Hex-generation system from seawater and air. Seed for decarbonization on the island of Gran Canaria

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The Canary Islands currently have total dependence on oil as a source of energy. Being, in 2018, 98% of the primary energy used, and the remaining 2% was renewable energy [1]. Europe and therefore Spain has a decarbonization plan for 2050. But 2040 has been proposed for non-peninsular territories. The truth is that time is running out, and no action has been taken. It should be mentioned that the islands are fuel stations for ships in the middle of the Atlantic Ocean. The energy that is served to ships is half of that consumed on the islands [1].

Project description

The project will be powered by renewable energies, in the case presented here, it is a single 3 MW wind turbine. It will have a water desalination plant consisting of two 24 m3/h plants, since water is lacking on the islands as is currently the case in many places of the planet [2]. It is true that electrolyzers are being developed that run on salt water, but in any case, the island needs desalinated water, not only to produce hydrogen but for any activity. Today the island has more than 80 desalination plants in operation, and desalinated water is 86% of the water used [3].

Subsequently, a 2.5 MW electrolyzer is added. But hydrogen is known for its difficulties in storing and transporting it, with ammonia emerging as a hydrogen carrier that is gaining strength day after day. So, an air separator is added (Pressure Swing Adsorption) to the process, from which nitrogen is obtained, and a Haber-Bosch cycle where hydrogen is mixed with nitrogen, obtaining ammonia. The system is equipped with compressors, pumps, and storage tanks for all these products.

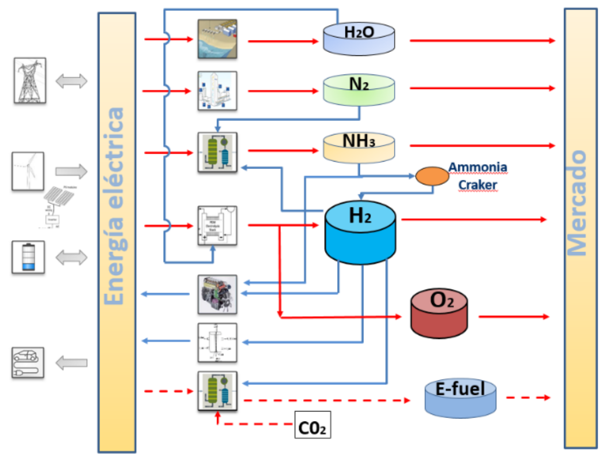

Figure 1. Project outline

Given the importance of decarbonizing, the project includes a 1 MW / 0.4 MWh Lithium-ion battery, H2 and NH3 fuel cells and a generator that allows the simultaneous combustion of both compounds, as well as a charger for electric vehicles. Which will serve to reconvert the current existing Fuel plants. As well as learning how to manage all these processes.

So we will have 4 products: electricity, water, hydrogen and ammonia. The raw material are air and sea water. All the machinery to be used is well known, presenting different maturity grade.

After holding talks with gas companies on the island. They tell us why to see only the energy use of the plant, when intermediate products are also in demand. Therefore, the oxygen obtained from the electrolyzer and nitrogen are incorporated into the market. Remaining six green products.

The innovation that this project presents, it is getting all these processes to operate optimally. In fact, optimization software using multi-objective genetic algorithms has been selected [4]. Where a different weight can be applied to each target. The most important are the reduction of emissions, renewable integration, maximizing the economic benefit, or minimizing the shortage of some of the products offered. The input variables will be technical restrictions of each of the processes [5], an estimate of the demand, the level of each of the product deposits, a measure of the energy resource with an estimate of it, and the hourly price of electricity. With all this, the software will put the various processes into operation to a greater or lesser extent. The main consumer of the plant is the electrolyzer with 68% of the power.

The software to be produced has the advantage of being modular, that is, with the same software it is possible to delete or add processes, introducing their peculiarities. This is very necessary because if anyone wants to replicate the project in a place with excess freshwater, the desalination is eliminated. In the future, the creation of e-fuels could be added through a Fischer-Tropsch cycle or any other process because it´s near to Power Station.

Characteristics and results

The project consists of a series of processes to obtain green products, powered by renewable energy and connected to the grid. Grid connection is so important, as both benefit simultaneously. The processes, being some of them flexible, can be considered storage systems, what today is called Power to Gas, or Power to chemicals, increasing consumption in off-peak hours, allowing a greater penetration of renewables, since the few wind farms on the island are 200 h of wind, disconnected from the grid per year [6]. And on the other hand, operating connected to the grid allows us to dispense with large storage systems to guarantee a more continuous and stable production. The advantages of producing ammonia are several:

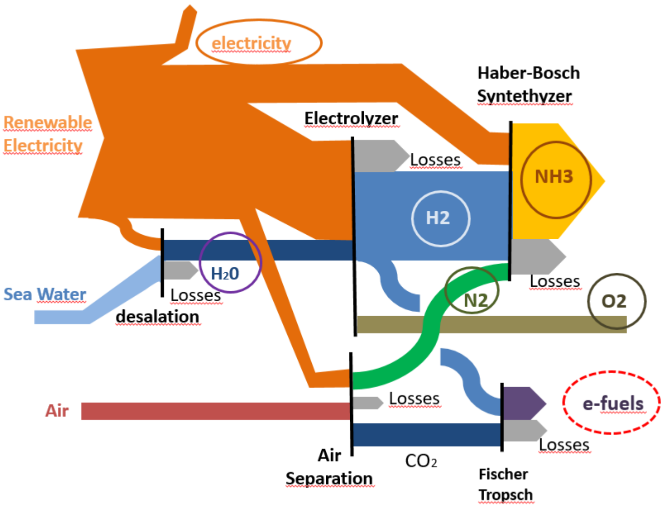

Figure 2. Flowchart.

- It makes it possible to take more advantage of natural energies, since it avoids creating seasonal storage on the island. Since in times of abundance of the resource, ammonia would be exported to other places, and in times of scarcity, this green fuel would be imported. Counting the present project with a NH3 cracking station in H2.

- Consolidate the position of fuel supplier in the middle of the Atlantic, by being able to supply ships with green fuels, which will soon sail the seas and more, given the decarbonization objectives of the IMO. In the case of commuter ships, its fuel will be hydrogen, and if it is long-haul it will be ammonia.

- It is the only way to reach the decarbonization objective by 2040, in a site that depends exclusively on oil [1].

- It could greatly reduce the carbon footprint caused by: a rampant water shortage, a food dependency on the outside of over 80%, the purchase and transport of more than 4,000 t of nitrogen fertilizers per year.

- Helping to mitigate several of the great social problems existing on the island: a high abandonment of agricultural land, a high unemployment rate.

- Following The energy storage strategy of Spain, and its decarbonization objective, a Li-ion battery, electric vehicle charger, a combustion generator, and fuel cell have been added, both for H2 and NH3. Allowing to revert the stored energy back to the grid, being able to observe that hybrid storage of both compounds is of interest for this purpose [7].

Gross electricity production of 12,600 MWh would be obtained, equivalent to 4,200 equivalent hours per year. Carrying out the simulation of a year of operation, direct injection to the grid of 3,150 MWh has been obtained, the discharge to the grid the first year from the batteries would be 567 MWh, 0.21 hm3 of desalinated water, 116.42 t of H2, and 145 t of NH3 have been produced per year.

With all these green products and taking into account the location of the plant [8], the emission into the atmosphere of 4,532 t of CO2/year would be avoided.

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