SCIENCE

The potential of green hydrogen

Hydrogen gas is a fuel with plenty of potential. But because it is highly combustible, managing it safely is key. Energy utilities firm SP Group has found a way to do this, with hydrogen generated using renewable energy. Its concept lab at Woodleigh Park is now 100 per cent powered by renewable energy.

HOW IT WORKS

1 Solar panels
Sunlight is harnessed and converted into electricity. This electricity is used mainly to power the lights, computers and air-conditioners in the building.

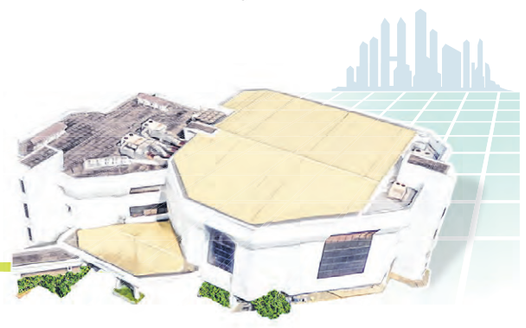
2 Water electrolyser
Excess electricity generated by the solar panels during bright, sunny days is channelled to the water electrolyser. At this stage, electricity is used to drive a chemical process known as electrolysis, which separates water (H_2O) into its two component elements, hydrogen (H) and oxygen (O).
These are collected in gaseous form – hydrogen gas (H_2) and oxygen gas (O_2).

3 Metal hydride storage tanks
The oxygen gas generated in step 2 is discharged into the environment. But the hydrogen gas is stored in metal hydride tanks comprising powder made of a special metal alloy. The hydrogen gas is absorbed by the metal alloy, allowing the gas to be stored safely at low pressure.

4 Fuel cell
When electricity is needed during periods when there is no sunlight, such as at night or during cloudy days, the hydrogen stored in the tanks is converted back into hydrogen gas by heating it with the hot water from the fuel cell. Hydrogen gas is then sent to the fuel cell to combine with oxygen from the atmosphere, to produce electricity and hot water.

ADVANTAGES OF HYDROGEN ENERGY SYSTEM

- Hydrogen gas is generated using a renewable energy source, instead of fossil fuels.
- Hydrogen is stored in a safe way.
- Overcomes challenges such as the intermittency of sunshine, since electricity can be "stored" in the metal hydride tanks.



SP Group's zero emission building

BY THE NUMBERS

The energy consumption of the building is around **2,000kWh** a month

Approximately the monthly consumption of **5** 4-room HDB flats

The indoor floor space of the building is **574 sq m**

It's about the size of a 20-foot container

Source: SP GROUP, GOOGLE MAPS STRAITS TIMES GRAPHICS: LEE HUP KHENG

H is for clean, alternative power

Singapore looking to producing hydrogen the zero-emissions way by tapping solar energy

Audrey Tan
Environment Correspondent

Left: (From far left) SP Group deputy director Lu Yang; Mr Goh Chee Kiong, chief executive of SP Group's new energies business; and SP Group senior engineer Sethu Sundar Pethaiah standing in front of a hydrogen energy system at its concept lab in Woodleigh.

Below: These solar panels are part of SP Group's trial off-grid system, which uses solar energy to charge up a hydrogen fuel cell, an emerging technology that may help Singapore reduce its fossil fuel reliance.
ST PHOTOS: MARCELLIN LOPEZ

As fossil fuels burn to feed the world's hunger for energy, the blanket of greenhouse gases in the atmosphere is thickening.

But as temperatures climb and extreme weather events pummel various parts of the world, nations are starting to realise that greener ways of powering cities and economies are needed.

Renewable energy, such as that from the sun, wind or tides, is a solution that has been widely deployed around the world.

But alternative "clean fuels" such as hydrogen gas have also been gaining attention from the research community, including in Singapore.

