Catalytic technology has revolutionised global industry. One such example is the artificial production of hydrogen, an ideal vector of renewable energies such as solar and wind due to its capacity to hold a vast amount of energy and produce zero emissions. *International Innovation* explores the role of catalysis and advances in technologies to produce low-cost hydrogen gas as a route to sustainable energy.

Catalysis, or a change in the rate of a chemical reaction, is an essential technology applied daily in the production of chemicals and materials, fuel and energy conversion, pollution control and food processing. The catalyst is the material that causes a chemical reaction to occur at greater speed without being consumed in the process. Economically, catalysis is key within major sectors of the world’s industry and, subsequently, makes a significant contribution to its GNP. The process of manufacturing high energy fuels such as gasoline, diesel and hydrogen is almost completely dependent on catalysts; their use in gasoline production is seen as one of the most significant achievements in chemical engineering of the 20th Century. While catalysis is breakthrough technology for renewable energies such as solar or wind power, finding a way to store this energy; for example, as electric energy or in hydrogen gas, remains an issue.

**Hydrogen to the rescue**

Though the production of solar energy is becoming more economical and efficient, electrochemical batteries are not developing at the same rate as solar photovoltaic technology. Therefore, at present, the use of electricity from solar energy is generally restricted to real-time, during peak power demand.

An alternative to these batteries is hydrogen gas. Emerging as a key player in the race for clean, renewable, solar energy, it can carry an extremely large amount of energy. Moreover, only a small amount is needed to provide a lot of power, and its chemical stability means that energy can be stored for much longer.

Producing hydrogen gas artificially requires the use of a photoelectrochemical cell. These produce hydrogen bubbles as a result of a catalytic reaction where solar energy is used to make electricity, which in turn powers an electrolyser that splits deionised water into its constituent parts – oxygen and protons (H+ ions). The protons exchange through an electrolyte membrane, combining with electrons at a cathode to produce hydrogen gas.

**Optimising oxygen**

Much scientific attention has been focused on developing ways to produce large amounts of low-cost hydrogen to transport clean, renewable energy. Research has predicted that if a commercial electrolyser and solar panel could be combined, it may reduce the cost of generating this energy vector. The process of producing solar energy also needs to become more efficient – in the range of 15 and 20 per cent.

Though there are concerns regarding the efficiency of this overall method, these are less to do with producing hydrogen and more to do with the production of oxygen during the splitting of water. Silicon or other materials generally used within a solar cell corrode too quickly and metal oxides split water extremely slowly. Excitingly, discoveries have been made in the past few years that are leading this field in the right direction, such as the use of a thin protective layer of nickel to prolong the use of silicon from hours to days. Yet, finding the most efficient, inexpensive catalysts for the reaction remains crucial for commercial use.

**Promising perovskite**

More recently, groundbreaking research into the use of perovskite in solar cells has increased the efficiency of hydrogen conversion from water using solar energy to around 12 per cent. Perovskite is a common mineral made up of rare earth elements, giving it a major advantage. A device combining two electricity-generating perovskite solar cells with nickel and iron catalysts – which are cheap and abundant – is extremely promising, particularly due to the reduced cost of iron and nickel electrodes over more traditional platinum-based ones.

Perovskite solar cell technology is steadily increasing in its efficiency to convert sunlight into electrical energy, correspondingly becoming more attractive commercially, with companies promising perovskite-based technologies on the market within the next few years. The high likelihood of hydrogen conversion efficiency improving is also encouraging, bringing the large-scale use of renewable hydrogen fuel closer to reality by leaps and bounds.

**Catalysis is key**

The cheap production and storage of hydrogen, facilitated by catalysis, would not only overcome the problem of renewable energy’s intermittent nature, it would also represent a source of clean and reliable power. Ultimately, it has the potential to reduce dependence on oil and other fossil fuels, as well as cut global carbon emissions.