A Review of Environmental, Economic, and Application Aspects of Green Hydrogen Production Technologies

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Table S1: Various H_2 production methods with their advantages and disadvantages, system efficiency, operating temperature, energy efficiency, and H_2 production cost (Anwar et al., 2021)

Production method	Advantages	Disadvantages	Temperature range (°C)	Efficiency (%)	Estimated cost (US$.kg^{-1})	Ref
Steam methane reforming (SMR)	• Conventional method • Developed infrastructure	• CO and CO_2 emissions • Unstable supply	700-1000	74-85	2.27	(Ahmed et al., 2016; Chi & Yu, 2018; Pinsky et al., 2020)
Gasification of solid fuel (Coal)	• Inexpensive feedstock • Abundant in nature • Neutral CO_2	• Inconsistent H_2 production • Formation of tar • Generation of heavy oil	700-1000	60-75	1.48	(Chi & Yu, 2018; Pinsky et al., 2020)
Biomass process	• Inexpensive • Renewable source dependent	• H_2 production depends on the season. • Unclean H_2 due to CH_4 as a byproduct	800-1000	35-50	1.8-2.05	(Chi & Yu, 2018; Pinsky et al., 2020)
Water electrolysis	• Conventional technology • Eco-friendly • No carbon footprint • Low energy requirement • Useful O_2 as an additional product	• Storage problems • Shipping issues • Applicable only for a specific purpose	500-1000+	60-80	10.30	(Anwar et al., 2021; Chi & Yu, 2018; Pinsky et al., 2020)
Solar energy	• Abundant energy source	• Variation in the intensity of solar radiation	200-2000	20	10-30	(VEZIROGLU, 2002)
Nuclear energy	• Carbon free • Sustainable	• Uncertain future • Depend on the mining of uranium	300-950	45-50	4.5-7	(Balat & Balat, 2009; Chi & Yu, 2018; Pinsky et al., 2020)
Wind energy	• Pollution free • Reduction of GHG emissions	• Prone to global climate change • Fluctuation issues due to the variability of wind energy	---	21	7-11	(Anwar et al., 2021; Chi & Yu, 2018; Pinsky et al., 2020)

Table S2: Calculation of the H_2 production cost based on the various options. A study conducted by Achour et al. (2023)

Case No	Total chemical and utility cost (US$/hr)	Total chemical and utility cost (US$/d)	Electricity cost (US$/kW/h)	Hydrogen production (kg/hr)	Total electricity cost	Total energy required (kW/hr)	Electricity cost of producing 1 kg H_2 (US$/hr)	Desalination cost (US$/kg H_2)	Total cost (US$/kg)
First option									
Case 03	0.368	8.84	0.06	22.12	69.69	1010	3.149	0.028	3.51
Case 15	0.384	9.22	0.06	22.12	69.69	1010	3.149	0.029	3.53
Second option									
Case 03	0.368	8.84	0.104	22.12	105.04	1010	4.747	0.034	5.11
Case 15	0.384	9.22	0.104	22.12	105.04	1010	4.747	0.035	5.13
Third option									
Case 03	0.368	8.84	0.168	22.12	169.68	1010	7.669	0.051	7.720
Case 15	0.384	9.22	0.168	22.12	169.68	1010	7.669	0.052	7.721

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