THE ADVANTAGES OF HYDROGEN

The main reason hydrogen gas is touted as a "clean" fuel is that it does not produce carbon dioxide when it is burned to produce energy, unlike other forms of fossil fuel.

Carbon dioxide is the main greenhouse gas driving global warming.

Mr Goh Chee Kiong, chief executive of the new energies business at home-grown energy utilities company SP Group, said: "When hydrogen gas is used as a fuel, it produces water and energy."

But for hydrogen to be a truly green fuel, it has to be generated in a way that also produces zero emissions, he said.

Hydrogen is abundant in the environment, but it exists in other forms, such as water and methane.

As the United States Department of Energy explains on the website of its Alternative Fuels Data Centre, "one of the challenges of using hydrogen as a fuel comes from being able to efficiently extract it from these compounds".

For example, hydrogen gas can be extracted through a chemical process known as electrolysis, which involves running an electrical current through water to split the water molecule into its component elements.

Mr Goh noted: "If the electricity required for electrolysis comes from fossil fuel-generated sources, then hydrogen gas may not be that green after all."

Another potential of hydrogen lies in its energy storage capability, which can be used in tandem with renewable energy systems.

Renewable energy sources are often intermittent. Even in sunny Singapore, solar energy has its limits. Overcast days, for instance, make it harder for solar panels to do their job.

But if excess electricity produced during sunny, cloudless days can be stored, such zero-emissions electricity can power offices and homes even when there is no sunlight.

Traditional energy storage options include lithium ion batteries, which function like the regular batteries used in home appliances. But the drawback is that these gradually lose their charge over time.

Mr Goh noted the potential of hydrogen fuel cells, which, in essence, work like batteries in that they can "store" electricity generated: "In temperate countries, there is plenty of sunshine during the summer months.

"If excess renewable energy generated during this period can be stored effectively over months, this green energy can be used again during the winter months, when energy consumption for heating is expected to go up."

Professor Subodh Mhaisalkar, executive director of the Energy Research Institute at Nanyang Technological University (NTU), said batteries are an energy storage technology, whereas hydrogen can be used for energy storage and electricity generation.

He said: "With significantly higher energy per kilogram compared with batteries, hydrogen is an ideal long-term large-scale energy storage solution. Batteries, on the other hand, are more suitable for applications that need short response periods of minutes to hours."

But despite hydrogen's advantages, some obstacles to its wider use are that it is expensive and easily combustible. Research is ongoing to lower the costs and also make it safer to transport and use.

A SINGAPORE PILOT

In Singapore, SP Group is trialling a hydrogen energy system at its concept lab in Woodleigh.

The system, developed in partnership with investment firm Marubeni Corporation and Tohoku University in Japan, generates green hydrogen through electrolysis powered by solar energy.

The hydrogen is then stored in special tanks comprising a metal alloy. Hydrogen atoms bind to the metal alloy, allowing it to be stored safely at low pressure.

Since October last year, the building, which consumes about 2,000 kilowatt hours of electricity a month – equivalent to the monthly usage of five four-room Housing Board flats – has been able to operate independently from the national grid.

SP Group said this makes the building the first zero-emission building in South-east Asia.

There are other "net-zero" energy buildings here, which typically harness solar energy. These buildings produce more energy than they consume, but may still draw from the national grid at night.

While the cost of such hydrogen energy systems is high today, more research and greater deployment would bring costs down, Mr Goh said, pointing to a similar trend in solar photovoltaic technology.

He declined to reveal the cost of the hydrogen energy system, but said SP Group was investing in the technology as it recognised the potential for such a system to be deployed around the world.

Professor Chan Siew Hwa, a hydrogen expert and President's Chair in Energy at NTU, said hydrogen is an attractive option for Singapore, which has limited renewable energy options.

"We have to diversify energy sources beyond that of solar in order to develop energy solutions to meet our electricity needs more reliably and quickly. Hydrogen has stood up to be a promising choice for Singapore's future energy outlook," he said.

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