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TECHNO-ECONOMIC AND ENVIRONMENTAL ASSESSMENT BY LCA FOR THE OPTIMAL DESIGN OF 'POWER-TO-GAS' ENERGY SYSTEMS

Analyse Technico-Economique et Evaluation Environnementale par ACV pour la conception optimale de systèmes énergétiques de type « Power-to-Gas »

According to the Special Report on Global Warming of 1.5 °C by the Intergovernmental Panel on Climate Change (IPCC), there is an urgent need for an energy transition and the development of renewable energy systems. Yet, the intermittent nature of renewable power generation has long been a potential barrier to their increased penetration in the electric mix. To meet this challenge, Power-to-Gas (PtG) systems represent a promising alternative to recover the overproduction of electricity issue, i.e., from PV and wind parks in the form of a gas energy carrier. PtG create greater flexibility in energy systems and act as a link between the electric power and the natural gas networks.

This study will allow the development of a methodology for the optimal design of PtG supply chains, relied on a systemic vision of process engineering will include technical-economic and environmental criteria through Life Cycle Assessment (LCA). The deployment and design of a PtG supply chain is performed by using a multi-objective optimization formulation based on mixed integer linear programming (MILP) with a multi-period horizon (2030-2050), with limited sources of energy available (wind, PV, hydro) to produce hydrogen by water electrolysis. The CO_2 source stems from methanisation and gasification. Following electrolysis, the methanation between hydrogen and CO_2 produces methane and water. The chain offers two products: hydrogen and methane, which have different demands and uses.

The objectives to minimize are the unit cost of the methane and hydrogen, and their CO_2 equivalent emissions throughout the total period studied. Some key optimization variables are the number and size of unit plants and hydrogen transport. The methodology is applied to the case study of Occitanie region, France.

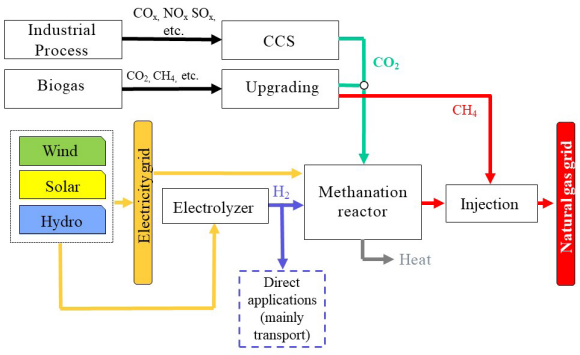

Figure 1: Exemplary Power-to-Gas process chain