Performance of Green Hydrogen:

Fuel Cell Improvement of the Energy Obtention Process.

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The Problem

MAP OF THE PRESENTATION

1

GENERAL ASPECTS

Functioning.

Types of fuel cells.

Applications.

2

PEMFC AND SOFC FUEL CELLS

Characteristics.

Advantages and disadvantages.

3

IMPROVEMENTS

Technical aspects that can be improved.

Arrival at solutions.

1 GENERAL ASPECTS

ELECTROLYSIS PROCESS

$$2H_2O \rightarrow 2H + O_2$$

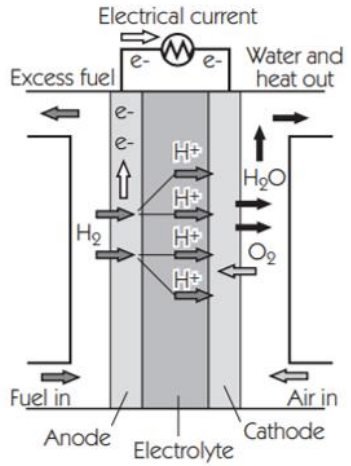


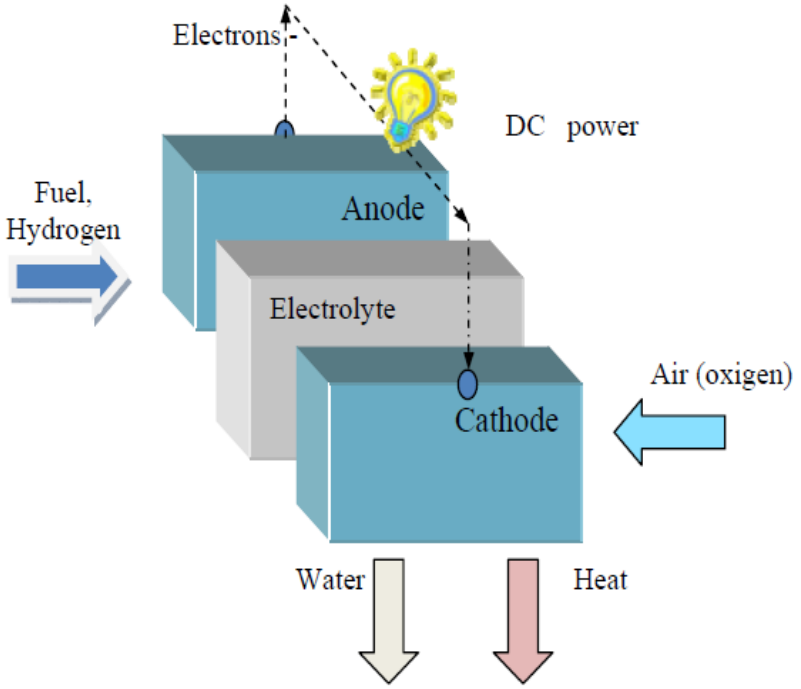
Fig. 1. The Fuel Cell. [2]

"Fuel cells are devices capable of doing the reverse electrolysis process"

$$2H + O_2 \rightarrow 2H_2O$$

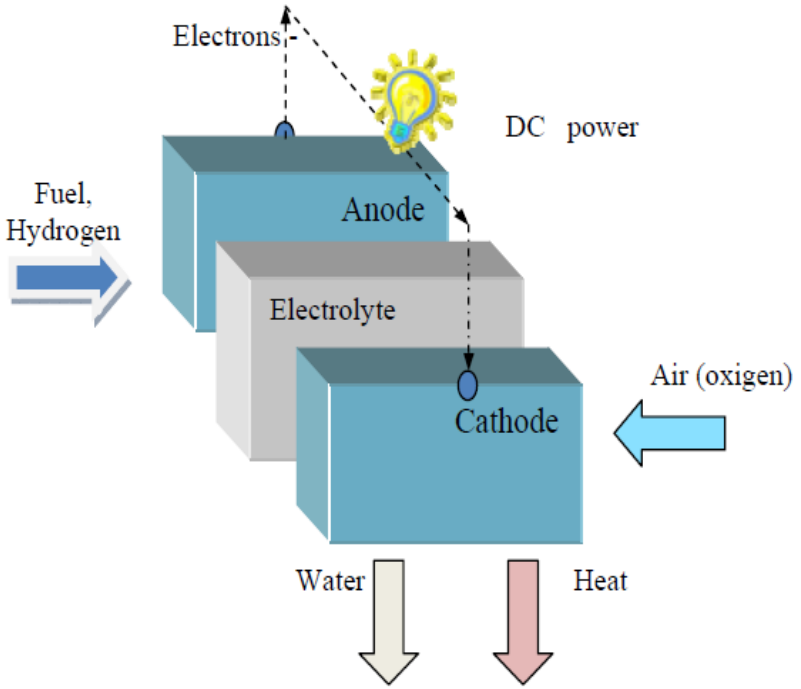
HOW?

