Hydrogen is the future

Green hydrogen is to become an important component of the new energy world. The European Union has presented a comprehensive plan for the period up to 2050, and also in Austria research and development are making rapid progress.

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Hydrogen currently is a hot topic not only in Austria. The international energy industry is also discussing what role this element can and should play in the energy transition. And the answer is almost unanimous: a major role. For many years now, it has been used as a molecular gas with the chemical formula H2 in many mostly industrial applications. The largest quantities are used in oil refineries, the chemical industry (for example, fertilizer production) and iron and steel production. Because hydrogen in comparison with coal, oil, and natural gas leaves virtually no exhaust gases when burned, it can partially replace these energies and be increasingly converted into electricity and heat. Hydrogen can supply industry with heat at high temperatures, drive electric motors when converted into electricity, and is regarded as an increasingly important energy storage medium - just as Jules Verne suspected back in 1874. In the novel "The Mysterious Island", the writer put a few words into the mouth of engineer Cyrus Smith that many readers must have smiled at: "I am convinced, my friends, that water will one day be used as a fuel, that hydrogen and oxygen, its constituents, will become an inexhaustible source of heat and light whose intensity is quite undreamed of. Water is the coal of the future."

Writer Jules Verne saw the enormous potential of hydrogen as early as the 19th century: "Water is the coal of the future." © Sime Basioli on Unsplash

Hydrogen + oxygen = energy + water

Was Jules Verne taking a shot in the dark with these statements? Pure conjecture and right by mere coincidence? Hardly, because hydrogen and its production by splitting water using electric current (electrolysis) were already known at the beginning of the 19th century. In 1838, chemist Christian Friedrich Schönbein had discovered the basic principle of the fuel cell and thus one of the most important prerequisites for making hydrogen usable for mankind. In an experiment, he had platinum wires surrounded by hydrogen and oxygen in an electrolyte solution and detected electrical voltage between the wires. His discovery, by now an integral part of chemistry lessons, was that the reaction of hydrogen with oxygen produces water and - since the reaction is exothermic - energy as a by-product. As heat during its combustion, as electrical energy in the fuel cell.

Hydrogen color theory: from gray to green

So why hasn't hydrogen long been playing a major role in the energy world? Because the production of the gas is costly. Like electricity, hydrogen is not a primary energy carrier that can simply be mined somewhere and used, but must first be produced: either by converting other chemical energy carriers or by splitting water. In either case, more energy is required than is bound up in the hydrogen produced. The type of conversion process is decisive for the gas's carbon footprint: If hydrogen is obtained from natural gas by steam reforming, as is usually the case at present, it is referred to as "gray". The production of one ton of hydrogen releases around ten tons of carbon dioxide; if this is captured and stored, it is called blue hydrogen. Only if it is produced exclusively on the basis of renewable energy sources is it considered green hydrogen and is climate-neutral. The splitting of water with electricity from renewable sources (electrolysis) is seen as the most essential technology for this, but processes such as direct water splitting using solar energy (photolysis) could also play a role in the future. Production by electrolysis using surplus green electricity, i.e. electricity from wind and sun, which could otherwise not be used due to the temporal and/or local discrepancy between electricity production and electricity demand, is particularly sustainable - while the entire production path is almost completely emission-free.

Some manufacturers already have fuel cell cars in their model range, but the vehicles are still very expensive. © 123rf

Making the energy system more flexible

Which brings us to one of hydrogen's greatest strengths: its energy storage potential. Few energy carriers can be stored in sufficient quantities for weeks, months and even years like hydrogen, and when needed can be converted back into electricity, used directly or converted into synthetic fuels such as e-fuels. If the desired decarbonization of the energy industry is to succeed, i.e., the reduction and elimination of CO2 through the promotion of renewable energy sources, it is precisely these options for making the power grid more flexible that are needed in addition to more wind turbines, photovoltaics, biomass and the like. Only if the fluctuating and constantly growing amounts of electricity from wind and solar power can be used beyond the current demand and integrated into the power system, will complete conversion to renewable energy sources be feasible. The problem here is that the production of green hydrogen is still comparatively expensive, making the entire process uneconomical in most cases.

