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Decarbonizing the Global Shipping Industry

Is Hydrogen Fuel the Answer?

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Decarbonization is coming to the global shipping industry. Accounting for nearly one-quarter of all carbon emissions from the world's transportation sector and one billion tons of carbon dioxide annually, shipping stands at a critical juncture in its efforts to reduce carbon emissions and mitigate its environmental impact.

Among the emerging alternatives to traditional fossil fuels, hydrogen is one of the most promising candidates due to its potential for zero carbon emissions, the relative ease of retrofitting existing ships with hydrogen fuel cells and the high energy intensity needed to propel enormous ocean-going vessels. This article explores the prospects of hydrogen fuel as a replacement for fossil fuels in maritime transport in the context of some of the emerging and overlapping technology, regulatory and public policy issues.

What is Hydrogen Fuel?

Hydrogen fuel is a clean energy carrier that can be produced through various methods, the most common being electrolysis of water (separating a water molecule into hydrogen and oxygen). When used in fuel cells, hydrogen combines with oxygen to produce electricity, emitting only water vapor and heat as byproducts. The power generated from this process offers a pathway to decarbonization by eliminating greenhouse gas emissions from ships. Hydrogen, however, is only as clean as the fuels used to produce the hydrogen itself.

Types of Hydrogen Fuel

Hydrogen is the most abundant element in the universe, but it rarely exists on Earth on its own. Consequently, it must be produced from existing compounds that contain hydrogen, such as water, using an external energy source. There are four primary types of hydrogen: Grey hydrogen is produced using conventional fossil fuels (typically natural gas) that emit carbon emissions. This accounts for 95 percent of the 70 million metric tons of hydrogen produced annually. Blue hydrogen is produced from fossil fuels combined with carbon capture and storage technology sequestering between 50 and 90 percent of carbon emissions. Green hydrogen is produced using renewable sources like wind or solar. Green hydrogen is particularly attractive for the shipping industry due to its potential for zero-carbon emissions throughout its lifecycle, aligning with ambitious climate targets. Because renewable sources are less energy intensive than fossil fuels, the costs to produce green hydrogen are currently significantly higher than grey and blue hydrogen. Finally, white hydrogen is found in naturally occurring deposits requiring exploration and extraction. Historically, scientists doubted there was enough white hydrogen on Earth to justify further investment and study; however, large deposits were recently discovered in France leading to speculation that white hydrogen could also be a viable source.

Current Environmental and Regulatory Frameworks

The International Maritime Organization (IMO) has set ambitious targets to decarbonize shipping, including a goal to cut greenhouse gas emissions by at least 50% by 2050 compared to levels in 2008. Regulatory frameworks such as the IMO's Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) are driving decarbonization efforts globally, pushing shipping companies towards adopting cleaner fuels like hydrogen. Governments are pushing hydrogen as well. Germany, for instance, aims to create 10 gigawatts of electrolysis capacity to produce green hydrogen by 2040. In the US, the Biden Administration announced in October 2023 that US$8 billion from the Bipartisan Infrastructure Law would be used to launch seven regional clean hydrogen hubs across the nation to research and accelerate the development of deployable, low-cost green hydrogen.

Private industry is also on board. Several of the world's largest container shipping lines, such as Maersk, CMA CGM and MSC, are actively exploring hydrogen fuel and other alternatives to meet their commitments to net-zero emissions by 2050. Consequently, each is investing heavily in hydrogen-powered vessels and infrastructure.

Recent Technological Accomplishments

Recent technological advancements have accelerated the development of hydrogen fuel cells for maritime applications. Pilot projects and demonstrations have shown promising results, with hydrogen-powered ships successfully navigating waters and demonstrating the technology's feasibility. In May 2024, the US Coast Guard approved the Sea Change, a 75 passenger fully hydrogen-powered ferry, for commercial operation by the San Francisco Bay Area Water Emergency Authority.

Innovations in hydrogen storage and refueling infrastructure are also underway to support the scalability of hydrogen-powered vessels in the near future. While less energy dense than standard bunker fuel, hydrogen can be stored on-board in liquid form requiring minor changes to storage capacity in existing ships reducing transition costs and time.

Challenges and Recent Developments

The commercial use of hydrogen powered vessels is not without its challenges. For hydrogen shipping to take hold, there must be sufficient infrastructure in place. To facilitate the operational and commercial viability of hydrogen powered vessels, the following steps are required:

- Establishing hydrogen production facilities near ports
- Developing a network of hydrogen refueling stations
- Implementing safety regulations and standards for the handling and storage of hydrogen
- Investing in research and development to optimize hydrogen technologies
- Collaboration between stakeholders, governments and international organizations to facilitate hydrogen shipping development

Paying for the necessary hydrogen infrastructure will likely involve a combination of:

- Private equity
- Public policy incentives
- Tax credits/grants
- Public/private partnerships

The regulatory side of hydrogen shipping is also evolving. Major classification societies such as DNV and the American Bureau of Shipping have promulgated white papers and guidelines on hydrogen shipping. It remains to be seen whether current shipping and marine pollution regulations are broad enough to apply to hydrogen vessels, or if additional regulatory guidance specific to hydrogen vessels are required.

