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Integration of a Microbial Electrolysis Cell and an Oxy-Combustion Boiler

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Abstract : In the present work, a study of the coupling of a Bioelectrochemical System together with an oxy-combustion boiler is carried out; specifically, it proposes to connect the combustion gas outlet of a boiler with a microbial electrolysis cell (MEC) where the CO2 from the gases are transformed into methane in the cathode chamber, and the oxygen produced in the anode chamber is recirculated to the oxy-combustion boiler. The MEC mainly consists of two electrodes (anode and cathode) immersed in an aqueous electrolyte; these electrodes are separated by a proton exchange membrane (PEM). In this case, the anode is abiotic (where oxygen is produced), and it is at the cathode that an electroactive biofilm is formed with microorganisms that catalyze the CO2 reduction reactions. Real data from an oxy-combustion process in a boiler of around 20 thermal MW have been used for this study and are combined with data obtained on a smaller scale (laboratory-pilot scale) to determine the yields that could be obtained considering the system as environmentally sustainable energy storage. In this way, an attempt is made to integrate a relatively conventional energy production system (oxy-combustion) with a biological system (microbial electrolysis cell), which is a challenge to be addressed in this type of new hybrid scheme. In this way, a novel concept is presented with the basic dimensioning of the necessary equipment and the efficiency of the global process. In this work, it has been calculated that the efficiency of this power-to-gas system based on MEC cells when coupled to industrial processes is of the same order of magnitude as the most promising equivalent routes. The proposed process has two main limitations, the overpotentials in the electrodes that penalize the overall efficiency and the need for storage tanks for the process gases. The results of the calculations carried out in this work show that certain real potentials achieve an acceptable performance. Regarding the tanks, with adequate dimensioning, it is possible to achieve complete autonomy. The proposed system called OxyMES provides energy storage without energetically penalizing the process when compared to an oxy-combustion plant with conventional CO2 capture. According to the results obtained, this system can be applied as a measure to decarbonize an industry, changing the original fuel of the oxy-combustion boiler to the biogas generated in the MEC cell. It could also be used to neutralize CO2 emissions from industry by converting it to methane and then injecting it into the natural gas grid.

Keywords : microbial electrolysis cells, oxy-combustion, co2, power-to-gas
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