253-26-falces

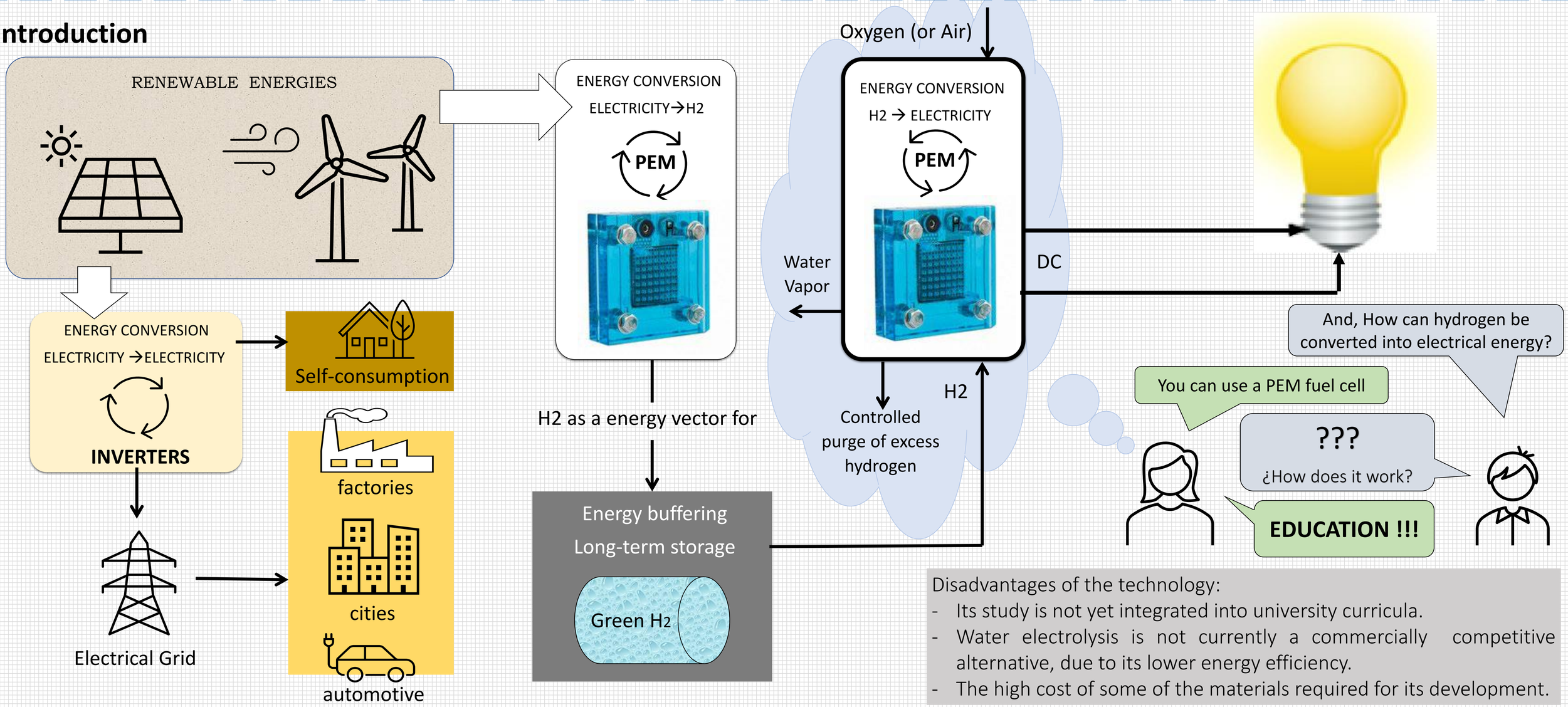
24th International Conference on Renewable Energies and Power Quality (ICREPQ'26)
Santander (Spain), 10th to 12th June 2026

Laboratory experimental platform for studying renewable energy integration using green hydrogen