Another significant challenge is commercial. Whether freight rates for hydrogen-powered vessels are commercially viable is currently an open question. For hydrogen-powered vessels to become commercially viable, the economics of operating the vessels needs to complement the environmental interests in pursuing the technology, and shippers will have to be willing to pay the freight rates.

US Legislative Initiatives in Support of Hydrogen

In the 118th Congress, Sens. Chris Coons (D-DE) and John Cornyn (R-TX) have continued bipartisan and bicameral efforts on the Hydrogen Infrastructure Initiative to bolster hydrogen deployment and support new infrastructure in hard-to-decarbonize sectors such as shipping. The Hydrogen for Ports Act (H.R.6872/S.647), led by Sens. Coons and Cornyn, and Reps. Katie Porter (D-CA) and Gus Bilirakis (R-FL), would support infrastructure for hydrogen-derived fuels, including ammonia, at ports and in the shipping industry. Additionally, Sens. Coons and Cornyn, alongside Rep. Brian Fitzpatrick (R-PA), introduced the Hydrogen Infrastructure Finance and Innovation Act (HIFIA) (S.649/ H.R.7200), which would require the Department of Energy (DOE) to establish a hydrogen infrastructure finance and innovation pilot program. Finally, Sens. Coons and Cornyn have introduced the Hydrogen for Industry Act (S.646), which would require the DOE to establish programs that provide grants or cooperative agreements to support the use of hydrogen in energy.

Efforts to spur development of hydrogen as a fuel source have been encouraged through funding provided through the Bipartisan Infrastructure Law (BIL), and tax credits enacted through the Inflation Reduction Act (IRA). The BIL authorized and appropriated US$8 billion for the Regional Clean Hydrogen Hubs. On July 5, 2023, the DOE announced plans to spend up to US$7 billion for the seven finalists and a further $US1 billion for a Demand-side Support Initiative. In October 2023, the DOE announced the seven finalists, and in November 2023, the DOE issued a notice of intent (NOI) for potential funding to accelerate the research, development, demonstration and deployment (RDD&D) of affordable clean-hydrogen technologies.

The Biden-Harris Administration has strongly supported clean hydrogen production and R&D efforts. In June 2023, the DOE announced the US National Clean Hydrogen Strategy and Roadmap, which provides a strategic framework for achieving large-scale production and use of clean hydrogen. The DOE Hydrogen Program is led by the Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE), with participation by other DOE offices. Additionally, the Biden-Harris Administration has launched the Hydrogen Interagency Task Force to advance collaborative interagency efforts to promote clean hydrogen.

Despite concerns that a second Trump administration could seek repeal or rollback of certain provisions of the Inflation Reduction Act or BIL, provisions related to hydrogen have Republican support, given the growth of jobs and new energy facilities in Republican districts.

EU Regulatory Initiatives in Support of Hydrogen

The EU has, similarly, been active in pursuing various policy and regulatory initiatives to decarbonize shipping. The most noteworthy initiative is the already enacted Fuel EU Maritime Regulation (Regulation (EU) 2023/1805). This regulation aims to reduce the greenhouse gas (GHG) intensity of energy used on ships with a gross tonnage of 5,000 or more, affecting both EU and non-EU voyages. Importantly, the Fuel EU Maritime Regulation, which will enter into force on January 1, 2025, sets an initial reduction target of 2%, with a progressive goal of an 80% reduction by 2050. It specifically addresses the energy used for ship propulsion and sets the stage for alternative fuels such as hydrogen.

A key aspect of that regulation, relevant to hydrogen fuel, is a provision for double counting towards the mandatory reductions in energy use on ships when Renewable Fuels of Non-Biological Origin (RFNBOs), as defined under Directive (EU) 2018/2001, are used – Article 5(1) of Regulation (EU) 2023/1805. If hydrogen-based fuels meet specific conditions, they would qualify as RFNBOs and benefit from this double counting. This provision is strategically designed to increase the market appeal of RFNBOs, including hydrogen fuels, and to encourage their production and commercialization. As a result, this regulation may significantly influence the global sale and production of hydrogen fuels at both the EU and international levels.

Outlook

As the global shipping industry seeks to decarbonize and meet environmental standards, significant challenges for hydrogen remain, including scaling up of green hydrogen production and infrastructure development. Hydrogen is not the only alternative, and without a clear winner, the shipping industry and public and private investors are hesitant to take on the financial risk. It is expected that between US$1-1.9 trillion is required to fully decarbonize shipping. Continued investment and collaboration between governments, research institutions and the private sector are crucial to realizing the full potential of hydrogen fuel and achieving a carbon-free future for global shipping.

While hydrogen fuel holds great promise for decarbonizing the global shipping industry, its widespread adoption hinges on overcoming technical, economic and regulatory hurdles. A fully hydrogen-powered shipping industry is by no means certain, but stakeholders should prepare for a decarbonized shipping industry and monitor the developing regulatory framework, including grants, tax credits and other incentives, to advance this goal.

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