MAIN STRUCTURE OF FUEL CELLS



1 GENERAL ASPECTS

TYPES OF FUEL CELLS



1 GENERAL ASPECTS

TYPES OF FUEL CELLS

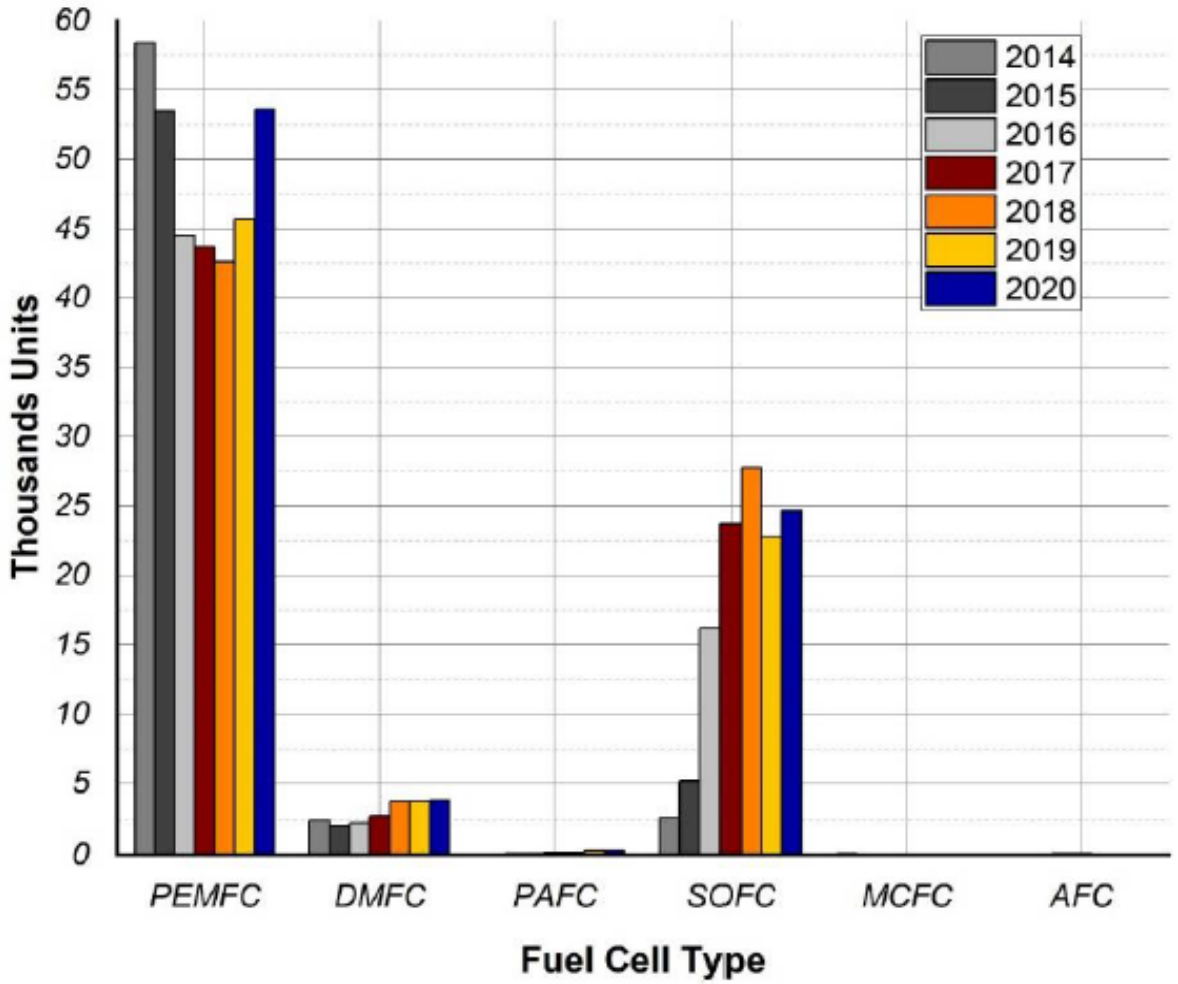
	AFC Alkaline	PEMFC Polymer Electrolyte Membrane	DMFC Direct Methanol	PAFC Phosphoric Acid	MCFC Molten Carbonate	SOFC Solid Oxide
Operating temp. (°C)	<100	60-120	60-120	160-220	600-800	800-1000
Electrolyte	KOH	Perfluoro sulfonic acid (Nafion membrane)	Perfluoro sulfonic acid (Nafion membrane)	H_3PO_4 immobilized in SiC matrix	Li_2CO_3-K_2CO_3 eutectic mixture immobilized in γ-$LiAlO_2$	YSZ (yttria stabilized zirconia)
Electrode materials	Anode: Ni Cathode: Ag	Anode: Pt, PtRu Cathode: Pt	Anode: Pt, PtRu Cathode: Pt	Anode: Pt, PtRu Cathode: Pt	Anode: Ni-5Cr Cathode: NiO(Li)	Anode: Ni-YSZ Cathode: lanthanum strontium manganite (LSM)
Applications	Transportation Space, Military Energy storage systems			Combined heat and power for decentralized stationary power systems	Combined heat and power for stationary decentralized systems and for transportation (trains, boats etc.)	
Realised Power	Small-medium sized plants 50 kW-11 MW	Small plants 0,5-400 kW modular	Small plants < 5 kW	Medium sized plants >11MW	Small power plants 100 kW-2MW	Small power plants 100-250 kW
Lifetime	Not available	60,000-80,000 h	1,000 h	30,000 – 60,000 h	20,000 – 30,000 h	90,000 h
Investment Cost [€]	200-700/kW	3000-4000/kW	>10000/kW	4000-5000/kW	4000-6000/kW	3000-4000/kW