A. Falces, P. Lara-Santillan, E. Zorzano-Alba, C. Capellán-Villacián, T. Laencina-Santolaya and L.A. Fernández-Jiménez

Department of Electrical Engineering E.T.S.I.I., La Rioja University
C/ San José de Calasanz, 3 – 26004 Logroño (Spain)
Phone/fax number: +0034 941 299 497, e-mail: alberto.falces@unirioja.es

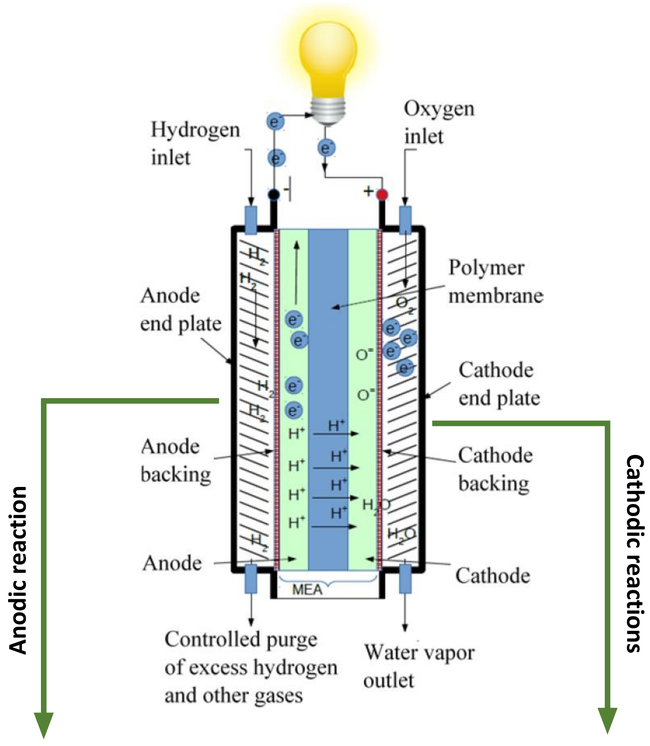
Introduction



Disadvantages of the technology:
- Its study is not yet integrated into university curricula.
- Water electrolysis is not currently a commercially competitive alternative, due to its lower energy efficiency.
- The high cost of some of the materials required for its development.

Execution of the laboratory teaching session

1º.- Operation of a PEM fuel cell.

