A COMPARISON OF ECONOMIC BENEFITS OF HYDROGEN PRODUCTION IN DC BASED WIND FARMS

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Abstract

This paper presents an innovative concept for offshore hydrogen production using a wind farm with a direct current (DC) collector grid. Wind farm operators can sell their electricity on the spot market or receive a fixed feed-in compensation, depending on local regulations [1]. With an electrolyzer, there is also the potential to produce and sell hydrogen. Based on actual wind data, an optimized strategy is presented to maximize the financial benefits of incorporating an electrolyzer into the DC wind farm. The strategy for offshore DC wind farm operation is evaluation for effectiveness under different electricity and hydrogen price scenarios.

Introduction

The urgent transition from fossil resources to renewables in the electricity, transport, gas, and heat sectors is a pressing challenge that requires innovative solutions. Although wind and solar energy, through wind farms and photovoltaic (PV) parks, offer a viable path for the electricity sector, a long-term strategy must also consider the other sectors. A promising solution is the electrification of these sectors, but it's not feasible to electrify all applications, making hydrogen a viable alternative for certain purposes. As a result, the synergy between energy production and electrolysis plays a crucial role. But recent studies often use wind data with daily resolution or perform general optimizations. Advantages of DC grids are not considered at all. [2,3]

Methodology

A wind farm with 12 wind turbines of 5 MW each is simulated in an offshore DC setting, combined with a 20 MW electrolyzer. Real weather data with a resolution of 10 minute is used to simulate the produced electricity and forecast data is used to participate in the day-ahead and intraday energy market following a simple strategy. A fixed feed-in tariff is also considered as an alternative. Based on different price scenarios for energy and hydrogen, several simulations are presented to derive an operation strategy for the DC wind farm.

The proposed DC collector system offers significant advantages over AC systems, such as the elimination of reactive power and skin effect, resulting in reduced cable diameter, copper usage, and increased resilience. Additionally, the use of a two-conductor DC setup, as opposed to a three-conductor AC system, provides significant cost savings for materials. DC-DC converters, which operate at higher frequencies than typical AC transformers, contribute to a significant reduction in size and weight, a critical consideration for offshore platforms.

Results

This study highlights the advantages of DC grid technology and shows the economic feasibility of offshore hydrogen production. The comparison of different market strategies enables wind farm owners to increase their revenues, and the results are also put into the context of AC collector grids.

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References

[1] F. Peng *u. a.*, „Review on bidding strategies for renewable energy power producers participating in electricity spot markets“, *Sustainable Energy Technologies and Assessments*, Bd. 58, S. 103329, Aug. 2023, doi: 10.1016/j.seta.2023.103329.

[2] G. Calado und R. Castro, „Hydrogen Production from Offshore Wind Parks: Current Situation and Future Perspectives“, *Applied Sciences*, Bd. 11, Nr. 12, Art. Nr. 12, Jan. 2021, doi: 10.3390/app11125561.

[3] M. Scolaro und N. Kittner, „Optimizing hybrid offshore wind farms for cost-competitive hydrogen production in Germany“, *International Journal of Hydrogen Energy*, Bd. 47, Nr. 10, S. 6478–6493, Feb. 2022, doi: 10.1016/j.ijhydene.2021.12.062.