Membrane filtration as a strategy for seawater desalination as a resource for water electrolysis and H_2 production

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Background

Rapid Expansion

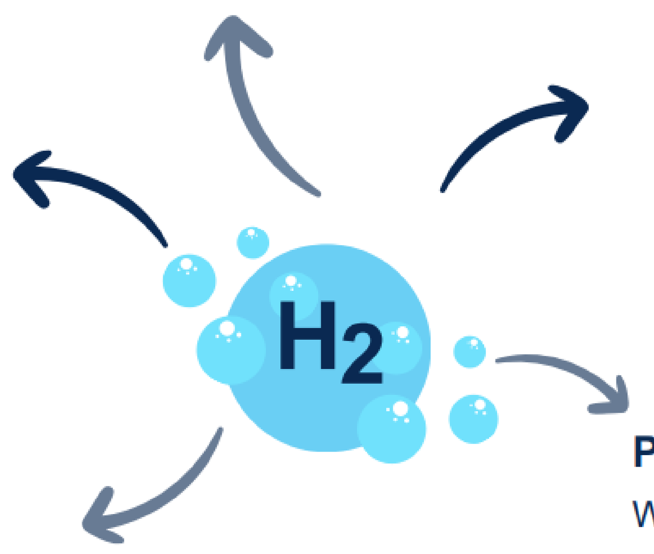
In 2021, the installed electrolysis capacity was three times more than in 2020, reaching 500 MW. The 2030 outlook estimates a total capacity of 134-240 GW.
EU Industrial strategy emphasizes the importance of abundant, accessible, and affordable low-carbon energy

EU Hydrogen Strategy

Hydrogen is an essential energy carrier in the EU plan to accelerate energy transition and decarbonize hard-to-abate industries

Challenges

- Lack of dedicated infrastructure
- High production costs. Green hydrogen = 2-3 times grey hydrogen costs (2019)
- Energy losses throughout the value chain
- High price of metals: nickel (3.5% of the total cost), iridium, and platinum (12% of the total cost)
- **Water sources accessibility**



Clean Energy Generation

Green hydrogen production via water electrolysis powered by renewable sources (e.g., solar or wind) contributes to a zero-carbon future by reducing greenhouse gas (GHG) emissions

Potential Water Sources

Wastewater, groundwater, tap water, **SEAWATER**, surface water, rain water, air

Most electrolysers in the market require high purity water.
WATER TREATMENT

Figure 1. Hydrogen: A promising solution for decarbonization and Europe's commitment to sustainable energy [1], [2], [3]

