SIEMENS

Background Information

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“Green” hydrogen offers wide-ranging perspectives for a sustainable future

Against the backdrop of ever scarcer resources, the sustainable generation of power is becoming an ever more pressing issue worldwide. One of the aims of expanding our use of renewable energy sources is to make a marked reduction in carbon emissions. One of the challenges we face is to find a way of storing surplus wind and solar power and reintroducing it to the grid when needed. Siemens has developed a PEM (Proton Exchange Membrane) technology which enables large quantities of energy to be captured and stored by transforming electrical energy into hydrogen. The electrolysis system has already been successfully tested by Siemens’ partner RWE, and continues to be further developed by Siemens. The hydrogen produced using this method can be put to use in many ways, for example as a valuable material for use in industry, as a fuel for mobility and as an energy carrier in the supply of electricity and gas.

As the generation of power from renewable energy sources is highly susceptible to fluctuations, finding a way of absorbing the occurring energy peaks is vital. In future, dynamic performance and flexibility will be particularly important attributes, as plants will need to respond with extreme speed and reliability to fluctuating power generation levels if they are to make optimum use of the available energy and at the same time contribute towards ensuring a stable grid. This prompted Siemens to develop an electrolysis technology which offers a range of benefits compared to conventional alkaline methods: The PEM electrolyzers are suitable for high current densities and are capable of responding to the extreme fluctuations in power production from wind and solar power plants within just milliseconds. A proton-exchange membrane (PEM) acts as the electrolyte, separating the areas in which oxygen and hydrogen are created. Electrodes made of precious metal are attached to the front and back of the membrane, which are connected to the plus and minus

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pole of the voltage source, and it is here that the water separation takes place. By using membrane technology, the PEM electrolyzers are also capable of being temporarily operated in the overload range. “Alongside their highly dynamic response, the new electrolyzers also offer the benefit that they don’t need to be kept at a certain operating temperature, but can be completely switched off and require no pre-warming phase prior to switching on. This makes for a considerable saving of operating costs in stand-by, and enables efficient, reliable operation without residues such as potassium hydroxide caustic potash”, explains Gaelle Hotellier, Head of the Hydrogen Solutions business segment at Siemens AG. The PEM electrolyzers also deliver hydrogen at a pressure up to 35 bar. This eliminates the need to bring it up to higher pressure to allow further processing or storage, saving the need to invest in compressors.

Hydrogen as a valuable resource – how customers benefit

The hydrogen recovered using electrolysis offers a wide range of benefits and multiple uses. Surplus eco-electricity can be used to produce hydrogen which can be stored in the form of an energy carrier, for instance in underground storage facilities. As demand grows, the energy-rich gas could be used to drive turbines and produce electricity which is then fed into the grid (“reconversion to electricity”). As Hotellier explains, the PEM electrolyzer lends itself ideally to use as a dynamic balancing component to compensate for fluctuations in the grid. “This makes the electrolyzer a strategic key component for energy suppliers, grid operators and renewable energy providers”.

Hydrogen can also be used as a material in industrial processes, for instance in the production of fertilizers, as a building block in the chemical industry, in the food industry to harden fats or for copper production. Around the world, over 500 billion cubic meters of hydrogen are used every year, of which to date over 95 percent are produced using a carbon-heavy gas reforming process. This can be substituted by hydrogen produced from electrolysis with all the accompanying benefits to the emission balance of industrial processes. Another application is direct utilization in fuel cells for all kinds of vehicles.

In addition, if electrolysis is performed using electrical energy from regenerative sources, hydrogen production can be made practically climate neutral. “We have succeeded in providing ‘green hydrogen’ which can not only contribute towards the

prevention of any appreciable carbon emissions, but is also available as a carbon-free fuel for mobility applications," explains Hotellier.

Pioneering technology already in application

The PEM technology pioneered by Siemens has now reached such a stage of maturity that it is already being used in practice. Using a practical containerized design, the first generation of PEM systems has a nominal output of 0.1 megawatts (MW) and produces between two and six kilograms of hydrogen an hour. The Simatic PCS 7 is used as a process control system, and other Siemens components such as low and medium-voltage switchgear and DC inverters have also been integrated. "The use of proven technology and many years of technical experience have ensured an electrolysis system which is highly efficient overall, and which guarantees high system availability coupled with low running costs", explains Hotellier. Customers also benefit from the local availability of service engineers around the world.

