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**ROLE OF GREEN HYDROGEN IN THE SHIPPING INDUSTRY**1, a)Khojesh Hedaoo, 2, b)Lovekesh Sethi, 3, c) Keshav Kumar Kashyap

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# *ABSTRACT*

**The maritime transport sector is under increasing pressure to reduce greenhouse gas (GHG) emissions. Switching from conventional fuels such as heavy fuel oil to alternative fuels is one of the most effective strategies for reducing GHG emissions. Green hydrogen is an exciting new option for the shipping industry. Nonetheless, its potential application will be determined by factors other than its environmental friendliness. Economic, technical, and safety considerations must all be considered. This paper examines the potential use of green hydrogen in the shipping industry, including an assessment of production routes, storage, and safety. Benchmarking is also done in comparison to existing 'grey' and 'blue' production routes for shipping industry applications. Furthermore, the safety and health issues of hydrogen are compared to conventional and emerging maritime shipping fuels.**

# *KEYWORDS:*

# *GREEN HYDROGEN, PRODUCTION ROUTES, FUTURE ASPECTS,BARRIERS,STORAGE AND SAFETIES*

**INTRODUCTION**

# GREEN HYDROGEN

Green hydrogen is hydrogen that is produced using renewable energy[[1]](file:///C:\Users\Ladies-FacultyRoom\Downloads\1.%09Magill,%20Jim.%20%22Blue%20Vs.%20Green%20Hydrogen:%20Which%20Will%20The%20Market%20Choose%3f%22.%20Forbes.%20Retrieved%2022%20January%202022) or low-carbon energy. [[2]](file:///C:\Users\Ladies-FacultyRoom\Downloads\2.%09%20Cho,%20Renee%20(7%20January%202021).%20%22Why%20We%20Need%20Green%20Hydrogen%22.%20State%20of%20the%20Planet.%20Archived%20from%20the%20original%20on%2018%20June%202021.%20Retrieved%2022%20January%202022) Green hydrogen emits much less CO2 than grey hydrogen, which is made by steam reforming natural gas and accounts for the majority of the hydrogen market. The creation of green hydrogen via water electrolysis accounts for less than 0.1 percent of overall hydrogen production. [[3]](file:///C:\Users\Ladies-FacultyRoom\Downloads\3.%09.%20www.activesustainability.com.%20Retrieved%2022%20January%202022) It might be used to decarbonize hard-to-electrify sectors like steel and cement production, so assisting in the fight against climate change.

Certified green hydrogen requires an emission reduction of >60-70% (depending on the certification body) below the benchmark emissions intensity threshold .

"Hydrogen has the greatest potential to decarbonize difficult-to-abate sectors including steel, cement, and heavy-duty transport," according to BloombergNEF. [[4]](file:///C:\Users\Ladies-FacultyRoom\Downloads\Takada,%20Aya;%20Stopczynski,%20Stephen%20(9%20November%202020).%20%22Japan%20Eyes%20Replacing%20Oil%20With%20Hydrogen%20Amid%20Carbon%20Neutral%20Push%22.%20BloombergQuint.%20Archived%20from%20the%20original%20on%2025%20November%202020.%20Retrieved%2016%20June%202021) Green hydrogen can be utilized to make green ammonia and has been used in transportation, heating, and the natural gas business.

# TYPES OF HYDROGEN

We currently have several different technologies that permit us to obtain hydrogen. But not all are sustainable. A color code has been established to

differentiate between the [four types](https://www.irena.org/publications/2020/Nov/Green-hydrogen), based on the impact and emissions each generates[[5]:](file:///C:\Users\Ladies-FacultyRoom\Downloads\%22What%20is%20green%20hydrogen%3f%22.%20www.activesustainability.com.%20Retrieved%2022%20January%202022)

* **Grey hydrogen**: produced with fossil fuels and emits a lot of CO2.
* **Blue hydrogen**: produced with fossil fuels through carbon capture and storage technologies (less polluting than grey). Around three-quarters of the hydrogen produced today comes from natural gas. Blue hydrogen could be an initial solution, while green hydrogen production capacity, and storage for industries such as steel, come on stream. But blue hydrogen does not eliminate carbon emissions, only reduces them.
* **Turquoise hydrogen**: produced by pyrolysis from natural gas, but still a fossil fuel and, as such, is not emission-free.
* **Green hydrogen:** A clean fuel that permits the storage and use of energy from renewable sources. It is already considered the substitute for fossil fuels in industries that are difficult to decarbonize and heavy transport sectors such as maritime transport and aviation. Governments and economic sectors alike have recognized that green hydrogen will be an essential pillar for a sustainable energy transition. The best-known option for producing green hydrogen is the electrolysis of water from renewable electricity. It consists of the decomposition of water (H2O) into oxygen (O2) and hydrogen (H2) gases by a direct electric current traveling across electrodes in the water.

