Interreg
Atlantic Area
European Regional Development Fund
SEAFUEL

HYDROGEN ENERGY

CASE STUDY

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France
Marine Applications for Hydrogen

The Port of Marseille has committed to developing a $851m hydrogen production facility

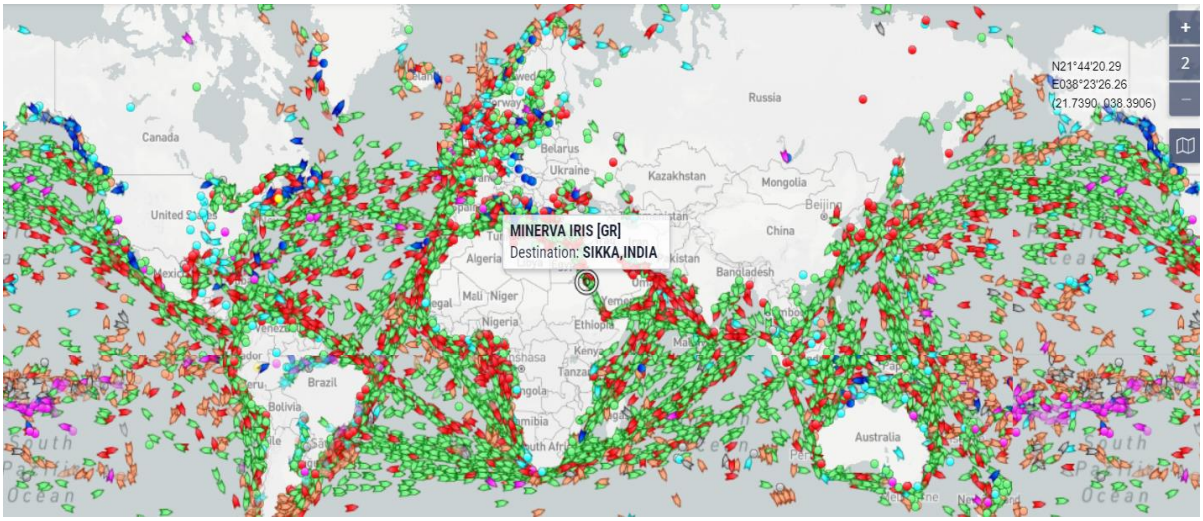
Background

The SEAFUEL project is looking at investigating the potential for utilization of hydrogen as a fuel for powering the local transport fleet and supporting the shift towards a low-carbon economy. The project has set out to develop a fully integrated H2 refueling station that takes excess renewable energy, passes it through an electrolyser, converts it to H2 then stores it before it is dispensed to a hydrogen powered vehicle when required for utilization.

The areas involved in the SEAFUEL project are all in peripheral island locations. This leads to several challenges – remoteness, reliance on import of energy often over great distances – but also provides opportunity to show what can be done with hydrogen in a closed system. There is also an abundance of water for use in electrolysis, all be it seawater, which provides different challenges. And this also opens up another area for study when thinking about not just the opportunity to produce hydrogen, but to think about other ways in which it can be used.

