types of large vessels. I just went through this and (1) verified all of the links worked, and (2) updated the information on the projects / vessels that were covered in the original posts.

https://www.energycentral.com/c/ec/floating-anodes-and-cathodes