# GREEN HYDROGEN BENEFITS

Green hydrogen has been identified as a critical component of the inescapable energy transition that the world's major economies must lead to attain carbon neutrality and halt climate change. In terms of the relevance of the new energy system, the benefits of this clean fuel speak for themselves:

* **Clean energy**: the only waste it produces is water. 100 percent renewable energy: created utilizing non-depleting natural resources such as wind and solar energy.
* **Long-term storage:** can be compressed and stored in ad hoc tanks.
* **Transportable**: Because compressed hydrogen is a light element, it can be handled more easily than, say, lithium batteries.

**BARRIERS TO THE DEVELOPMENT OF GREEN HYDROGEN**

* **Electrolysis only produces around 5% of hydrogen worldwide.** The current production of hydrogen is based mainly on natural gas and coal, which together represent 95%. **Grey hydrogen production represents the emission of around 830 million tonnes of carbon dioxide per year,** equivalent to the CO2 emissions
* The high cost of production is the fundamental reason for green hydrogen's poor use. Despite this, the hydrogen market is predicted to develop, with some estimates predicting that the cost of producing hydrogen will drop from $6/kg in 2015 to roughly $2/kg by 2025. Major European corporations have announced plans to convert their truck fleets to hydrogen power by 2020.

# GREEN HYDROGEN IN SHIPPING INDUSTRY

Green hydrogen could play a crucial role in the maritime industry’s journey towards decarbonization. Produced through electrolysis, H2 is free of carbon emissions and could be widely available across the globe in the future, as marine fuel or as a key enabler for synthetic fuels. Many in shipping recognize hydrogen’s potential, but the barriers to implementing H2 technology are substantial. More testing is needed on the safety aspects of handling, storage, and bunkering hydrogen. Testing and modeling need to be fine-tuned to hydrogen’s unique properties and safety considerations. There are uncertainties about the behavior of cryogenic hydrogen (LH2), as well as thresholds when detonations occur.

## How does it work?

[[6]](https://www.bbc.com/future/article/20201127-how-hydrogen-fuel-could-decarbonise-shipping)Once hydrogen is created, it can be utilized to power ships in a variety of ways. It can be burned in an internal combustion engine, which is what Hydroville is doing right now. One disadvantage is that burning anything in the air, which is mostly nitrogen, will always produce nitrogen oxides, which are important air pollutants.

According to Mao, these emissions might be reduced by installing after-treatment equipment. However, hydrogen can also be utilized in a fuel cell, which chemically turns the fuel into energy without the need to burn it and produces just water as a byproduct. "The biggest obstacles of making something function aboard a ship are simply getting it large enough," says the author.

However, the difficulty in storing it makes it unsuitable for long-distance shipping. In the current system, hydrogen cannot simply replace bunkering fuel. It must be frozen at cryogenic temperatures of -253C to be stored as a liquid on board a ship (-423F). Even yet, it takes up a lot of space - eight times more than the quantity of marine gas oil required to produce the same amount of electricity, according to EDF data.

Many experts believe that using green hydrogen to generate green ammonia, another fuel that can be combusted or utilized in a fuel cell, is a better alternative than using hydrogen as a catch-all phrase for synthetic fuels. Ammonia is easier to store than hydrogen (it requires refrigeration but not cryogenic temperatures) and takes up roughly half as much space due to its density. It can also be turned back to hydrogen onboard a ship, allowing it to be carried and stored as ammonia on the ship before being used in a hydrogen fuel cell.

# CHALLENGES OF HYDROGEN AS A SHIPPING FUEL

[[7]](https://www.csis.org/analysis/hydrogen-key-decarbonizing-global-shipping-industry)When coupled with oxygen, hydrogen is extremely flammable and has a wider ignition range than most traditional fuels, allowing it to burn at both low and high concentrations. There are, however, safety precautions that can be taken to reduce the risk of fire during storage, transit, and lighting.

