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High Performance PEM Electrolyser for Cost-effective Grid Balancing Applications

HPEM2GAS - Deliverable report

D5.4 Cost and life cycle analysis on advanced PEM electrolyser

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Summary

The aim of this study was to evaluate the energy and environmental performance of the HPEM2GAS PEM electrolyser stack manufacturing and a techno-economic assessment for the hydrogen produced from RES and injected in the natural gas (NG) grid through PEM water electrolysis technology.

Concerning techno-economic assessment, the electrolysis system was located in Emden (Germany) and the hydrogen produced was injected in the local NG grid. The electrolyser system was fed by electricity produced from a local wind farm. The LCOES was used to evaluate the cost of stored hydrogen for two scenarios, one based on current market for water electrolysis and the other based on costs projection at year 2050.

The electrolyser system analysed achieved a LCOES of 4.11 €/kg for the current scenario with a capacity factor of 60% (5256 working hours per year). Electricity The LCOES of hydrogen represented 43.7% of total costs followed by the system (26.8%) and the stack (19%). The sensitivity analysis was also performed; a reduction of 25% of CAPEX permitted to lower the LCOES of 13%. Similar result was achieved with an increment of stack lifetime of 100% (20 years).

The LCOES of hydrogen was lower for the 2050 scenario due to the reduction of both the cost electricity and CAPEX. The 2050 scenario was an optimistic business case useful to understand the technology potential. In this case the LCOES was 1.4 €/kg and the items that influenced mainly it were the system (33%) followed by electricity cost (27%). A CAPEX reduction of 25% permitted to achieve a LCOES of 16% lower than the base case.

The introduction of hydrogen-based electrical energy storage on large-scale needs incentives to compete with NG market price for current scenario. However, a competitive market price with NG was achieved for hydrogen in 2050 scenario. This result is quite useful considering that the price of NG is estimated increase in 2050.

Cost distribution analysis between the HPEM2GAS project and a previous EU project ElectroHyPEM showed a reduction of the stack influence on the total system cost from 54% to 32%. This result was mainly due to the new catalysts and membrane developed able to reach a current density of 3 A/cm^2 (1 A/cm^2 in the previous project).

The LCA methodology, based on the standards of the ISO 14040 [17] and ISO 14044 [18], was used to quantify energy and environmental impacts associated to the HPEM2GAS PEM electrolyser stack manufacturing.

In the LCA analysis three scenarios were assessed s reported in the following.

- The Baseline Scenario investigates the primary energy use and the environmental impacts for the entire stack manufacturing process;
- The Scenario 2, in addition to taking into account the raw materials, considers also the energy used in the stack manufacturing. In detail, a literature value, was used as electricity use to produce the entire stack;
- Scenario 3, based on results of the previous scenario, the system boundaries are enlarged and also include the stack use stage in addition to the stack manufacturing stage.

Primary data were provided by the different manufacturers involved within the HPEM2GAS project, and secondary data from literature and environmental databases.

The MEAs are responsible for the highest environmental impact for all of the 13 impact categories investigated, reaching values higher than 95% in for all the impact categories investigated. GHG emissions are about 353.57 t of CO_2 eq/Stack. Among the different stages, the highest contribution is due to the

assembly of the MEAs (99.36%). The total primary energy throughout the stack manufacturing process is 4.48 103 GJ/Stack, of which 4.34 103 GJ/Stack (approximately 97%) of non-renewable energy and 140.93 GJ/Stack of renewable energy. All others, stack components have a contribution to the environmental impacts lower than 1%.

The LCA results show that, despite the stack produced in the context of the HPEM2GAs project has a reduced content of the platinum group materials (PGM) compared to the state of art stacks (0.07 mg/W compared to 0.5 -1.5 mg/W of the state of art), the PGMs are the main contributors to the potential energy and environmental impacts produced during the stack manufacturing process. Therefore, an important finding of this study, in line with the main goals of the HPEM2GAS project, is that the primary energy use and the environmental impacts of the stack manufacturing process can be decreased by decreasing the use of PGM.

Even if in the Scenario 2 a literature value was used as electricity use to produce the entire stack, the results show that the energy consumption during the stack manufacturing process have a contribution to the potential environmental impacts lower than 1%.

The results of Scenario 3, in which the LCA system boundaries were extended to include the stack use, show that the environmental impacts of this stage can be reduced if the system works as close as possible to the nominal conditions.