Decarbonization of shipping – emerging alternative fuels from a US perspective

While the impact of COVID-19 on seafarers and port congestion have grabbed headlines over the past year, no single issue has dominated the maritime industry press more than decarbonization as climate change represents the greatest challenge of this century. According to the [U.S. Environmental Protection Agency (EPA)](https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data), transportation – including road, rail, air and marine – contribute about 14 percent of the global greenhouse gas (GHG) emissions. Shipping alone transports close to 80 percent of global trade by volume and is estimated to contribute 2-3 per cent of GHG emissions. These numbers are propelling the shipping sector into the decarbonization limelight.

Published 17 February 2022

Written by Sean T. Pribyl (Holland & Knight LLP)

In response, the International Maritime Organization's (IMO) ambitious strategy is to reduce total GHG emissions from shipping by 50 per cent compared to 2008 levels by 2050 and to reduce the carbon intensity of shipping by at least 40 per cent by 2030 (and 70 per cent by 2050). Industry initiates like The Getting to Zero Coalition are pledging to develop commercially viable zero-emission vessels by 2030. The Clydebank Declaration following the 2021 United Nations Climate Change Conference (COP26) aims at creating so-called "green corridors," and the World Shipping Council considers fuel supply development as a critical pathway to zero-carbon shipping.

However, even with these ambitious industry goals, there is no silver bullet solution to decarbonization, and there is no "one size fits all" approach to decarbonization efforts. Therefore, a range of considerations will be brought to bear as governments will likely leave it to the private sector market to determine the dominant options. This leaves maritime industry stakeholders in the precarious situation of making investment decisions for future fleets with a general lack of clarity regarding the "best" option for alternative fuels.

In reality, the challenges with decarbonization in the shipping sector are permeating the full range of the industry, including governments, the boardroom and C-suite, lending institutions and propulsion plant designers. In the main, the path to decarbonization will require significant changes as to how power and propulsion is generated on board. Lower or zero-emission vessels will not be limited to one type of fuel or power source, and a combination of fuel options will likely be required. To that end, the first step in merging innovative solutions with germane legal requirements is to understand both the advantages and drawbacks of the various proposals being pursued while attempting to navigate the complex regulatory labyrinth of the alternative fuels. Let's consider the current top contenders to replace heavy fuel oil.

Liquefied natural gas (LNG)

LNG is widely recognized as the largest segment of the alternative fuel market, in particular for ocean-going vessels, and has been used as a fuel for around 20 years. LNG consists of natural gas that is liquefied at very low temperatures for further transport on tanker vessels. It is considered a leading option due to its zero-sulfur content, which meets the International Maritime Organization (IMO) 2020 sulfur cap requirements. Also, its carbon dioxide emissions are approximately 20 per cent lower than that of distillate fuels and very low sulphur fuel oil (VLSFO) products. Classification society DNV predicts that by 2050, more than 40 percent of marine fuels will be LNG . Accordingly, LNG is widely considered the leading "bridge fuel" to other alternative fuel options. In fact, LNG is already being considered for a proportion of the world fleet as there are more than 500 (as of June 2021) LNG-fueled ships in operation and on order (not including LNG carriers).

However, the use of LNG as a marine fuel is not without its disadvantages. LNG is flammable and thus presents an increased threat to safety, issues that permeated discussions on LNG imports when originally siting LNG facilities decades ago. Such discussions also gave rise to federal versus state jurisdictional debates as the federal government urged promotion of LNG sites in areas such as Boston. The events on Sept. 11, 2001, raised concerns about public safety, and LNG facilities were further scrutinized. In response, the US Coast Guard (USCG) took precautions to enhance the security and safety of each US-bound LNG ship and its cargo from the point of departure to arrival in the United States, and the "shipment of liquefied natural gas (LNG) from Yemen to Boston, Mass., exemplifies [a] layered approach to mitigating risk and the care and attention to planning, coordination, and execution that assures the safety and security of these ship movements." To assist in resolving the state and federal conflict over LNG sites, the Energy Policy Act of 2005 (EPAct 2005) gave the Federal Energy Regulatory Commission (FERC) exclusive oversight of construction, expansion, safety and operation of LNG terminals.

When assessing LNG for use as a fuel aboard ships, existing U.S. regulations do not specifically address the design and installation of natural gas fuel systems on commercial vessels, save for boil-off gas used on LNG carriers. As such, the USCG has relied on the standards set forth in the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) in developing equivalencies for compliance. The IGF Code provides international standards for the design of natural gas fueled ships and took effect as a mandatory code on Jan. 1, 2017, for vessels that must meet requirements in the International Convention for the Safety of Life at Sea (SOLAS) that also use natural gas or other fuels with a flashpoint of less than 60 degrees Celsius.

