Anion–Exchange Membrane Water Electrolyzers and Fuel Cells

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2. H_2 for AEM water electrolyzers and fuel cells

2.1 H_2 production involving AEM water electrolyzers

By producing 1 kg of H_2 through water electrolysis, approximately 9 kg of water as well as at least 48.75 kWh of electricity (calculated with 80% efficiency) are required.[1, 2] If the global demand for H_2 was produced via water electrolysis today, an estimated 3.6 million gigawatts (GW) of electricity and billion tons of freshwater are required. The huge amount of water supply will not be a limitation for water electrolysis while the tremendous electricity demand will raise a great challenge and offer an opportunity for the present renewable electricity industry.[3, 4] The year 2020 witnessed an increase of 260 GW from renewables compared with 2019, and the worldwide total renewable energy has reached more than 2799 GW. Among them, hydropower (47.6%), wind energy (onshore and offshore, 26.2%), and photovoltaic (PV) solar energy (25.5%) account for 99.3% of global renewables. China, the US, Brazil, India, Germany, Japan, Canada, Spain, France, and Italy are the top ten renewable resource producers, and their energy capacity hits 894.8, 292.0, 150.0, 134.2, 131.7, 101.4, 101.2, 59.1, 55.3, and 55.2 GW, respectively. So far, hydropower is still the largest component of renewables, but its share has decreased from 79% in 2011 to 47.6% in 2020. Conversely, the relative renewable contributions of PV solar energy and wind energy increased from 5% and 16% in 2011 to 25.5% and 26.2% in 2020, respectively. Considering the tremendous electricity consumption involved in producing green hydrogen, the reliability and cost-effectiveness of renewable electricity directly determine the scale and price of green hydrogen.[5, 6] Taking H_2 production via PV electrolysis system as an example, the overall H_2 production cost mainly consists of the expenses for components such as the electrolyzer stack, photovoltaic modules, wiring, converter, rectifier, panel mounting materials, labor, daily maintenance, etc.[7, 8]

The newly installed electrolyzer capacity is projected to reach over 54 GW by 2030, and it will be mainly distributed in Asia, Europe, Australia, the United States, etc. Notably, the average project size is expected to increase from 0.6 MW in 2020 to approximately 3,000 MW in 2028, when the average cost of hydrogen production will be significantly reduced. In 2020, the alkaline electrolyzer (61%) and the PEM water electrolyzer (31%) are the two most common types of newly installed electrolyzer technologies. The installed capacity of AEM water electrolysis is very small, although it is a very promising technology. Enapter (Germany) is a great example of commercialization of AEM electrolyzers and has committed to developing kW– and MW–scale AEM electrolyzer systems.[9, 10]

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