Hydrogen is less energy-dense than bunker fuel, even in liquid form, hence hydrogen fuel cells will take up the greater volume on cargo ships, reducing efficiency and increasing the potential cost of lost cargo. This shift, though, should be minor: With simple improvements to fuel capacity, such as replacing 5% of cargo space with hydrogen fuel, 99 percent of US-China journeys in 2015 could have been powered by hydrogen.

Green hydrogen is nearly four times more expensive than grey hydrogen, and blue hydrogen is 30–80 percent more expensive than grey hydrogen. While retail prices of blue and green hydrogen are expected to fall as the cost of renewable electricity and electrolysis decreases, government intervention is required to encourage private investment in green hydrogen technology and to develop the refueling and hydrogen transportation infrastructure required for blue and green hydrogen to be competitive with grey hydrogen.

### Necessary change

Following a sluggish start to climate action over the previous decades, there are signs that the shipping industry is starting to pay attention to the threats posed by the climate catastrophe. According to Smith, a major portion of the industry now believes it will be necessary to transition away from fossil fuels, with hydrogen-derived fuels like ammonia being the most likely alternatives. He argues, "There are a million issues regarding how we get from where we are now to that end goal." "However, the notion that this is where we're headed is now very, very, very mainstream."

# FUTURE OF HYDROGEN IN SHIPPING

**The global shipping industry is responsible for 3% of our total emissions of CO2. Green hydrogen fuel, while not yet ready to replace oil or gas bunker fuels industry-wide, does not cause any emissions in use and maybe the best possible solution to this problem. However, heavy regulation such as an international carbon tax is required to make sustainable energy alternatives a reality in this industry.**

**Hydrogen is gaining traction as the cleanest of all future fuel solutions, and many shipping stakeholders recently sent a letter to the EU Commission encouraging it to promote the use of green hydrogen by ships as part of the EU's impending marine fuel law.**

Hydrogen is the fuel of the future, but it is not that easy. The process of making hydrogen is expensive relative to both fossil fuels like natural gas and hydrogen captured in less clean ways. It’s hard to transport and store hydrogen. Unless combined with other chemicals, it must be compressed to 700 times atmospheric pressure or refrigerated to minus 253 degrees Celsius. Hydrogen also likes to explode. These are the challenges that are needed to be overcome, and then only hydrogen can be used as a fuel in a fully-fledged manner on big ships.

# WORLD’S FIRST HYDROGEN FERRY

# The MF HYDRA is a Norled-operated zero-emission vessel that will be the world's first vessel to run on liquid hydrogen. MF HYDRA is more than 82 meters long and has a capacity of up to 300 passengers and 80 automobiles. It travels at a speed of roughly nine knots. With an 80m3 capacity. The vessel can ply its route in the fjord area thanks to its liquid hydrogen tank. For up to three weeks, you can travel between Hjelmeland, Nesvik, and Skipavik without refueling. Its Batteries can work in tandem with liquid fuel thanks to a smart propulsion mechanism. The hydrogen fuel cells and also includes a redundancy feature that allows the ferry to sail on biodiesel.

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**CONCLUSION**

Several features of hydrogen as an alternative fuel for shipping are covered in this paper. To begin, we emphasise that new hydrogen production methods should be used to gain an environmental advantage over the use of diesel fuel, and we specifically highlight the use of electrolysis for hydrogen production because it has the potential to be a zero-carbon fuel throughout its entire lifecycle. The storage of hydrogen, on the other hand, is likely to be the biggest issue. As a result, numerous hydrogen storage technologies have been evaluated for their suitability as a storage method for hydrogen uses in the maritime industry. Shipowners, ports, and regulatory bodies such as the International Maritime Organization (IMO) will have to make strategic decisions about hydrogen storage for shipping. After this paper, we identify the most significant issues associated with the usage of hydrogen in maritime applications. One of the key hurdles for hydrogen utilization in maritime ships is the construction of a new bunkering infrastructure. We think that by offering a clear overview of green hydrogen as an efficient fuel for the maritime industry, we can assist in making these strategic decisions by reducing emissions that hurt the environment, particularly ocean life.

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