Techno-economic analysis of using renewable hydrogen for inland shipping in Europe

Student

Luca Philipp Stauss

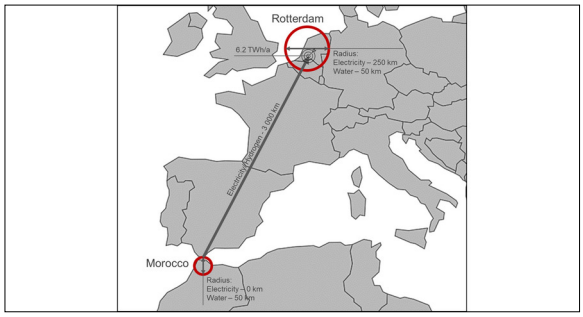
Definition of Task: The European inland and coastal navigation sector heavily relies on fossil fuels for its energy needs, making it an important area for transitioning to a de-fossilized Europe by 2050. In order to comply with the target of a de-fossilized navigation sector, retrofitting the shipping fleet of Europe with combustion engines using renewable hydrogen as energy carrier is one of multiple promising solutions. For the purpose of finding the most suitable energy carrier, an initial step is to analyse the various options from a well-to-tank perspective. The primary objective of this research is to analyse and compare various hydrogen well-to-tank value chain scenarios to identify preferred pathways from a techno-economic perspective.

Approach: To achieve the aim of the research, multiple possible value chains were predefined and their technical, means environmental and economic impact was calculated. The technical impact was quantified by calculating the specific carbon dioxide equivalent emissions (gCO2eq), nitrogen oxide emissions (gNOx) and particular matter emissions (gPM10) per kilowatt hour (kWh) of hydrogen. The economic impact was quantified by calculating the specific costs (€) per kWh of hydrogen.

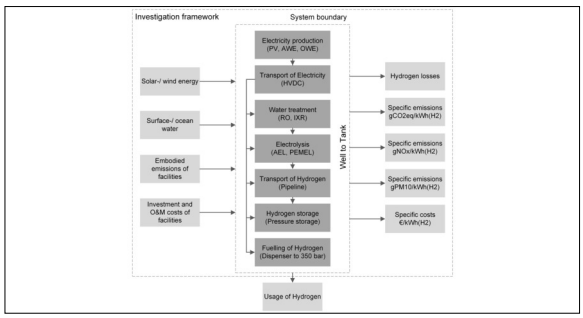
Result: The analysis shows that scenarios based on photovoltaic (PV) electricity production in Morocco generally result in specific emissions of hydrogen more than twice as high as scenarios based on aquatic wind energy (AWE) and onshore wind energy (OWE) production in the North Sea region. However, contrary to specific emissions, drawing conclusions about the specific costs of hydrogen solely related to the electricity production technology is challenging. The costs vary significantly due to additional process steps, such as energy transmission, within the value chain.
The calculation of the North Sea region related value chains leads to specific emissions of hydrogen of 16-18 gCO2eq/kWhH2, 0.04-0.05 gNOx/kWhH2 and 0.01 gPM10/kWhH2 and to specific costs of hydrogen of 0.17-0.22 €/kWhH2. The calculation of the Morocco related value chains leads to specific emissions of hydrogen of 47-54 gCO2eq/kWhH2, 0.100.11 gNOx/kWhH2 and 0.03-0.04 gPM10/kWhH2 and to specific costs of hydrogen of 0.120.19 €/kWhH2.

This assignment concludes that, from a techno-economic perspective, no clear interdependency between emission and cost results can be identified across the scenarios for renewable hydrogen sourcing in the European inland and coastal navigation sector. Therefore, without a weighting of the KPIs according to their importance, it is not possible to determine the best scenario in terms of both emissions and costs. However, when examined separately, preferred scenarios can be identified based on emission or cost analysis.

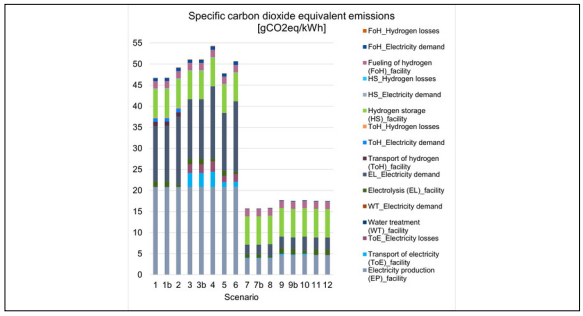
Value chains and locations considered within the assignment
Own presentment



Investigation framework of the assignment
Own presentment



Representative diagram of specific carbon dioxide emissions of different scenarios
Own presentment



Advisor
Prof. Elimar Frank

Subject Area
Energy and Environment