Green H_2 from Offshore Production

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Introduction

In order to achieve the goal of keeping the global temperature increases below 2 degrees Celsius, development of new technologies, producing green, renewable energy is called-for. The development is also needed to fulfil the sustainable development goals (SDG), as e.g., SDG13 "Climate action". Green hydrogen is an alternative fuel that can substitute for conventional fuel production and reduce emissions (American Bureau of Shipping, 2022). The technology is based on a process of electrolysis. Electricity is produced from wind, solar or wave energy and is used to split, or electrolyse, hydrogen and oxygen elements from pure water. Thereafter the hydrogen is stored and exported to shore by ship or pipelines.

In this text we will further discuss the possibilities, challenges, and the state of the technology today. Lastly, we will discuss whether green hydrogen production is a promising technology for the future and if it has the potential to replace non-renewable forms of energy.

Potential

Both the demand for electricity (e.g., between day & night), as well as the production of wind energy (depending on wind intensity) vary significantly. Therefore, one of the great challenges we face regarding the shift to renewable energy is energy storage (Agarwal et al., 2016). Offshore hydrogen production could provide a solution, by allowing for a chemical storage of wind energy. This way, when production outweighs demand, surplus energy can be used to power electrolysis and produce hydrogen. The energy stored this way can be made available for the electric grid via fuel cells when the demand is high. This technology could help in making the energy output from renewables more predictable and would allow for a higher share of renewable energy in the global energy mix in accordance with SDG 7 "Affordable and clean energy" target 7.2.

Another application for green hydrogen is as an energy-dense fuel both for heating and vehicles. This is especially beneficial in applications where electrification is not feasible, for example heavy-duty transportation, such as shipping of cargo (Saeedmanesh et al., 2018). Green hydrogen as a zero-emission fuel can therefore contribute to reducing carbon emissions from the transport sector, working towards target 13.2 of SDG 13.

Challenges

Even though offshore hydrogen production has the potential to supply energy in a sustainable matter, the technology also has a few challenges that must be addressed. Offshore wind energy production is linked to changes in river flows (Pfeiffer et al., 2021). This change may have a significant environmental impact and have negative consequence for nearby wildlife. This is because reproductive and early life cycle stage of fish are highly sensitive to variability in river flow. In order to fulfil SDG 14's "Life below water" targets to protect marine wildlife, areas close to rivers could be used to protect wildlife instead of decay it with offshore hydrogen production.

Other than that, offshore wind farms also have an impact of marine mammals because of the noise of the during pile driving (Bailey et al., 2014). This is a major concern for endangered whale species such as the blue whale (*Balaenoptera musculus*), humpback whale (*Megaptera novaeangliae*), and fin whale (*Balaenoptera physalus*). Especially the whales are a great concern for noise pollution because they are sensitive to low frequencies sounds that may inflict communication between whales. Other animals such as jellyfish is also proven to be sensitive to low frequencies underwater noise pollution (Solé et al 2017). The jellyfish may damage their statocyst. Statocyst is the balance organ, and this damage will weaken their sense of orientation. When underwater noise pollution inflicts with species such as whales and jellyfish, this will also have consequences for the surrounding ecosystems.

Another challenge with offshore hydrogen production is that the current price of green hydrogen production is currently more expensive than alternative hydrogen production with fossil fuels (American Bureau of Shipping, 2022). It is estimated that green hydrogen production can be up to twice as expensive compared with other production methods. If the price of offshore hydrogen production does not get cheaper, the production conflicts with SDG7 (affordable and clean energy), since it may not be affordable.

State of tech

Green hydrogen is still a developing energy source. There are more and more projects, and many companies and countries are interested in it, but for the moment no completed project has seen the light of day (Battersby, 2021). There are several reasons for this, particularly because of the development of renewable energy sources such as solar and wind power, which is still under-exploited and does not offer enough to produce green hydrogen efficiently

However, with the ambition of zero carbon, projects are taking shape on many scales. This is the case of the European Union for example: in a 2020 document, the share of hydrogen in the current energy mix of the EU is around 2%. It has set itself the goal of increasing it considerably to reach 14% by 2050 (European Commission, 2020). The EU also plans to invest in research, up to 470 million euros by 2050, which would see renewable hydrogen projects democratized in the Union. The projects concerning hydrogen produced offshore could multiply in the future.

On a country scale, many governments are increasingly interested in the possibility of combining energy production with a zero-carbon objective. In Europe, the Netherlands is the forerunner in this field: the PosHydon project, for example, has been supported with 3.6 million euros by the Netherlands Enterprise Agency (RVO), a Netherlands government agency (PosHYdon, 2021). PosHydon is currently the first offshore green hydrogen producing structure project. The project is mainly supported by NextStep, a company that works on decommissioning oil and gas infrastructures. It will develop offshore wind energy in the North Sea region off The Hague, using an existing platform (detained by Neptune Energy) that already uses renewable electricity. The goal for NextStep is to start construction of the infrastructure by 2030.

Another promising Dutch initiative is H2opZee, an offshore green hydrogen infrastructure project (RWE, 2022). Like PosHydon, it will be in the North Sea and will produce up to 500 MW of additional green hydrogen, the advantage being that the catalyst will use an existing pipeline to transfer the energy produced. This project is still in the feasibility study stage, but the company RWE, which is piloting it, hopes to see a realization of the project by 2030.

Discussion and conclusion

Placing the process of electrolyses close to the windmills offshore will save electricity from being lost in transport from the turbines (American Bureau of Shipping, 2022). When wind energy is transported to shore some energy is lost in transportation, but by placing hydrogen production close by this energy can be utilized instead. This is a measure towards more energy efficiency and relates to SDG 9 “Industry, innovation and infrastructure”. However, there are concerns regarding offshore hydrogen production when it comes to protecting marine wildlife. This is because of the change of river flows and underwater noise pollution that offshore hydrogen production might cause. This is the reason why offshore hydrogen production conflicts with SDG 14.

Moreover, there are still problems, such as the cost of production. Hydrogen is currently more expensive to produce than fossil fuels, which hinders its competitiveness and undermines SDG7's commitment to affordable and clean energy. This is a problem that tends to be solved progressively: thanks to technical progress and the increase of renewable energy in the energy mix, the price of hydrogen tends to decrease and therefore to become more interesting in the future. Green hydrogen also represents a new employment opportunity: whether in research, construction, engineering or even many indirect jobs. By 2050, the European Union expects nearly 1 million new jobs just for renewable hydrogen, 2/3 of which will

be indirect jobs. This opportunity links to SDG 8, allowing for the creation of new decent jobs and the possibility of making it a driving force for economic growth.

Finally, renewable hydrogen from offshore wind turbines is also in line with the advancement of SDG 12 on responsible energy consumption and production. Green hydrogen is a renewable energy source with many benefits that can only improve and become a reality in the future and is part of a decarbonized energy production.

Green hydrogen production is a new promising technology for the future, as the demand of hydrogen is rapidly increasing. Offshore hydrogen production may contribute to SDG 13's targets and positively interacts with other SDGs (7, 9, 12). However, offshore hydrogen production conflicts with targets in SDG 14, which must be considered before implementation. Therefore, more research must be done concerning the impact that offshore hydrogen production has on marine wildlife.

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