AMMONIA PRODUCTION FROM A NON-GRID CONNECTED FLOATING OFFSHORE WINDFARM: A SYSTEM LEVEL TECHNO-ECONOMIC REVIEW

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ABSTRACT
This paper investigates the technical and economic feasibility of a floating offshore wind driven ammonia production system with a capacity of 300 tons/day. The ammonia plant is located on a plantship and there is no connection to the grid. An analytical model (MATLAB based) for this system was based on an all-electric Ammonia plant and the use of 4.5 MW wind turbines.

INSPIRATION
- Recent trends in the offshore wind sector indicate a shift towards installation of windfarms further away from the shore [1].
- Currently transmission through electric cables, but increasing distance leads to higher reactive power losses, thereby making it inefficient, and with addition of higher costs and engineering complexity, it is not a long-term solution.
- This leads to investigation of ammonia as an energy storage medium for the offshore windfarms.

BACKGROUND
- Dissertation by Morgan (2013) provides a techno-economic review of a 300 tons/day ammonia production system from a grid connected offshore windfarm [2].
- Connection to the grid allowed a uniform ammonia production despite variations in the wind.

MODEL DESCRIPTION
The turbine model selected is Wind 2 Energy W2E-151-4.5MW turbine and enlarging its rotor diameter to 162m. The electrical energy from the wind farm will desalinate sea water and the distilled water produced will run through the electrolyzers which will produce hydrogen gas. To produce nitrogen, air separation method is used. Hydrogen is compressed at around 150 to 250 bars in compressors. The next step is to feed the produced hydrogen and nitrogen in an ammonia synthesis loop, which is a continuous cycle of gases that travel at high temperature and pressure through an adiabatic reactor. The ammonia plant is on a plant ship and there is no connection to the grid.

SITE SELECTION AND WIND PROFILE

The wind speed at 90m above sea level is 10 m/s at a site which is 50 nautical miles from the shore of Massachusetts and has a depth of 60 meters [1]. In addition, the Weibull distribution is used to estimate annual wind distribution at hub height of 140m.

RESULTS AND DISCUSSIONS
The divisions certainly help to increase the net annual production but with considerable increase in the LCOA as well. Here the term division implies the use of number mini-ammonia plants with the combined potential of rated ammonia production. The LCOA is lowest at almost ($1566/ton of NH₃) when there are only 2 divisions as shown in figure 3. The LCOA for the baseline grid connected all-electric ammonia plant calculated by Morgan (2013) was $1224/ton of NH₃ [2]. It is almost $350/ton of NH₃ higher here.

FUTURE WORK
- Ammonia production calculation on 10 min wind data.
- Opportunities to optimize energy flow from windfarm to the ammonia plant.
- Possible to produce ammonia throughout the year.
- Estimation of accurate wind turbine prices. Any reductions or additions in the capital expenditure of wind turbine prices will have an amplified effect on the LCOA.
- Accurate estimation of the efficiency and capital expenditure of an ammonia powered gas turbine cycle.

REFERENCES