Role of Membrane Technologies

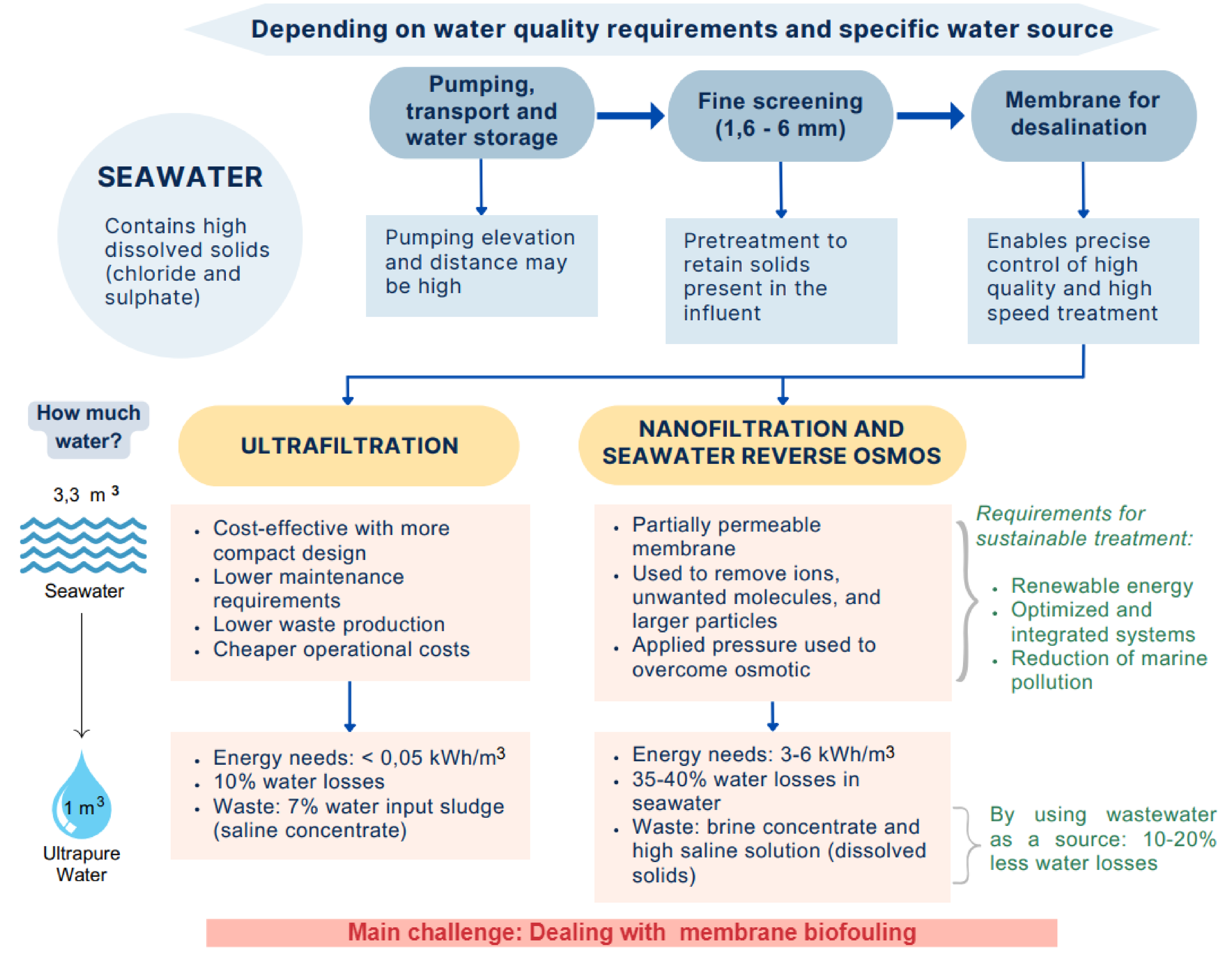


Figure 3. Seawater desalination for water electrolysis [8], [9], [10], [11], [12]

Water Electrolysis

A process that involves separating hydrogen and oxygen from water molecules by applying an electrical current.

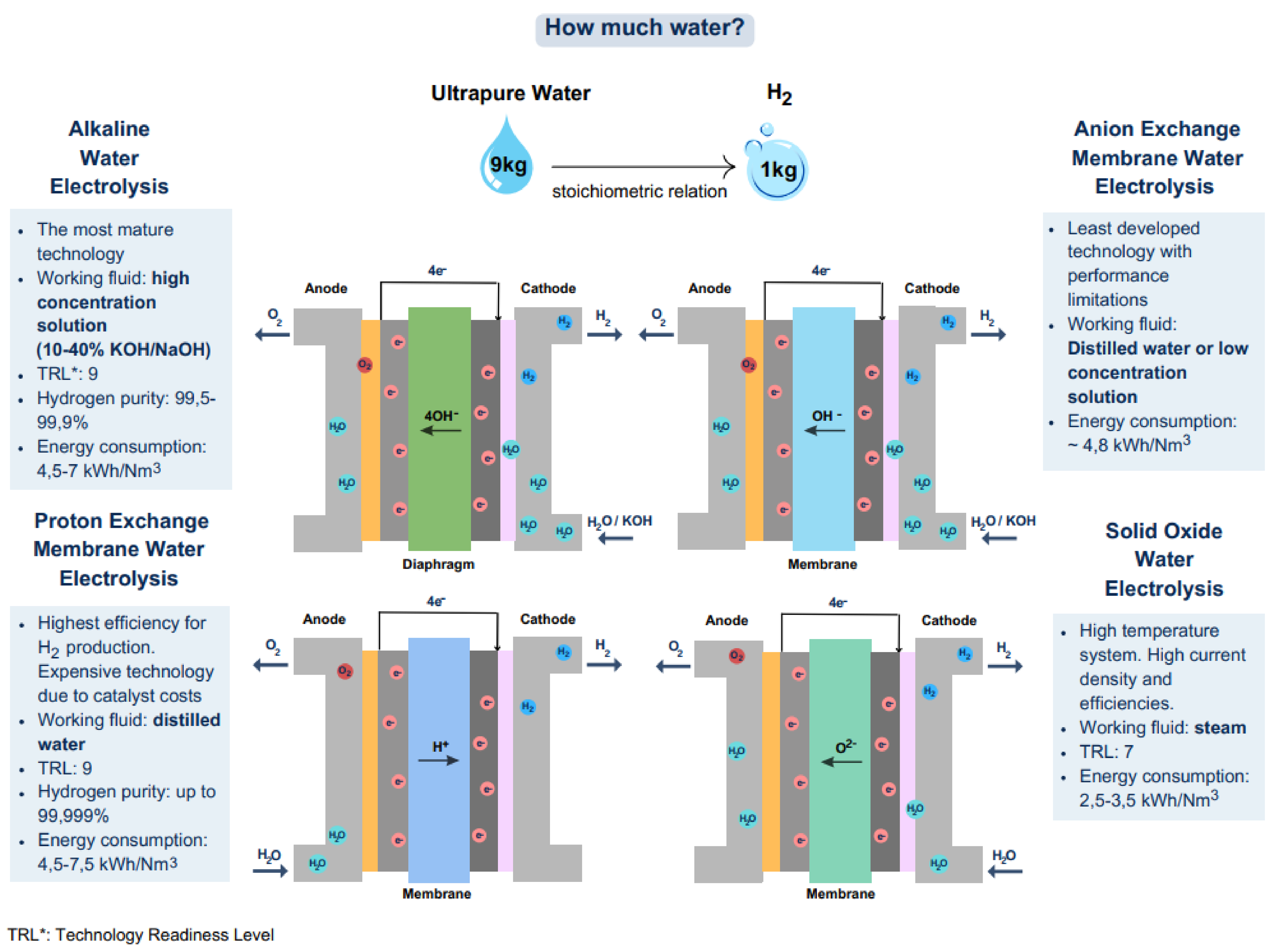


Figure 2. Four leading water electrolysis technologies and water purity requirements [4], [5], [6] ,[7]