1 GENERAL ASPECTS

MAIN FUEL CELLS PRODUCED

PEM AND SOFC

- Most researched
- Versatile
- Massively produced



2 PEM AND SOFC FUEL CELL

POLYMER ELECTROLYTE MEMBRANE

Fuel Cell Type	Advantages	Disadvantages
Proton Exchange Membrane (PEMFC)	High power densities, proven long operating life, adoption by automakers.	Lack of CO tolerance, water and heat management, expensive catalyst.

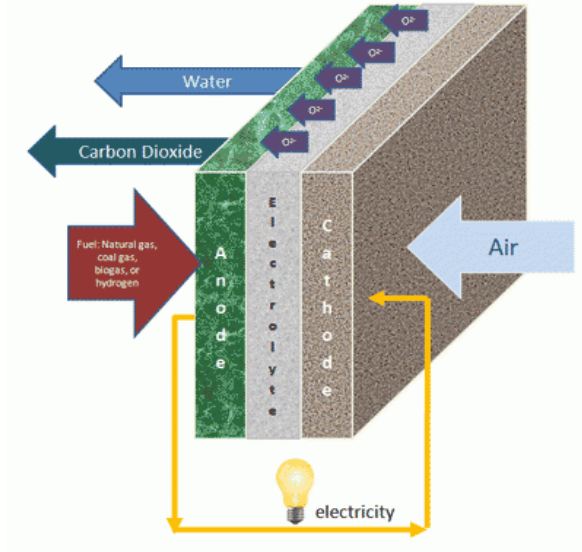
SOLID OXIDE

Fuel Cell Type	Advantages	Disadvantages
Solid Oxide (SOFC)	high efficiency, internal fuel processing, high grade waste heat.	High operating temperature (materials), High cost.

3 IMPROVEMENTS

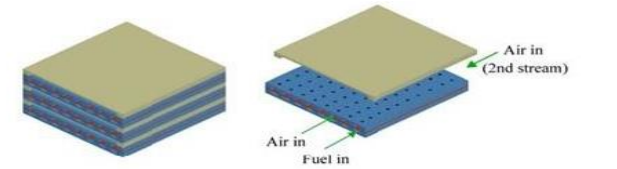
PEMFC

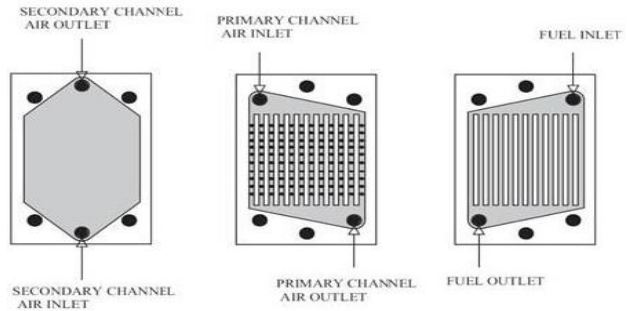
- Catalyst Cost Reduction
- Cell Temperature Range Control
- New Developments in the Low Temperature PEMs



SOFC

- Pore size optimization in anodes
- Planar SOFC Thermal Management
- New Materials





