**Design of an offshore renewable energy-based process for hydrogen production by electrolysis**

Leonardo Bozzoli\*, Valeria Casson Moreno, Valerio Cozzani

*LISES – Laboratory of Industrial Safety and Environmental Sustainability, Dipartimento di Ingegneria Civile, Chimica, Ambientale e dei Materiali, Alma Mater Studiorum - Università di Bologna, via Terracini 28, 40131 Bologna, Italy*

*\* leonardo.bozzoli@unibo.it*

**1.Introduction**

Green hydrogen is one of the most promising energy vectors in the perspective of energy supply chains decarbonization. Currently, the production of hydrogen is mostly carried out using natural gas, oil and coal as precursor. To obtain green hydrogen, renewable energy sources (RESs) are required in order to avoid the fossil fuel consumption and CO2 production [1]. Offshore RESs, such as wind, wave and sun offer several advantages compared to the onshore ones, for example a more stable energy intensity, a higher energy density and significant amount of available space for devices installation [2]. Furthermore, close to decommissioning-phase, offshore platforms could represent an opportunity to create a hub for hydrogen production, avoiding platform removal, a technically complex and highly impacting process from both environmental and economic standpoints. The aim of this study is to provide design criteria for an offshore process for green hydrogen production able to exploit the energy available from sun, wind and wave.

**2. Methods**

The following steps allow the optimal selection of the energy converters for each RES considered in a selected offshore site (for the present case sun, wind and wave):

1. Selection of the offshore site that must have the following characteristic: the presence of a close to decommissioning phase platform and the availability of data related to RESs. Data collected for each RESs must cover at least one year to investigate all seasonal variations and timestep have to be of one hour or lower to analyze RESs unpredictability.
2. Elaboration of collected data to calculate the potentiality for each RES and to allow the selection of the most suitable converter for the maximum source exploitation. Such selection is driven by the potentiality of the source and by the nominal operativity conditions of each converter.
3. Calculation of power produced by each converter based on the timestep selected.
4. Determination of converters mix and power availability for the processes.
5. Calculation of energy requirement for MVC and AEL processes and quantification of green hydrogen production.

In the present study, the production of green hydrogen is based on Alkaline Electrolysis (AEL) [3], considering an upstream step for seawater desalination trough Mechanical Vapour Compression (MVC) [4]. The AEL technology is selected because of its lower water consumption with respect to the PEM technology, while MVC is selected for its lower power consumption if compared to Multi-Stage Flash Distillation and Multi-Effect Distillation.

**3. Results and discussion**

A platform located 18 km offshore Ravenna (Adriatic Sea), called Garibaldi C, is selected as a case-study, in compliance with the constrain reported in step 1: indeed, the natural gas in the reservoir is depleting and wave data are provided by a metric wave buoy called Nausicaa, while for wind and sun data European Centre for Medium-Range Weather Forecast database is used, for a representative year (i.e. 2017) with hourly timesteps. Data are elaborated to evaluate the solar potentiality, wind yearly average velocity and wave potentiality, amounting respectively to: 5950 kJ/m2/y, 4.2 m/s and 1 kW/m. Given such potentialities, the most suitable converter for each RES is selected, i.e. high efficiency photovoltaic (PV) panel (226 W/m2), wind turbine (WT) designed for low wind potentiality (1500 kW of nominal power) and point absorber (20 kW of nominal power) as wave energy converter (WEC). Then, for each converter, the hourly average power production is calculated. For what concern solar panel, to calculate the power production the procedure reported in “UNI/TS 11300-4” is used; regarding WEC and WT, power matrix and power curve are used respectively, two tools providing the power produced from the converters based on the wind velocity and the significant wave height and the equivalent wave period respectively for WT and WEC. To equilibrate the power production from each RESs, the area of PV panels and the number of WECs are settled in order to obtain the same peak power production of the WT; the nominal power of 1500 kW is selected as target because is the nominal power of the single wind converter selected, resulting in the simplest possible case study. The area needed for PV panels is 8540 m2, the number of WECs needed is 100. With the given potentiality for each RES converter, the hourly green hydrogen production is calculated as the power needed from the AEL and the MVC. In this work 1.5 MW of available power for the processes is selected. As shown in Figure 1, lower processes potentiality increases load factor (total energy used by AEL dived by total energy AEL would consume operating full time), but also increase the number of hours in which the power production by converters mix exceed 1.5 MW (waste of power), while higher processes potentiality decreases the load factor without sensibly increasing the hydrogen production. The power consumption of the MVC process is about 10 % of all energy consumption while the power consumption of AEL is 90 %. Given the energy mix, the resulting green hydrogen production is equal to 1.05 million of Nm3/y.

 

**Figure 1.** Green Hydrogen production and load factor for different AEL potentiality.

Due to its high transient response, the AEL system do not need a backup system to provide a steady electricity; thus, the use of a back-up system can be avoided, therefore fossil fuel consumption, representing an advantage for both environmental and economic aspects related to the process under design.

**4. Conclusions**

The conceptual design of a green hydrogen production system based on electrolysis fed by electricity provided by RESs converters was carried out. The aim is to prove the feasibility of the system, resulting in a significant amount of hydrogen production, providing the required data for economic optimization and footprint evaluation.

**References**

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