Subsequently, the Coast Guard Office of Design and Engineering Standards (CG-ENG) issued a policy letter, "Equivalency Determination – Design Criteria for Natural Gas Fuel Systems" that establishes design criteria for natural gas fuel systems that provide a level of safety that is at least equivalent to that provided for traditional fuel systems required by existing regulations. The policy letter uses the IGF Code as a baseline standard for vessels using gas or other low flashpoint fuels as an alternative to those fuel systems covered by current domestic regulations. Beyond the safety concerns inherent with using LNG as a marine fuel, availability also includes the necessary bunkering infrastructure and expanding the LNG bunker fleet to include Jones Act compliant vessels – industry measures that are still being developed.

Hydrogen and fuel cells

The use of hydrogen as a marine fuel on board ships is being developed, as proponents of hydrogen suggest it may support an essential component of the pathway to decarbonization. Compressed or liquefied hydrogen fuel burns with zero carbon or GHG emissions and is non-toxic, colorless and odorless. However, hydrogen has a significant flammability range and low ignition energy. Moreover, hydrogen does not exist naturally and thus must be produced through energy-intensive processes. Most hydrogen is currently produced from coal or natural gas, although it is important to understand that there are several ways to produce hydrogen:

- **Gray and brown hydrogen**

: Gray hydrogen is relatively inexpensive, although it is derived from natural gas and generally uses fossil fuels as the energy source. It is produced from natural gas through steam methane reformation, and brown hydrogen is produced from the gasification of coal.

- **Blue hydrogen**

: Blue hydrogen is produced from fossil fuels such as natural gas and coal, essentially a similar process as gray hydrogen, but most of the carbon emitted during its production is "captured" and not released into the atmosphere.

- **Green hydrogen**

: Green hydrogen is produced through renewable energy in which the hydrogen is derived from a clean source. For example, green hydrogen can be produced by the electrolysis of water and is considered clean but expensive.

As with LNG, there are no existing federal regulations that specifically cover the design and operation of hydrogen-powered vessels, including hydrogen as a vessel fuel, use of fuel cells for vessel propulsion or hydrogen bunkering. Hydrogen is currently designated as a cargo that is too hazardous for bulk carriage , though it may be transported in containers in accordance with the Hazardous Materials Regulations in Title 49 of the Code of Federal Regulations (CFR).

The IMO has not mandated international requirements for the use of hydrogen as a marine fuel, although the IGF code and the"Interim Recommendations for Carriage of Liquefied Hydrogen in Bulk"offer guidance on options for alternative design and conducting risk assessments to address inherent risks with the use of low-flashpoint fuels. The overarching goal of the IGF Code and any alternative design approaches is to ensure an equivalent level of safety is achieved by novel systems or technology as compared to those of other low-flashpoint gases. To this end, MSC.1/Circ.1455 "Guideline for Approval of Alternatives and Equivalents" may be of use to stakeholders. The USCG is also responsible for the evaluation of hydrogen as a vessel cargo and fuel, in particular by conducting risk assessments to verify that a system is appropriately safe and can exhibit at least an equivalent level of safety as conventional fuel systems and gas applications.

Hydrogen also faces obstacles to widespread implementation beyond the above-referenced safety concerns. Currently, hydrogen is not feasible for deep-sea shipping, as the energy density of hydrogen is about half of that compared to other traditional marine fuels, and low energy density fuels create a storage problem, which impacts available range of operations. This is compounded as space onboard vessels is limited, and thus availability is a key consideration, in particular as bigger fuel storage tanks would impede on cargo carrying capacity. The bunkering network needed to support hydrogen as a marine fuel remains undeveloped given that there is only one hydrogen-powered vessel in the U.S. Also, the bunkering facilities for liquid hydrogen may have higher capital costs than LNG bunkering facilities. That being said, recent reports indicate that while the prices of alternative fuels remain uncertain, hydrogen fuels could be cheaper than gas and biofuels, though much more is needed across the sector to develop certainty in pricing and economies of scale.

As with other alternative fuels, there are no specific regulations governing methanol as a marine fuel and thus will follow equivalency assessments as a novel use fuel. Methanol is currently produced using natural gas feedstock and is a liquid at ambient pressure. When compared to other alternative fuels, its temperature makes storage and handling much simpler. However, methanol may not be a net-zero option due to methane emissions during production and combustion, and it may only provide a relatively limited reduction in carbon dioxide emissions compared to traditional marine fuels, although it is suggested that methanol derived from biomass can bring up to a 50 per cent reduction. The scalability of biomethane is also an obstacle, although green methanol container ships are becoming available.

