SWIRL AND VORTEX METERS WILL AID GREEN HYDROGEN PRODUCTION

The route to net zero will require big changes in the way we generate energy. In this article, David Bowers, Product Manager UK & Ireland Measurement & Analytics, describes how technology innovation is making clean energy possible.

Climate change and pollution in general are major challenges facing the modern world. Much of the unwelcome effects on the environment that we are seeing today are down to an over reliance on fossil fuels in the past. Burning fossil fuels to generate electricity not only produces greenhouse gases such as CO2 and methane, it also leads to elevated levels of gasses such as carbon monoxide and nitrous oxide that are harmful to health.

The COP26 summit in Glasgow encouraged countries to draw up ambitious emissions reduction targets for 2030, and thereafter aiming to reaching net zero carbon emissions by the middle of the century.

Achieving these targets will mean moving to forms of energy that do not rely on carbon emitting fossil fuels, but which are based on renewable sources.

This means that the search is on for an energy source that can offer much of the convenience and ubiquity of fossil fuels, with few or none of their drawbacks.

Some of the major advantages of fossil fuels is that they can be easily stored and transported and so are ready when needed and have a high ratio of energy to volume (energy density). They can be used in a wide range of applications, from large power plants, to district heating schemes, furnaces and boilers for smaller factories, individual houses and in transport. They can also act as a chemical feed stock for industrial processes.

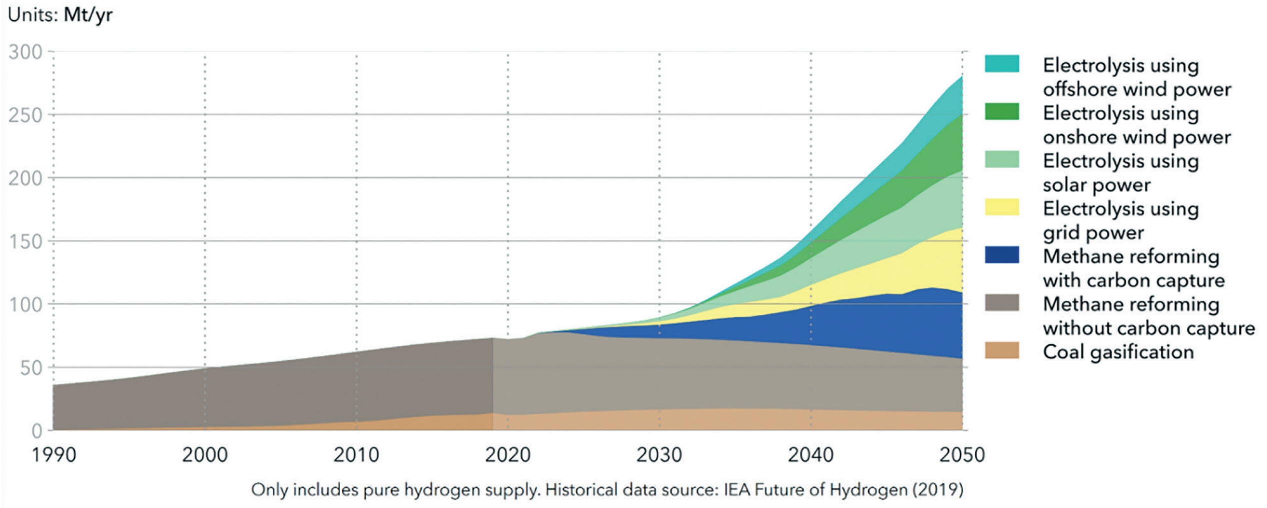

Figure 1: Estimates of hydrogen production from different sources by 2050 (source: IEA)

SwirlMaster

An alternative is renewable sources such as wind and solar. Although these can help reduce emissions, they are intermittent, and it is difficult to store the electricity produced.

Hopes for hydrogen

Hydrogen is considered one of the key fuels to help de-carbonise energy use, as it offers many of the advantages of both fossil fuels and wild and solar – it can be produced with low or zero emissions, can be stored and transported readily, is clean burning (producing only water as a by-product) and can be used in further chemical processing or production.

It can be used as fuel for transport and electricity peaking plants (power plants fired up to meet fluctuating or peak demands of energy demand), while burning hydrogen can also provide heat for many types of industries and both residential and commercial buildings. Hydrogen can also act as a feedstock for chemicals such as fertilizers, fuel refining and plastics.

Although inherently clean, the production method chosen for hydrogen has a big effect on its environmental credentials. In the most polluting method, it can be produced by burning coal, while green hydrogen, the most ecologically friendly type, is produced by electrolysis using renewables or nuclear energy - hydrogen is generally classified as green, grey, blue, brown or white depending on the method used.

If hydrogen is to make a significant contribution to mitigating climate change, most must be in the form of green hydrogen.

The International Energy Agency (IEA) estimates that achieving Net Zero emissions by 2050 will mean that total hydrogen demand from industry will have expanded by 44 percent by 2030 – some 21 million tonnes will be made up of with low carbon hydrogen [1] Some progress has already been made, with nearly 70 MW of electrolysis capacity installed in 2020, doubling the previous year's record. [2]

To encourage the production of green hydrogen, a number of countries have put strategies in place to develop a viable domestic hydrogen sector. Europe is expected to lead the field and in fact already has a number of green hydrogen plants in operation. This will rise through significant government investments and the EU aims to produce 10 million tonnes of renewable hydrogen by 2030 and to import 10 million tonnes by 2030. [3]

In addition to EU ambitions, most European countries also have their own hydrogen strategies, as do Canada, Chile, USA, China, South Korea, Japan, Australia, Saudi Arabia, Qatar, UAE, India and Israel.

Three major green methods

Three main electrolysis methods can be used to produce green hydrogen.

