Technical Publication

Green Hydrogen (H2) From Renewables Using PEM Fuel Cells Relies on Accurate Liquid/Air Flow Monitoring Switches

By Richard Koeken, Applications Engineer, and Florian Stahl, Product Manager,
Fluid Components International (FCI)

FLUID COMPONENTS INTERNATIONAL LLC
A PST BRAND

Visit FCI online at www.FluidComponents.com | FCI is ISO 9001 and AS9100 Certified

FCI World Headquarters
1755 La Costa Meadows Drive | San Marcos, California 92078 USA
Phone: 760-744-6950 **Toll Free (US):** 800-854-1993 **Fax:** 760-736-6250

FCI Europe
Persephonestraat 3-01 | 5047 TT Tilburg, The Netherlands | **Phone:** 31-13-5159989 **Fax:** 31-13-5799036

FCI Measurement and Control Technology (Beijing) Co., LTD
Room 142, Building 11, Zhongguancun Software Park, Haidian District | Beijing 100193, P. R. China
Phone: 86-10-58985520

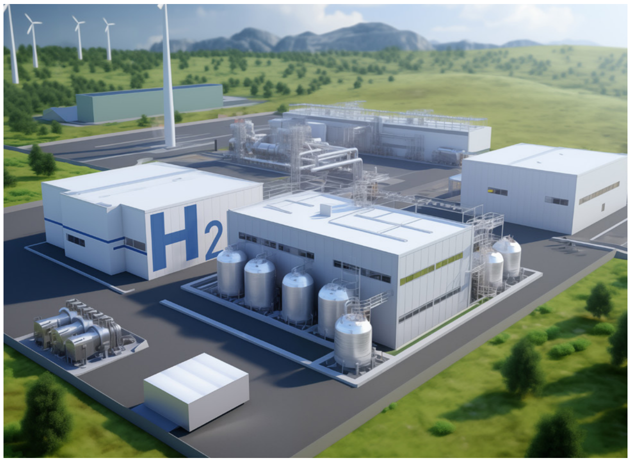

Fig. 1: H2 PEM Electrolyzer Power Plant

The design engineers at a European industrial equipment firm recognized early that their turnkey solution for a green hydrogen (H2) proton exchange membrane (PEM) fuel cell electrolyzer would require accurate liquid and air flow monitoring/switching instruments. Their compact, complex equipment would be required to produce enough green H2 from renewable energy resources for blending into existing natural gas grids.

The conversion of surplus wind power and solar energy into green H2 gas using PEM electrolyzer stack units is becoming increasingly popular around the globe. At both wind and solar electric power plants, green H2 is produced, fed and blended into the existing natural gas network or piped to large tank storage tank stations for later use as needed (Figure 1).

Producing green H2 energy requires pure water and renewable electric energy such as wind or solar and a PEM electrolyzer. When H2 is produced with 100 percent renewable electricity, green hydrogen makes an important contribution to reducing the carbon dioxide (CO2) emissions that are considered by many to be the primary cause of global warming.

Many countries have international long-term CO2 emission reduction goals that cannot be achieved with blue or grey hydrogen alone, which are produced using conventional fossil fuels. Green H2 gas generated from surplus renewable energy resources can be utilized by many industries in multiple applications that include:

H2 energy storage helps to balance the electric power grid when renewable energy is unavailable. Surplus electricity converted to green H2 gas can be stored conveniently over a long periods of time in tanks and then accessed again later on when renewables aren't available or sufficient (e.g. night time or windless days or peak demand periods for HVAC systems).

Green H2 will also help with the **decarbonization of industrial processes**: Producing raw materials and goods requires large amounts of fossil fueled conventional electric or gas energy, and green H2 can reduce/improve the CO2 balance of these processes in many industries (e.g., glass, cement or steel production).

Large district energy heating systems are possible with green H2 cogeneration. The PEM electrolysis process not only produces H2, but cogeneration heat is also a valuable byproduct (55°C, 131°F) that can be fed into large commercial or campus district heating networks or even into large multi-unit municipal residences.

Mixing captured CO2 emissions and H2 also produces high-quality **syngas for industrial applications**. Using this lower carbon content syngas can help refineries produce the major building blocks for chemicals, polymers or synthetic fuels.

The Challenge

All the processes to produce green, blue or grey H2 and all its many industrial and commercial applications have one thing in common: They depend on the accurate monitoring of liquids, air and gases under rugged conditions that often include high/low pressure variability (turndowns) and/or demanding temperatures, corrosive materials and explosive environments that can jeopardize safety during production, storage, transportation and application.

Hydrogen is a colorless, odorless, tasteless gas, which is undetectable by the human senses. With a small molecular size, H2 can leak relatively easily and can be spread quickly by wind or ventilation systems. When an accident occurs, H2 fed fires can spread rapidly with terrible consequences for nearby workers and plant facilities, as well as potential damage to nearby communities.