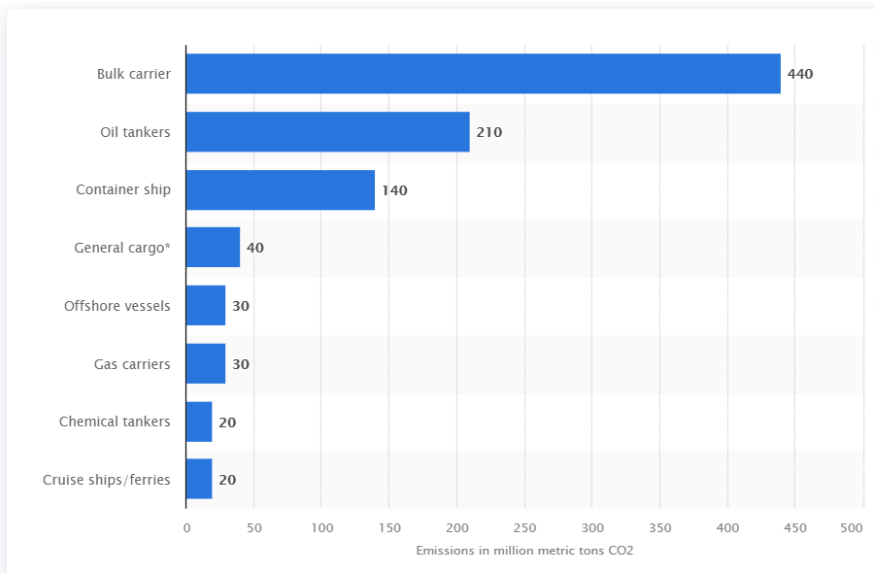
As reported by the UK Research and Innovation organization, around 90% of everything that is consumed by humans is moved by sea. This means that the shipping industry is responsible for around 940 million tonnes of CO2 annually across various sectors including bulk carriers, oil carriers, container ships and cruise ships among others, which is at least 2.5% of the world's total CO2 emissions.

At any given time, there are hundreds of thousands of ships at sea, as shown by this snap-shot from marinetraffic.com shows.



When this snapshot was taken 288,000 ships had been tracked during the previous 24 hours. Moreover, shipping tends to use what is know as “bunker fuel”. This is a toxic, tar-like sludge that usually contains 3,500 times more Sulphur than the diesel used for cars.

As can be seen in table 1 (below), there is a wide range of shipping types, and multiple fuel sources are used to power these vessels from battery cells to a range of bio-fuels from sources like mineral oils, vegetable and animal based bio-fuels, to methanol and even some coal burning vessels. However, a large majority – over 90% - of ships, both active and on order, are built to run on varying grades of oil refined from crude oil.



CO2 emissions in worldwide shipping in 2020, by ship type (in million metric tons CO2)

The International Maritime Organization has set a target of reducing the CO2 emissions in the sector by 50% by 2050.

In September 2020, the French government announced its national hydrogen strategy where it promised to make over €7bn available for the development of a low carbon hydrogen industry. The government's main objective is to have 20-40% of total hydrogen and industrial hydrogen provided by low carbon and renewable hydrogen by 2030. Three priorities have been set for this investment: (i) decarbonising industry (with a carbon neutral objective for 2050), (ii) developing hydrogen mobility and (iii) supporting and developing France's research capacity. (https://www.wfw.com/articles/the-french-hydrogen-strategy/)

The Vision – The Ports

When thinking of how to address these challenges, there are two areas. The first is the ships themselves and that will be looked at in more detail later. However, the time ships spend in ports and the various processed carried out in ports are also energy intensive and highly polluting.

The international transport forum noted that “Shipping emissions in ports are substantial and accounted for 18 million tonnes of CO2 emissions, 0.4 million tonnes of NOX emissions, 0.2 million of SOx emissions and 0.03 million tonnes of PM10-emisions in 2011, as well as various other emissions.” This accounts for up to 2% of the total emissions of the sector so is an area that can make an impact in reducing the totals if addressed. (https://www.itf-oecd.org/sites/default/files/docs/dp201420.pdf)

One way this can be tackled is to convert the ports both produce and use hydrogen and one area that has taken up this challenge is the port of Marseille in France. As reported in January 2022, the port of Marseille has teamed up with a company called H2V Fos to begin to develop a renewable hydrogen production plant in the port with a 600MW capacity. This development has seen an initial investment level of €750m required.

This capacity will allow it to produce 84,000 tonnes per year of green hydrogen obtained by electrolysis of water and renewable energy. The system will be made up of six separate 100MW production units. This is a sensible way of building the plant. As the technology for these plants is still in its infancy and under development, there is the potential for parts failures. By splitting the production across several plants, it allows for some level of production to continue if any of the parts of the individual plants are to malfunction.