Possibly the most mature and commercial method is alkaline electrolysis. By avoiding the use of precious metals, it has relatively low capital costs compared to other electrolyzer technologies. However, it does a have a significant drawback in that the process is difficult to start up or shut down and output

VortexMaster

cannot be quickly ramped up to meet increasing demand.

Another method is the PEM (Proton Exchange Membrane) electrolyzer. This uses pure water as an electrolyte solution, avoiding the need to recover and recycle the potassium hydroxide electrolyte solution used for alkaline electrolyzers. Plants using the method can be small and so suitable for brownfield urban locations. It can also produce highly compressed hydrogen at between 30–60 bar for decentralised production and storage at refuelling stations.

The third and newest method is Solid Oxide Electrolysis Cells (SOECs). These use ceramics as the electrolyte and have low material costs. They operate at high temperatures and with a high degree of electrical efficiency. As they use steam for the electrolysis process, they also require a heat source.

To make a success of green hydrogen production, there must be accurate and cost-effective methods of measuring parameters, such as flow. To encourage development in the industry, these must be suitable for both brown field sites and greenfield developments.

Managing production

The production of green hydrogen requires a number of analytics and instrumentation stages to measure parameters such as hydrogen purity, pressures, temperatures and flow rates. This starts at the water input to the electrolyzer and the output of hydrogen and continue through to the hydrogen input to the purifier and sending hydrogen for storage or to a distribution grid.

One of the most important measurements is the flow rate of both water, essentially the feedstock of the process, and the produced hydrogen.

Some of the most effective technologies for this are vortex and swirl flow meters.

Vortex flowmeters have become the standard flow measurement method for many industrial process applications, in particular for the measurement of gas and steam flowrates. They are based on the vortex shedding principle, a phenomenon that occurs when a flowing fluid comes up against a bluff obstacle in its path - vortices are alternately forced onto the side of the body and then detached or shed by the flow. The frequency of this vortex shedding is proportional to the mean flow velocity and therefore the volumetric flow. This is read by a piezoelectric detector.

In a swirl meter, a stationary turbine rotor is located in the inlet. The medium to be measured is forced to rotate and flows through the meter tube in a thread like rotation. The rotation velocity at the wall is relatively small and increases towards the tube center until a stable vortex core is formed. In the expanding section of the tube, the vortex core is displaced and forms a secondary rotation, proportional to the flow rate, which is again measured with a piezo-sensor.

Because both types have no moving parts, mechanical stress is eliminated as a cause of failure. This makes the meters much more reliable and able to continue to work for longer without requiring shutting down the process for maintenance.

Vortex meters have the benefits of easy installation and operation, a low price and high accuracy of 0.65 percent of the rate for liquids and 0.95 percent of the rate for gasses and steam. One of their drawbacks is that they require up to 15 times the pipe diameter as a straight stretch pipe of before the meter and up to 50 times the diameter if a valve is upstream of the device. This could be prohibitive if installing them on brown field sites where space may be restricted.

Swirl meters have the lowest installation costs, with far lower pipe length requirements, a large measuring span, and the highest accuracy of 0.5 percent of rate.

The CAPEX for an ABB SwirlMaster for example is higher than a traditional Vortex meter. However, when it comes to cost of ownership, the higher initial cost can turn quickly into significant savings over the lifetime of the meter due to higher accuracy and the savings on pipe runs and associated space requirements.

Many installations will use a mixture of both depending on the layout and access of the particular measurement site. Both types can also have a pressure and temperature capacity added, turning them into mass flow meters.

As hydrogen is a very light gas, with the smallest molecule in nature, hydrogen permeation can be a challenge particularly for pressure measurement applications. The hydrogen can permeate through the metal diaphragm of a pressure transmitter, can collect and become trapped inside the diaphragm, eventually destroying the instruments. ABB has overcome this issue with its unique H-shield technology, an impermeable alloy that prevents penetration by hydrogen molecules.

Measurement made easy

Increasingly, instruments are going digital, which has immense benefits over older analogue based units, including greater accuracy, range and depth of information. Digital technology offers operators and process engineers a highly detailed picture, both of the operating conditions of the process and the status of their measurement equipment.

Much more diagnostics information is available remotely, and an instrument's configuration can also be changed this way. Regular status updates cut maintenance time and costs, ensuring engineers are only deployed as needed. Data allows trends in the electrolysis process to be analyzed and turned into easily readable graphs. Using these, engineers can tell when an event, such as oxygen entering the hydrogen stream, occurred, as well as how changes in parameters could have caused it.

In the near future, many instruments will be connected over Ethernet, making them a node on the Internet and allowing data and commands to be exchanged from anywhere across the globe.

These digital instruments can be tied into a complete management system by ABB Ability SmartMaster, a verification tool suite and condition monitoring platform for use with a range of ABB devices. SmartMaster verifies the condition and performance of an instrument and can generate and store test reports for further analysis. Results can also be compared with historical measurements with a trending function.

Digital solutions such as vortex and swirl meters and verification tools ensure that hydrogen production processes are efficient and based on accurate information, as well as offering cost-effective installation choices – this will encourage the development of green hydrogen plants and help the world meet its targets for net zero.

References:

[1] https://www.iea.org/reports/hydrogen

[2] https://www.iea.org/fuels-and-technologies/hydrogen

[3] https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en#:~:text=The%20ambition%20is%20to%20produce,in%20energy%2Dintensive%20industrial%20processes.

Author Contact Details

David Bowers, Product Manager UK & Ireland Measurement & Analytics • ABB Limited

- Address: Howard Road, Eaton Socon, St Neots, Cambridge PE19 8EU, UK
- Tel: +44 (0)1480 475321 • Email: david.bowers@gb.abb.com
- **Web: www.abb.com/measurement**