Conclusion

Efficiency improvement of FC →  → Next source of power

Improvement → Analysis → Advantages and disadvantages → 

- Temperature
- Materials
- Catalysts

Upgrading of energy sources → Ensuring our survival, quality of life and a healthy planet → 

References

1. United Nations, "*The Sustainable Development Goals Report*", 2021. Accessed: May 20, 2022. [Online]. Available: https://unstats.un.org/sdgs/report/2021/The-Sustainable-Development-Goals-Report-2021.pdf
2. R. Busby. *Hydrogen and Fuel Cells: A Comprehensive Guide*, 1st edition. Tulsa, Oklahoma: Penwell, 2005. [Online]. Available: https://archive.org/details/hydrogenfuelcell00rebe/page/n1/mode/2up
3. L. Giorgi and F. Leccese, "Fuel Cells: Technologies and Applications", The Open Fuel Cells J. vol. 6, pp. 1-20, July 2013. Accessed: Sep. 6, 2013. doi:10.2174/1875932720130719001. [Online]. Available: https://benthamopen.com/contents/pdf/TOFCJ/TOFCJ-6-1.pdf
4. V. Cigolotti and M. Genovese, "Stationary Fuel Cell Applications: Current and Future Technologies- Costs, Performances, and Potential", *Advanced Fuel Cells*. Italy: IEA, 2021. Accessed: Aug. 20, 2022. [Online]. Available: https://www.ieafuelcell.com/fileadmin/publications/2021/2021_AFCTCP_Stationary_Application_Performance.pdf
5. Fortune Business Insights, "Direct Methanol Fuel Cell Market Size, Share & Growth [2028]", fortunebusinessinsights.com. https://www.fortunebusinessinsights.com/industry-reports/direct-methanol-fuel-cells-market-100779 (accessed Oct. 1, 2022)
6. V. Cigolotti *et.al*, "Comprehensive Review on Fuel Cell Technology for Stationary Applications as Sustainable and Efficient Poly-Generation Energy Systems", *Energies*, vol.14, no. 16, Aug. 2021. Doi: 10.3390/en14164963. Accessed: Aug. 20, 2022. [Online]. Available: https://www.researchgate.net/publication/353896313_Comprehensive_Review_on_Fuel_Cell_Technology_for_Stationary_Applications_as_Sustainable_and_Efficient_Poly-Generation_Energy_System

References

7. I. H. Tawil, F. M. Bsebsu, F. Hareb and A.M. Matook. (2008). Fuel Cells – The Energy Key of Future – Review and Prospective Study. Presented at First Conf. Exhib. Renew. Energ. Water Desalination. [PDF document]. Available: researchgate.net/figure/Fuel-Cell-Type-with-Their-Advantages-and-Disadvantages_tbl1_323401704

8. A. Ghani Olabi et.al, "Novel Trends in Proton Exchange Membrane Fuel Cells", Energies, Jul. 2022. Doi: 10.3390/en15144949. Accessed: Oct. 20, 2022. [Online]. Available: https://www.researchgate.net/publication/361794399_Novel_Trends_in_Proton_Exchange_Membrane_Fuel_Cells

9. A. Parekh, "Recent Developments of Proton Exchange Membranes for PEMFC: A Review", Frontiers in Energy Research, Sep. 2022. Doi: 10.3389/fenrg.2022.956132. Accessed: Oct. 21, 2022. [Online]. Available: https://www.frontiersin.org/articles/10.3389/fenrg.2022.956132/full

10. K. Ahmed, P. Vijay, M. Tadé, A. Amiri, Z. Shao and K. Föger,"SOFC Stack and System Modeling, Fault Diagnosis and Control", Journal of Energy and Power Technology. vol. 3, January 2021. Accessed: Jul. 31, 2020. doi: 10.21926/jept.2101004. [Online]. Available: https://www.lidsen.com/journals/jept/jept-03-01-004

11. "Why SOFC Technology", energy.gov. https://www.energy.gov/fecm/why-sofc-technology (accessed Sep. 14, 2022).

Thank you!

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The present presentation is part of the research activities in the Inglés II lesson at Universidad Tecnológica Nacional, Facultad Regional Paraná. Students are asked to research into a topic so as to shed light on a topic of their interest within the National Academy of Engineering's Grand Challenges or the United Nations' Sustainable Development Goals frameworks. If sources have not been well paraphrased or credited, it might be due to students' developing intercultural communicative competence rather than a conscious intention to plagiarize a text. Should the reader have any questions regarding this work, please contact Graciela Yugdar Tófalo, Senior Lecturer, at gyugdar@frp.utn.edu.ar