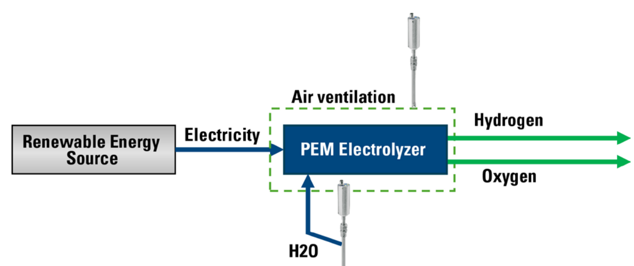

Fig. 2: PEM Electrolyzer

The preferred electrolysis technology to convert surplus wind or solar renewable energy into hydrogen is the PEM method (Figure 2). PEM fuel cells allow the electrolyzer to be operated at a dynamic partial load (compensating for the load fluctuations of the available renewable energy). Additionally, the PEM electrolysis method does not require aggressive chemicals or liquid electrolytes and produces high-purity H2 that can be used directly for re-fueling of systems and vehicles.

The engineering design/production firm's turnkey equipment solution included all pipe work, measurements, ventilation, the PEM electrolyzer and other utilities placed inside a compact stack container that can be installed next to an existing wind farm or solar power plant.

First, the engineers responsible for the design of the PEM Electrolyzer Stack unit identified several areas in the process that would require the monitoring and switching of liquids and air/gases. Each stack system would require one flow monitor/switch to monitor the deionized water flow at the water inlet point into the PEM electrolyzer and provide an alarm if the flow rate dropped below a pre-set flow switch point.

If the water flow were to drop below the pre-set flow rate, the efficiency of the electrolyzer would be compromised and there is a possibility of hazardous gases building up and creating an unsafe condition. Therefore, the engineers knew it was essential that the flow monitor/switch instrument specified for safeguarding the deionized water flow into the electrolyzer must have SIL 2 compliance and be ATEX Zone 2 certified.

Second, the engineers determined that two flow monitors/switches were needed to ensure the continuous flow of ventilation air into the container above a pre-set flow rate and an alarm must be provided when the flow drops below this point. Due to the possibility of H2 gas collecting inside the container and/or in the case of a gas leak, the engineers required that the air/gas instrument safeguarding the ventilation air flow must have SIL 2 compliance and ATEX Zone 2 certified.

The Solution

With these instrumentation requirements set, the PEM Electrolyzer equipment engineers contacted a local manufacturers' representative Ekomat for discussions about the project. The Ekomat team contacted thermal flow switch manufacturer Fluid Components International (FCI) to discuss the project's flow monitor/switch requirements.

In order to meet the requirements, the FCI applications engineering team recommended its thermal technology FS10i

Fig 3: FS10i Flow Switch

Flow Switch (Figure 3). This instrument's trend analog output (SIL 2 compliant) and relay output (SIL 1 compliant) offered the most accurate liquid/gas flow switch monitoring suitable for the stringent demands of this operating environment.

The engineers designing the PEM Electrolyzer agreed the FS10i Flow Switch met both their measurement and safety requirements. They were impressed by other features of this flow switch that included: a standard design for both deionized water and ventilation air monitoring, flexible installation and easy set-up with FCI's FS10 software including field calibration that allowed for a shorter pipe installation length and ATEX Zone 2 certification even though IP64 certification was sufficient because these instruments are installed inside a container.

The FS10i Switch's flow sensitivity (setpoint range) in liquids is from 0,003 to 0,15 MPS (0.01 to 0.5 FPS) and in air or gases is from 0,076 to122 MPS (0.25 to 400 SFPS). Its standard 1A relay trip point is easily set in the field for low or high trip point and the trip and reset points can be further tuned with hysteresis and time delay adjustments.

Also provided standard with the FS10i Switch is a 4- 20mA trending output of the flow rate for connection to ancillary controls or alarm systems. The FS10i Switch includes a 10-LED array for both an indication that the trip point has been exceeded (LED flashes on/off) and of relative flow rate (10 percent increments) across the flow range.

This versatile switch provides best-in-class features for installation in rugged duty and long-life in industrial plants, process and large buildings. Its flow sensor's thermowells are constructed of highly corrosion resistant Hastelloy C-22, and it will operate in fluid temperatures up to121°C (250°F) with an IP protection rating to IP67. It is the only flow switch in its price range to carry a SIL 2 compliance rating on the 4-20mA flow monitoring output and SIL 1 compliance on the alarm relay. It has no moving parts to clog and requires no routine maintenance, which saves technician time and expense over any mechanical-technology based flow switch.

To ensure best performance and installation ease, the FS10i Switch is available in a choice of flow element lengths (insertion depth) and process connections: a 50 mm (2-inch) length with a 0.25-inch NPT fixed threaded connection or a 150 mm (6 inch) length, variable depth, with 0.5 inch NPT compression fitting with either a Teflon or metal ferrule.

The FS10i is the only product in its class to carry a SIL 2 compliance rating with a 90% Safe Failure Fraction (SFF). The FS10i also carries global approvals: ATEX, CE, CRN, FM, FMc, IECEx and EAC/TR CU pending. Optional global agency approvals are also available for installation in Division 2/Zone 2 locations.

Conclusions

FCI initially supplied trial units of the FS10i Flow Switch for field evaluation by the equipment engineering team, which was pleased with the trial. FCI FS10i units were then ordered for installation into the first PEM Electrolyzer unit. To date, there have been no issues with the FS10i Flow Switches, which continue to perform flawlessly in this application.

The PEM Electrolyzer equipment firm has informed both the teams at Ekomat and FCI that it is expecting to ramp up production of the PEM Electrolyzers over the next several years. The demand for green H2 is growing as part of electric energy decarbonization efforts around the globe, which will speed the adoption of green H2 PEM Electrolyzer technologies and systems. ■