Assessing the use of Treated Wastewater for Green Hydrogen via SOEC

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Introduction

The European Union's goal of achieving carbon neutrality by 2050 has led to significant investments in sustainable energy research, particularly from renewable sources (RESs). Italy, with a projected energy demand of 366 TWh by 2030, is mandated by the EU to satisfy 75% to 84% of this demand using RESs[1]. Green hydrogen production through water electrolysis, particularly using Solid Oxide Electrolysis Cells (SOECs), is seen as a promising solution. SOECs have an advantage over Alkaline Electrolyzers (AEs) and Proton Exchange Membranes (PEMs) as they can use treated wastewaters, eliminating the need for pure water, which is already in short supply[3]. This study focuses on the potential of SOECs to operate effectively in high-temperature conditions and use water in its gas form as the inlet source, starting with treated wastewaters from municipal wastewater treatment plants.

Materials and Methods

Four distinct treated wastewaters with different characteristics in terms of capacity, industrial load, and treatment scheme were assessed for their potential as feedstock for hydrogen production using Solid Oxide Electrolysis Cells (SOECs), and the study used Aspen Plus software to model the process. SOECs were highlighted as an energy-efficient means of hydrogen production by harnessing thermal energy, with a focus on the vaporization and heating of water and air. The study detailed the electrolysis stack's setup, emphasizing the separation and utilization of different streams and the recovery of residual heat from the cell products. The modeling approach for the SOEC stack included equations for cell voltage, potential, and electric power consumption. Additionally, the study covered a thermal model incorporating energy and mass balance equations for various components, although it employed a simplified modeling approach.

Results and Discussion

This study demonstrates that treated municipal wastewater obtained from wastewater treatment plants (WWTPs) of varying capacities, industrial loads, and treatment schemes can serve as an ideal water source for SOECs to produce "clean" hydrogen. In particular, Italy aims to install 5 GW of electrolysis capacity by 2030 in line with the European Union's energy transition program. The solutions proposed in this article, utilizing wastewater from various WWTPs as sources of renewable energy, could contribute to meeting this pace. More specifically, in the Best-case Scenario (BS) with 7,500 hours of operation for a SOEC with a moderate power of 2.12 V supported by wind and conventional energy, this means that a WWTP (named as WWTP C) with a capacity of 120,500 P.E., an average flow rate of 27.500 m^3/d and an industrial load equal to 11%, can produce 0.10 Mt/y of hydrogen (which corresponds to approximately 15% of the national target) while a bigger WWTP (named as WWTP A - capacity of 620,600 P.E., average flow rate of 155,300 m^3/d and an industrial load equal to 15%) can produce 1.46 Mt/y, which exceeds the national target. Even in the Worst-case Scenario (WS) with only wind energy (where the operating time reduces to 2,000 hours per year), WWTP A can still contribute significantly, producing 0.39 Mt/y, and WWTP C contributes 0.03 Mt/y[4].

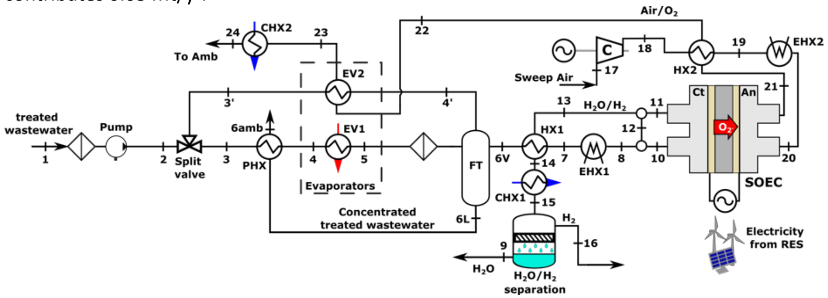

Figure 1. Layout of the SOEC stack.

Translating this hydrogen production into electricity, Italy's growing demand for electricity in 2030 requires adding 8.6 to 10.7 GW of capacity per year. WWTP A alone could cover 20% of the electricity demand in the best scenario and 5.4% in the worst scenario. WWTP C could contribute 1.3% in the best scenario and 0.4% in the worst scenario. These findings underscore the substantial potential of using wastewater as a renewable energy source to help meet Italy's electricity needs sustainably.

Significance

This study demonstrates that treated municipal wastewater from various wastewater treatment plants can be an excellent water source for Solid Oxide Electrolysis Cells (SOECs) to produce clean hydrogen. The primary goal is to highlight the feasibility and energy viability of using wastewater as a non-pure water source for green hydrogen production in a circular economy context. This approach proves to be energy-efficient, cost-effective and it has the potential to revolutionize clean energy production, particularly in regions where access to potable water is limited. The integration of wastewater treatment and hydrogen production can address multiple sustainability goals and contribute to a decarbonized future.

References

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Alexander KLYUSHIN - *MAX IV Laboratory, Sweden*

12:00 - 12:20 | Photo-thermo-catalytic H2 production for solar energy conversion

Simone LIVOLSI - *University of Milan, Italy*

11:00 - 12:20 | TUE-T23-01 | H2 production and utilization as energy vector

Bellecour 1+2+3

11:00 - 11:20 | Green hydrogen production from methane cracking via mechanical catalysis approach

Yu TIE - *Shandong University, China*

11:20 - 11:40 | Surface Evolution of Ni-Mo-MgO Catalyst in Methane Conversion for Hydrogen and Carbon Nanotube Production

Laura Alejandra GOMEZ GOMEZ - *University of Oklahoma, United States*

11:40 - 12:00 | Dynamic lattice strain oscillations in nanoalloy fuel cell catalysts

Zhi-Peng WU - *King Abdullah University of Science and Technology, Saudi Arabia*

12:00 - 12:20 | Assessing the use of Treated Wastewater for Green Hydrogen via SOEC

Marina MADDALONI - *Department of Civil, Environmental, Architectural Engineering and Mathematics, University of Brescia, Italy*

11:00 - 12:20 | TUE-T26-03 | CO2 conversion

Amphitheatre

11:00 - 11:20 | Intermediate transfer rate, ion migration, and acid strength determine the hydrocarbon yields for tandem CO2 hydrogenation

Manish SHETTY - *Texas A&M University, United States*

11:20 - 11:40 | Coupling ZnZrOx and SSZ-13 for CO2 hydrogenation to olefins

Julien DEVOS - *KU Leuven, Belgium*

11:40 - 12:00 | Low-nuclearity CuZnx ensembles on ZnZrOx catalyze methanol synthesis from CO2

Thaylan PINHEIRO ARAÚJO - *ETH Zurich, Switzerland*

PRESENTATION CERTIFICATE

Friday 19th July 2024, Lyon, France

On behalf of the organizing committee of the **18th International Congress on Catalysis**, we confirm that the following abstract was presented as part of the scientific program of ICC 2024 in Lyon, France, on July 14-19, 2024 :

- Presenting author

MADDALONI Marina

- Title of the abstract

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Sincerely yours,

David Farrusseng
General Chair of ICC 2024

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