Overall, water electrolysis requires deionized water Type I or Type II, as defined by the American Society for Testing Materials (ASTM) [8]. Water quality should also be measured in Total Silica, Total Organics, and Total Carbon for proper application assessment.

Summary / Outlook

Hydrogen production via water electrolysis is one of the most sustainable and efficient pathways to global decarbonization. It is rapidly scaling up, and with this, the resources consumption. Membrane-based seawater desalination is a low-impact of cost and well-established technology.

Different factors must be considered:

- **Water loss and waste generation related to water salinity levels**
- **In water-stress regions competition with other uses (agriculture and human consumption)**
- **Short-term and long-term reliability considering weather factors (e.g., droughts, climate change impact)**
- **Complexity of water collection and transport from water source to H_2 production point**
- **Energy consumption depends on the required number of unitary operations**
- **Renewable energy can contribute to a more sustainable system in both: water treatment and water electrolysis**

Membrane desalination technologies constitute a viable water source for electrolysis, mainly when renewable energy is available. Nonetheless, exploring alternatives such as treated urban and industrial wastewater can offer benefits such as reduced water loss, waste, and energy requirements.

References

[1] International Energy Agency, I. (2022). Global Hydrogen Review 2022. www.iea.org/t&c/
[2] IRENA (2021), Making the breakthrough: Green hydrogen policies and technology costs, International Renewable Energy Agency, Abu Dhabi. ISBN 978-92-9260-314-4
[3] Simoes, S. G., Catarino, J., Picado, A., Lopes, T. F., di Berardino, S., Amorim, F., Gírio, F., Rangel, C. M., & Ponce de Leão, T. (2021). Water availability and water usage solutions for electrolysis in hydrogen production. Journal of Cleaner Production, 315. https://doi.org/10.1016/j.jclepro.2021.128124
[4] Nasser, M., Megahed, T.F., Ookawara, S. *et al.* A review of water electrolysis–based systems for hydrogen production using hybrid/solar/wind energy systems. *Environ Sci Pollut Res* 29, 86994–87018 (2022). https://doi.org/10.1007/s11356-022-23323-y
[5] International Renewable Energy Agency, T. (2020). GREEN HYDROGEN COST REDUCTION SCALING UP ELECTROLYSERS TO MEET THE 1.5°C CLIMATE GOAL H 2 O 2. www.irena.org/publications
[6] Lamb, J. J., Hillestad, M., Rytter, E., Bock, R., Nordgård, A. S. R., Lien, K. M., Burheim, O. S., & Pollet, B. G. (2020). Traditional Routes for Hydrogen Production and Carbon Conversion. In Hydrogen, Biomass and Bioenergy (pp. 21–53). Elsevier. https://doi.org/10.1016/b978-0-08-102629-8.00003-7
[7] S. Shiva Kumar, Hankwon Lim, An overview of water electrolysis technologies for green hydrogen production, Energy Reports, Volume 8, 2022, Pages 13793-13813, https://doi.org/10.1016/j.egyr.2022.10.127
[8] Y.A.C. Jande, M.B. Minhas & W.S. Kim (2015) Ultrapure water from seawater using integrated reverse osmosis-capacitive deionization system, Desalination and Water Treatment, 53:13, 3482-3490, DOI: 10.1080/19443994.2013.873352
[9] European Commission, 2020a. COM (2020) 299 final communication from the commission to the European parliament, the council, the European Economic and social committee and the committee of the regions. Powering a climate-neutral economy: an EU strategy for energy system integration. Brussels, 8th July 2020. Available a. https://ec.europa.eu/energy/sites/ener/files/energy_system_integratio n_strategy_.pdf. European Commission,
[10] Abushawish A, Bouaziz I, Almanassra IW, AL-Rajabi MM, Jaber L, Khalil AKA, Takriff MS, Laoui T, Shanableh A, Atieh MA, et al. Desalination Pretreatment Technologies: Current Status and Future Developments. *Water*. 2023; 15(8):1572. https://doi.org/10.3390/w15081572
[11] Masaru Kurihara and Hiromu Takeuchi. Current Status and Future Trend of Seawater Desalination on Membrane Technology and Biotechnology as Sustainable Green Desalination in the 21st Century[J]. General Chemistry, 2022, 8(1-2): 210016-210016.
[12] Madsen, H. T. (2022). Water treatment for green hydrogen WHAT YOU NEED TO KNOW. Eurowater.

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