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POTENTIAL OF WIND-HYDROGEN (POWE2X) ENERGY SYSTEMS IN LATVIA

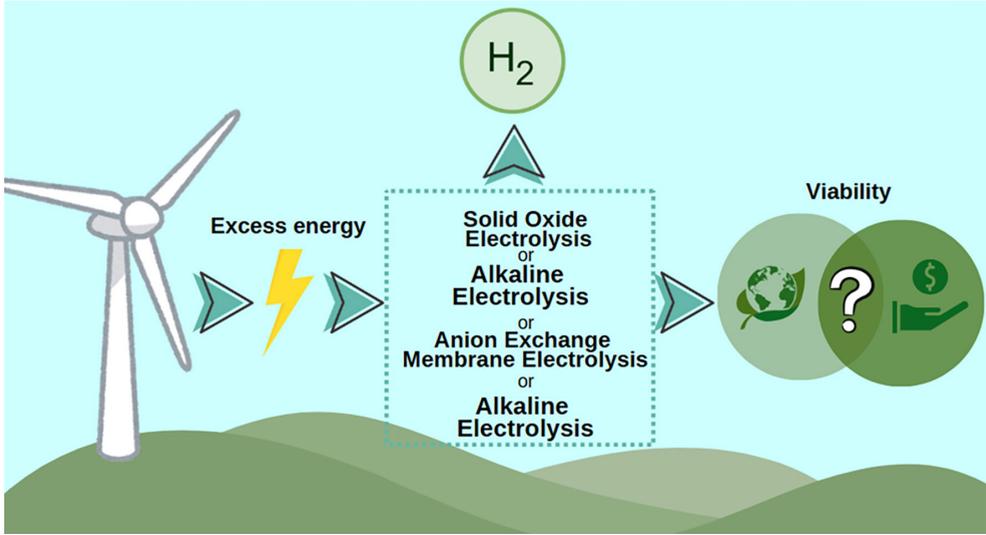
Anastasija TREIMANE^{1*}, Dagnija BLUMBERGA²

^{1,2} *Institute of Energy Systems and Environment, Riga Technical University, Āzenes iela 12/1, Riga, LV-1048, Latvia*

* **Corresponding author.** *Email address: Anastasija.Treimane@edu.rtu.lv*

Abstract – Growing concerns about greenhouse gas emissions have made the development and use of carbonneutral technologies a pressing issue in the European Union, particularly for replacing fossil energy sources. Among these, green hydrogen emerges as a promising alternative for replacing fossil fuels. Integrating windhydrogen systems addresses a key challenge in the wind energy industry – energy inconsistency – by aligning supply with demand. This problem is quite significant, because it was stated that most of wind energy is produced during low demand hours creating excess energy; consequently, it is sold during low energy price hours. By this, wind energy production becomes less profitable than it could be, so energy storage and Power2X technologies and its research becomes more relevant. However, the economic viability and climate impacts of Power2X system integration remain significant concerns. Latvia, where the share of wind energy is rapidly increasing, faces rising questions about renewable energy storage possibilities and their rationality. This study evaluates the potential of wind-hydrogen Power2X systems in Latvia by analyzing three methods for converting wind energy into hydrogen for storage and subsequent use, using Python mathematical modelling in system dynamics analysis of wind energy generation and hydrogen production technologies. Finally, the study calculates and compares the profitability and climate impact of the proposed Power2X systems against conventional energy sales during production hours. The results of this study present a comparison of five scenarios for wind energy usage. 1st scenario: direct wind energy selling during its production time. 2nd, 3rd, and 4th scenarios, respectively: wind energy is sold directly during its production time only when electricity prices are high. However, during periods of low electricity prices, this energy is used for hydrogen production via three different technologies – alkaline electrolysis, proton exchange membrane electrolysis, and solid oxide electrolysis. Using input data, the potential of each technology, as well as its economic and environmental viability is calculated and compared to the 1st (base) scenario. This dynamic model provides recommendations for the development of wind-hydrogen systems in Latvia, as well as a practical framework for evaluating the performance of dynamic wind-hydrogen systems in any other country and for any specific situation.

Keywords – *Decarbonisation; energy storage; green hydrogen; renewable; wind energy*



Green hydrogen production evaluation overview