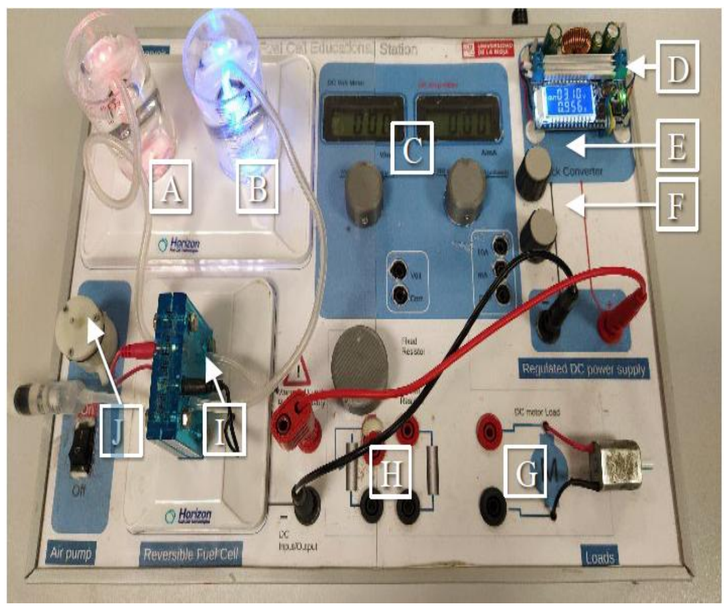


$2H_2 \rightarrow 4H^+ + 4e^-$

$O_2 + 4e^- \rightarrow 2O^=$

$2O^= + 4H^+ \rightarrow 2H_2O$

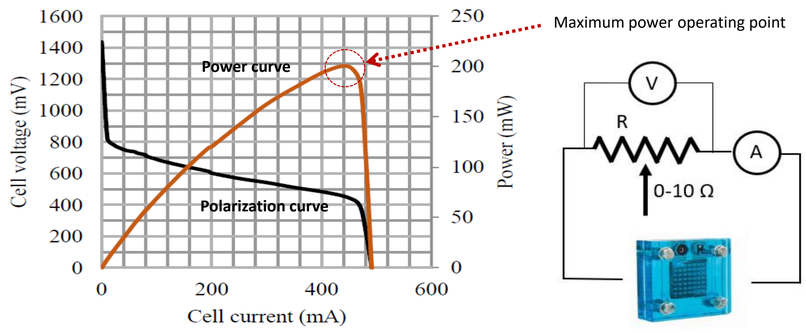
2º.- Laboratory experimental platform.



A.- Hydrogen tank
B.- Oxygen tank
C.- Measurement equipment
D.- Regulable power supply
E.- variable voltage supply
F.- variable current supply
G.- electric load (0-10 Ω)
H.- electric load (1Ω)
I.- PEM fuel cell
J.- Motor DC

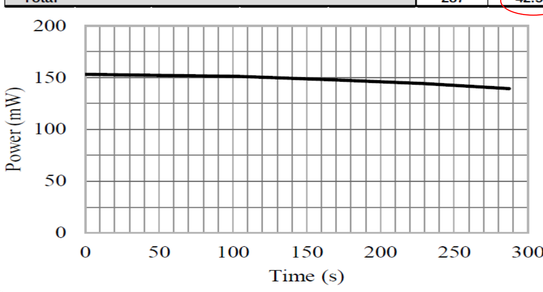
3º.- Activities.

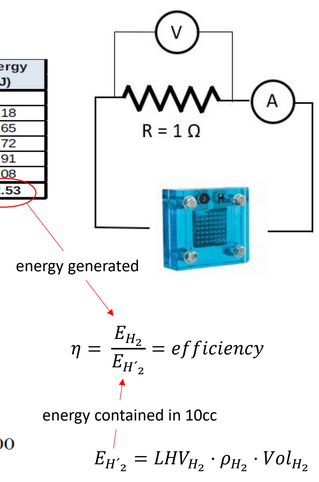
A:- Determination of the polarization curve.



B:- Determination of the electrical energy generated and efficiency of the PEM.

Vol. H (cc)	Time (s)	Cell Volt. (mV)	Cell Current (mA)	Power (mW)	Δt (s)	Energy (J)
10	0	625	245.0	153.1		
8	47	621	245.2	152.3	47	7.18
6	104	617	245.0	151.2	57	8.65
4	169	611	242.0	147.9	65	9.72
2	230	603	239.0	144.1	61	8.91
0	287	593	235.0	139.4	57	8.08
Total					287	42.53





$$\eta = \frac{E_{H_2}}{E_{H'_2}} = efficiency$$

$$E_{H'_2} = LHV_{H_2} \cdot \rho_{H_2} \cdot Vol_{H_2}$$

conclusions

- Renewable based hydrogen production offers a promising solution for energy storage, addressing the inherent intermittency of renewable sources..
- While green hydrogen production via water electrolysis is currently limited by low efficiency, continued research in this field remains essential for its future competitiveness.
- Future engineers must be equipped to manage the complete hydrogen lifecycle, including production, storage, and reconversion into electrical energy.
- Hydrogen technology education aligns with European Commission guidelines, such as the European Green Deal, which aims to transform surplus renewable energy into a manageable, clean resource.
- The experimental platform has been designed to enable undergraduate students enrolled in an elective course on the integration of renewable energy sources into power systems to acquire skills and competencies related to hydrogen production, storage and its subsequent conversion back into electricity.

GRUPO PLOCEL
Planificación, Operación y Control de Sistemas de Energía Eléctrica

Authors are very grateful to the University of La Rioja for their support through the teaching innovation project "Educational Platform for Hydrogen Technology-Based Systems" and the grant REGI25/35