H2V has already arranged other much smaller installations at other port sites in Grand Port Maritime de Dunkerque in Hauts-de-France and the Port-Jérôme industrial zone in Normandy. These sites are due to be commissioned in 2022 and the experience from these will hopefully provide information and data that will ensure the success of the large installation in Marseille which is due to take place between 2026-2031.

One benefit to having hydrogen produced in ports is that rather than the vessels being required to leave engines running to keep the on-board electrics systems running, they can be

plugged into the clean hydrogen energy being produced from renewable resources within the port instead. This reduces the emissions being produced both by the ship and the ports helping to push towards that International Maritime Organization target of a 50% reduction in emissions by 2050.

Many of the processes within a port can also be converted to hydrogen. For example, the vehicles located in the port can be converted to run on either hydrogen fuel cells or hydrogen powered electric vehicles. This helps to reduce the use of traditional fossil fuels in vehicles and reduce the Co2 emissions and carbon footprint of the port itself. The various buildings on site can also be heated by a district heating system reliant on hydrogen. This again reduces the need for traditional oil or natural gas, giving a positive boost towards reducing fossil fuel reliance and consumption and helping drive towards CO2 reduction targets.

The Vision – The Vessels

But while the ports themselves can make changes, as we have seen, the main driver for CO2 and emission production in the shipping sector is the vessels themselves. In terms of hydrogen, it has been debated that H2 is a fuel that is better suited to and more efficient when used in powering larger vehicles. There can't be many bigger vehicles than ships! One of the other key properties of hydrogen is its lightness, and this is a key factor in shipping as the lighter it can be the more

There are two kinds of vessel being developed and tested at the minute. One of these is a vessel that simply has its drive train converted to allow it to run on hydrogen. The other is a vessel which contains the ability to produce its own hydrogen for use. An example of this latter type is currently traversing the world's oceans – the "Energy Observer".

The Energy Observer combines a wide range of technologies including solar power, hydrogen, “high tech” wind, and some battery storage.

In Marseille, the Hynova Yachts company (https://www.hynova-yachts.fr/) have developed what is thought to be the first sea-faring craft to successfully launch, with the company vision stating, “blue is the new green”. This is slightly misleading as the intention of using the word “blue” in this case refers to use of sea water, rather than the traditional understanding of blue hydrogen as hydrogen derived from non-renewable sources such as methane gas.

The yacht itself utilises electro-hydrogen propulsion via a fuel cell system and is made up of two 150kw motors combined with two batteries. When the boat is stationary the fuel cells recharge the batteries, and when the boat is in motion the batteries and fuel cells combine to propel the boat at a cruising speed of 15 knots and a top speed of 25 knots.

The Hynova drive train is based upon the Toyota Mirai engine from road vehicles and delivers up to 60 kW rated net power. In this case, the vessel, like the Mirai, is driven by an electric motor powered by current. This current is generated by fuel cells with a chemical reaction that instead of producing CO2 in the atmosphere, releases water. Another key part of the vision of Hynova is to provide a relaxing and quiet sailing experience that is not currently available via the traditional combustion engine.

Conclusions

There are two key aligned areas that can be tackled with hydrogen solutions that can help governments to reach their targets for net zero energy. The opportunity to de-carbonise the ports themselves is one and the opportunity to de-carbonise the vessels is another. However, the “quick” win in this area would likely be the ports. As stated, there are generally over 250,000 vessels at sea at any one time, in a range of different styles. The age profile of these vessels is also vast with many of them being new, freshly built vessels with many years’ service left. It is unlikely to be financially viable to just set about retrofitting or replacing these vessels. Therefore a mixed approach is likely to be the best way forward with the ports leading the way while the shipping companies can be incentivized to change their production methods if these pilot models of H2 ships prove to be viable.

https://www.theguardian.com/uk-news/2017/may/18/dirty-diesel-ships-worst-offenders-pollutionwatch

https://www.ukri.org/news/shipping-industry-reduces-carbon-emissions-with-space-technolo-gy/#:~:text=The%20shipping%20industry%20is%20responsible,the%20world's%20total%20CO2%20emissions.