The first containerized PEM electrolysis systems were delivered in December 2012 as part of the CO2RRECT (CO_2 Reaction using Regenerative Energies and Catalytic Technologies) project to the RWE Research Center in Niederaußem, where RWE tested possibilities for power storage and CO_2 utilization using Siemens PEM technology. The second product line, the SILYZER 200, is currently undergoing final testing prior to its planned market launch later this year. The first commercial plants will then have a rated output in the single-digit MW range. Hotellier continues: "Our aim in the long term is to construct electrolysis parks with an output in the three-digit MW range which are capable of converting surplus electrical power from windparks into hydrogen. For the first time, this will enable large-scale buffer storage and contribute to maintaining a balanced power grid."

Concentration of expertise and innovative drive

To enable PEM technology to be scaled up for future series operation in large industrial plants, the search is on for ways of practical application. To this end, Siemens is working in cooperation with renowned representatives from industry, science and the environmental as well as technological funding sectors.

Siemens became involved in initiatives such as CO2RRECT, a project set up in 2010 in partnership with RWE, Bayer Technology Services and Bayer

MaterialScience as well as a further ten partners. Its remit was to research the possibilities of utilizing carbon dioxide in chemical production, using hydrogen from regenerative sources as the raw material. The project volume was 18 million Euro, with funding of 11 million from Germany's Federal Ministry of Education and Research. The first containerized PEM electrolysis system formed a part of this project. It produced the hydrogen required for the chemical conversion (reduction) of carbon dioxide.

Siemens also joined the "Clean Energy Partnership" (CEP) project in September 2012. The CEP is a collaborative demonstration project involving leading industrial corporations with a view to driving forward the development of hydrogen mobility. Its aims include testing the economy of hydrogen production from regenerative sources in real operation, ensuring fast, safe refuelling, and verifying the viability of efficient hydrogen vehicles in day-to-day operation. The role played by Siemens will be to equip CEP hydrogen refuelling stations with an electrolysis system based on PEM technology. The system will supply "green hydrogen" produced at least 50 percent from regenerative sources for refuelling fuel cell vehicles.

On the European level, Siemens has stepped up its commitment by joining the NEW-IG (New IG - New Energy World Industry Grouping) as a full member. This organization's mission is to speed up the market launch of fuel cells and hydrogen technologies (FCH – Fuel Cell and Hydrogen). Ms. Hotellier has been elected to the Board of the NEW IG, the industry partner of the European Commission and Research Community within the public-private-partnership "Fuel Cell and Hydrogen Joint Undertaking" (FCH JU).

Working in cooperation with Linde and the Rhein-Main University of Applied Sciences, Siemens recently took part in the "Energiepark Mainz" project, whose aim was to manufacture hydrogen through PEM electrolysis primarily for municipal use in industry as a general fuel, and for feeding into the local natural gas grid. It will use surplus energy predominantly from the nearby wind power station in Hechtsheim. The plant operator is the local power utility Stadtwerke Mainz, which is expecting the system to be commissioned this summer. The total cost of implementing the project will come to 17 million Euro, and has been funded with the support of Germany's Federal Ministry of Economics and Technology as part of its "Energy Storage Funding Initiative".

“Hydrogen which can be produced from regenerative energy and stored has the potential to become a key element in the bid to make renewable energies an integral part of modern power generation”, says Hotellier. “With our PEM electrolysis system, we are providing the necessary technological basis to help drive this innovation forward in partnership with others”.

Hydrogen electrolyzer: Detailed view of the PEM stack with its cells and membranes.

This backround information and a picture are available at www.siemens.com/presse/vor-hannover-pk-2015

For more information on hydrogen electrolyzers, please see http://www.industry.siemens.com/topics/global/en/pem-electrolyzer/silyzer/Pages/silyzer.aspx

For more information on CEP, please see http://www.performing-energy.de/index.php?id=3

For more information on NEW-IG, please see http://www.new-ig.eu/

For more information on Energiepark Mainz, please see http://energiepark-mainz.de/

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