PHOTOVOLTAIC CELL–WATER ELECTROLYSIS SYSTEM

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Contents

Summary

The combination of photovoltaic cell (PV) and water electrolysis is discussed, especially the special requirements for electrolyzers to be combined with the PV system.

1. Introduction

The PV–water electrolysis system is a combination of photovoltaic cells (PV) and water electrolyzers. Solar energy is one of the most promising renewable energy sources because of its abundance, and the photovoltaic cell system is becoming the major way to utilize it. The problem of the PV system is intermittence and fluctuation of output. As well as its inevitable shutdown at night, the PV system changes its output according to the weather conditions.

To compensate for this problem, an energy storage system is indispensable. There is also the need to transport energy, since the area with abundant solar energy is often far from the demand site. Hydrogen is regarded as a good means of storage and transportation of solar energy. The easiest way of using hydrogen for storage is making hydrogen by water electrolysis. This is why the PV–water electrolysis system has been developed. This seems to be quite a simple system, involving only the combination of an electric generation system and electrolyzers. But looking into the technical detail, there need to be some special technologies for this special purpose. In this article, only these points are discussed. The PV system, water electrolysis, and storage systems are described in other articles in this encyclopedia.

2. Total System

In this section, several ways of combining a PV system and a water electrolyzer are discussed.

2.1 Direct Coupling

As shown in Figure 1a, the output of a PV system is directly connected to a water electrolyzer. This is the minimum configuration and quite a simple system, but there are some problems.

Precise matching between PV and electrolyzer is required.

As shown in Figures 2 and 3, a PV system and an electrolyzer have different patterns of voltage–current curve for their operation. A PV system has a special combination of voltage and current for optimum output power and this maximum power point (MPP) changes according to the insolation, the incoming radiation energy from the sun. The voltage and current of the system must be decided to match PV and electrolyzers so that PV works at MPP. But even with this matching, when the insolation changes from the design point, the system operates outside the MPP and this causes power loss.

Loss of efficiency and cost increase as a result of differences of optimum design specification for PV and electrolyzer.

The PV system should operate at high voltage and low current to reduce ohmic loss and wiring cost of electric transmission. Since the ohmic loss is proportional to the current, this loss can be reduced by using high voltage–low current operation. The PV system often occupies a large area, and the electric transmission line can be long. In contrast, a water electrolyzer for this purpose operates at higher efficiency when built for low voltage operation, namely larger cell area with smaller number of cells. The requirements of electrolyzers are described in Section 3.

To allow high current transmission for a long distance makes the construction cost of electric wiring very high. Because of this difference of optimum design, a direct coupling system has lower efficiency than coupling through DC–DC converters. Therefore, direct coupling is suitable for a system where simplicity is strongly required.

2.2 Coupling through a DC–DC Converter

As shown in Figure 1b, PV and electrolyzers are connected through DC–DC converters. A DC–DC converter is a solid-state system that converts the voltage level, and therefore current level, of direct current (DC) just like a transformer for alternating current. By connecting the PV system and electrolyzers through DC–DC converters, as shown in Figure 1b, additional freedom in designing a PV–electrolysis system is acquired. By using DC–DC converters, PVs and electrolyzers can operate at different voltage. Therefore both PVs and electrolyzers can be designed to operate at their most efficient voltage. MPP tracking is also possible; the operating voltage of PVs is decided so that the maximum power can be derived from the solar radiation.

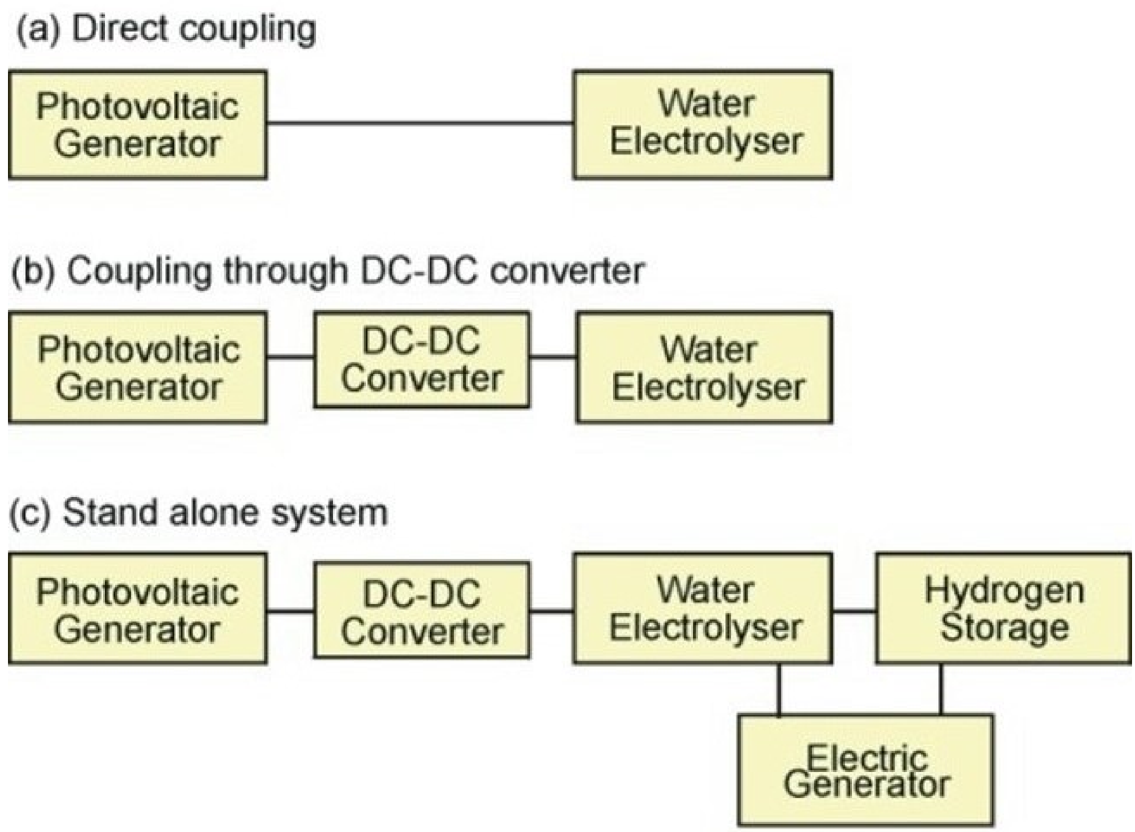

Figure 1. Coupling PV and water electrolysis.

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Biographical Sketch

Isao Abe, born September 16, 1939, in Osaka, Japan, received his Bachelor of Engineering degree from the Department of Fuel Engineering, Faculty of Engineering, University of Tokyo (1963), and Master of Engineering from the Department of Reaction Chemistry of the same faculty, the same university (1966). He worked for Showa Denko K.K. as a chemical engineer (1966–1999), and was involved in development of the advanced alkaline water electrolyzer under the Sunshine Project of the Japanese government as the director of technical development (1974–1984); during that period, he worked as formal alternate representative of Japan to the IEA Task IV (water electrolysis) workshop. He has been editor-in-chief of *Journal of the Hydrogen Energy System Society of Japan* since 1998.