14th February 2024

Analysing and optimizing the value of Hybrid renewable power plant interaction with GreenNH3 production in Future energy markets.

Introduction:

With significant growth in renewable energy penetration in grid all across the world, there is a paradigm shift in design objectives of wind and solar plants from producing energy at the Lowest LCOE, and also to include other objectives to maximize profitability from other revenue streams associated with time varying energy pricing, ancillary service and capacity markets. This results in increasing interests (The Hybrid Answer to Europe's Renewable Project Bottlenecks, 2023)for utility-scale renewable hybrid power plants(HPP).There is a definite need for new tools for optimal design and operation of these hybrid plants for future demanding energy markets. For hybrid power plants (with 1 or more generation sources) to have a required profitable operations by developer to maximize his benefit a third storage component is required which can be BESS, pump hydro, P2G options like Green H2 or Green NH3. This thesis explores and answers few of the research questions related to integration and interaction of the Green NH3 component to open source sizing and optimization tool for HPPs.

Problem:

Design and operation of a utility-scale (multi-MW) HPP is a complex problem and needs to integrate different aspects ranging from selection of technology specifications to operating strategies to monitoring the health (example - battery degradation). Although there is a multitude of tools available which have been developed for either larger hybrid systems or microgrid applications or individual technology plants, however, there is definitely a requirement for new tools with capabilities which are specific to utility-scale hybrid power plants.(Das et al., 2022).

The researchers at Technical University of Denmark are in the process of development of an open source tool called "HyDesign" for design and operation of utility scale renewable hybrid plants(Pablo et al., 2023).Latest version of HyDesign(V1.3.2) tool has Solar, Wind, BESS(Li-ion), simple Green H2 models in it. After careful study on the available information in the demo notebooks and documents and available scientific literature in paper (Das et al., 2022) it was understood that production of energy carrier GreenNH3 is currently missing in the tool which will lead to gap in the analysis and optimisation of all revenue streams of HPP.

Main research question/objective:

- How can the value(economic, technical benefits) of utility scale HPP be optimized by coupling with production of energy carrier Green NH3.

Focus of thesis is to develop the wind based HPP's models and their optimisation strategies in the open source tool HyDesign further by evaluating and adding the additional P2X components Green NH3, Green H2. **If possible**, relevant data from real world pilots like Siemens Green ammonia demonstrator and announced green hydrogen plants in the oman can be gathered for validation of results from the model.

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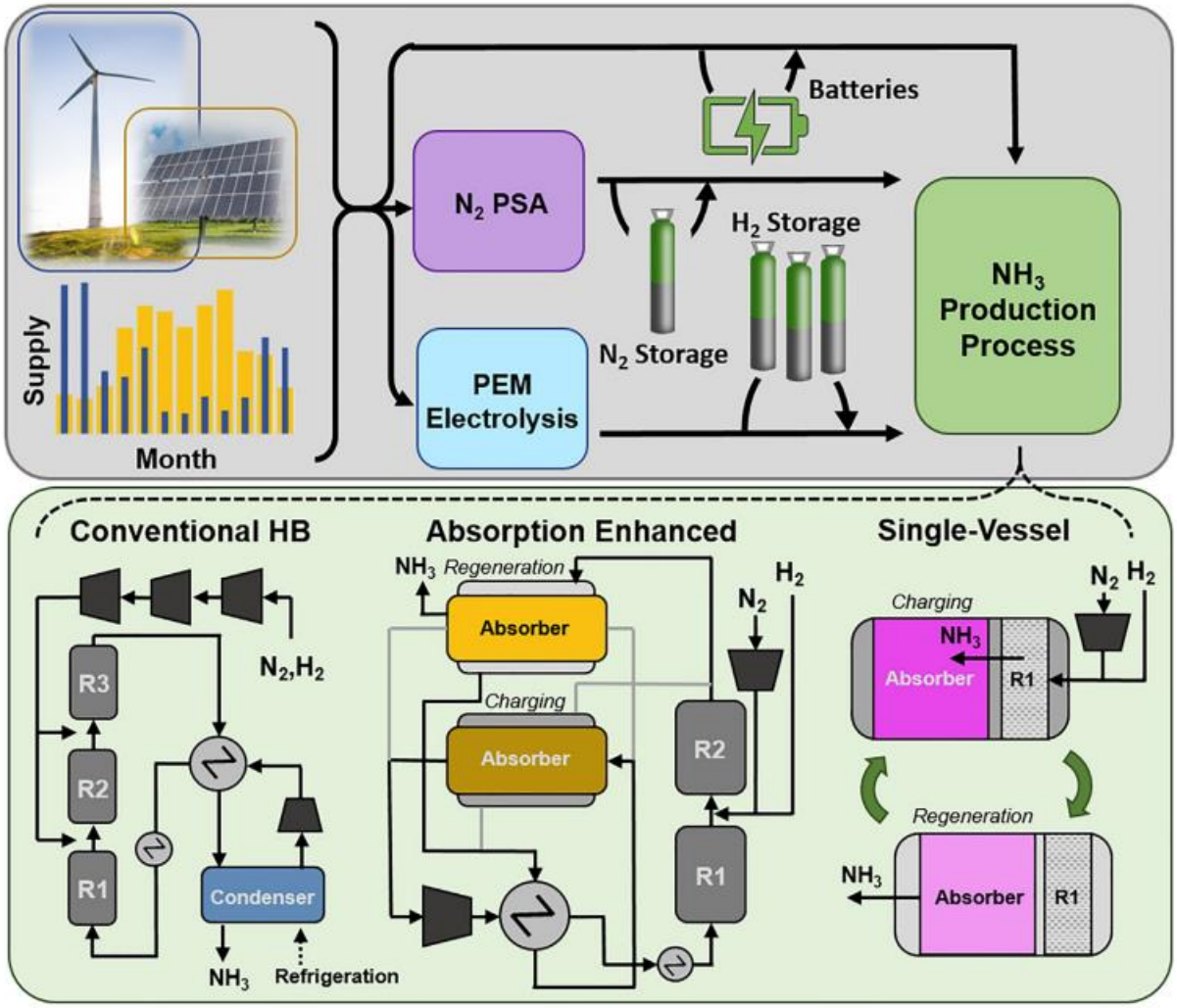

Figure 1 Schematic of green ammonia production from solar and wind energy(Smith & Torrente-Murciano, 2024)

Ammonia is produced through the conventional HB process (with or without ramping capabilities), the absorption-enhanced process, or the single-vessel integrated process. When using the conventional HB process, batteries and gas storage are implemented to buffer fluctuations in renewable energy supply due to constrained ramping capabilities. This Thesis project only covers the Haber Bosch process.

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