Biofuels and biodiesel

Biofuels are being explored as alternate fuel options and are already seeing limited blended use as marine fuels. They are renewable and low in carbon emissions. In the US, "biomass" refers to "organic matter which is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants." (42 U.S.C. § 8802(2)(a)). In turn, "biomass fuel" means "any gaseous, liquid, or solid fuel produced by conversion of biomass" (42 U.S.C. § 8802(3). Biofuels can be blended with traditional crude-derived marine fuel oils or used as a direct substitute fuel from various feedstocks such as corn ethanol or sugar through different processes.

The significant barriers inhibiting the widespread adoption of biofuel include environmental, economic and technical matters. To become a "green" option, biofuels must be sourced from sustainable feedstocks. Other concerns relate to scalability and market competition, as well as long-term storage issues with some biofuels.

Building on biofuel developments in the EPAct 2005 and Energy Independence and Security Act of 2007 (EISA), the U.S. Department of Energy (DOE) has more recently taken a considerable interest in the use of biofuels to power ships (among other modes of transport), and in April 2021 announced $61.4 million toward biofuels research to reduce transportation emissions.

Ammonia

Another zero-carbon fuel option being considered is ammonia. Similar to hydrogen, most ammonia is currently made using natural gas. Ammonia can be used as the energy source for fuel cells, or it can part of the fuel source to an internal combustion engine. Notably, "green" ammonia offers the dual potential towards zero-emission shipping in both "well-to-wake" and "tank-to-wake." Scalability of production and availability remain obstacles, as are novel engine technology designs, safety considerations and concerns about supply chain. Moreover, there are regulatory and technical barriers for the use of toxic fuels.

While there are many competing fuel options across several scenarios, but notably, in a recent "Maritime Forecast to 2050 Energy Transition Outlook 2021", DNV predicts that ammonia is one of the most promising carbon-neutral fuels, although in order for ammonia to be a viable future option, it must be manufactured through *shareholders, correspondents, or other contributors.*

low-carbon processes

Battery/electric

Electric and hybrid systems using batteries or fuel cells present yet another zero-emission option. Fully electric operations remain in the early developmental stages, and with the limitations of current technology, it is likely that battery-powered operations would be suitable only on short-sea trades or domestic passenger ferries. However, variations are being explored for a "hybrid" ship, wherein the ship could be fitted and powered with lithium-ion battery electric propulsion motors that could be charged from onboard diesel-driven generators or when plugged into a shore power supply.

In support of emerging battery technology, the CG-ENG Office has promulgated policy guidance entitled, "CG-ENG-Policy Letter No. 02-19: Design Guidance For Lithium-Ion Battery Installations Onboard Commercial Vessels,"due to increased interest in lithium-ion (Li-ion) batteries and other new types of stored energy technology onboard US flag inspected vessels. The policy document was promulgated due to the unique safety concerns associated with Li-ion technologies and establishes design guidance for commercial vessels using Li-ion batteries within the existing regulatory framework. The DOE has also placed a priority on funding for electric vehicles, which could include vessels.

Conclusion

US decarbonization efforts are moving at an unprecedented pace and are emerging as more complex and expensive than ever before, all while tracking critical international developments at the IMO. To meet decarbonization challenges, governments are exploring means to support alternative fuel options, such as renewable energy hubs and green corridors (trade routes between major port hubs), and collaboration within industry remains a central focus point. The recently passed Infrastructure Investment and Jobs Act also offers guideposts to potential opportunities. However, industry is still awaiting detailed climate strategy roadmaps while clarity remains elusive as to whether a "winner" in the range of alternative fuel options will emerge, leaving several alternative fuel options to co-exist, and all with a lack of directly applicable US regulations.

Time is of the essence if decarbonization efforts are to be met. To this end, those who position themselves as frontrunners for specific alternative energy options may be better poised for venture capital investment or to receive critical research and development (R&D) funding and develop alternative fuel proof of concept demonstrations, all of which remain critical to finding pathways toward technological maturity and cost reduction. And while R&D funding is developing, the lion's share in the U.S. is located in non-traditional maritime agencies, so navigating the right opportunities at the right time may very well determine future successes.

Author: Sean Pribyl is Senior Counsel with Holland & Knight LLP in Washington, DC. He focuses his practice on maritime law, international trade, and renewable energy matters, and is a 2021-2022 Institute of International Economic Law Fellow at Georgetown Law.