Dropping prices for green hydrogen

However, this is likely to change in the coming years. Forecasts predict a reduction in the generation costs of green hydrogen by one-third to one-half by 2030 and by around two-thirds by 2050 compared with current levels; green hydrogen will by then also be cheaper than blue hydrogen. Experts from the Boston Consulting Group see power-to-x as an "absolutely essential technology" for a successful energy transition, with a market potential of up to one trillion U.S. dollars (around 840 billion euros) by 2050. According to the study's authors, however, green hydrogen is not a panacea. As a high-quality energy carrier, it will be most useful where there are few or no other options for decarbonization and where it can exploit its high energy quality (exergy).

In the coming years, enormous sums will be invested around the globe in the expansion of renewable energy sources. Hydrogen has the potential to store the energy it generates for longer periods of time.
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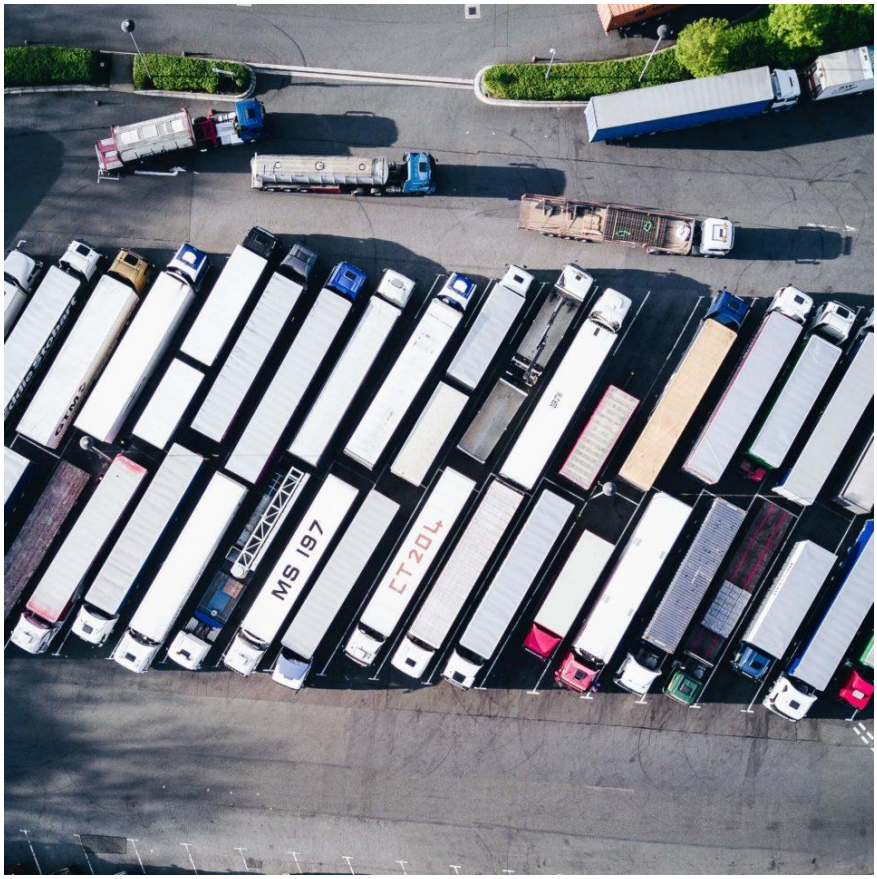
Austria is leading the way

In Austria, that is exactly what is happening. Thanks in part to support from the Climate and Energy Fund, a strong, internationally respected research community has been established in recent years. Numerous domestic companies, research institutes and universities have long focused their research and development efforts on fuel cell and hydrogen technologies. They, for instance, are among the leaders in manufacturing hydrogen refueling stations and as R&D service providers for electrolysis, fuel cells and vehicles. To promote research and development in application, grid and storage technologies for hydrogen and renewable gases, they have founded the "Hydrogen Initiative Showcase Region Austria Power & Gas" (abbreviated to "WIVA P&G") also overseeing the showcase region by the same name. To further promote Austria's strengths through research and innovation projects, white spots have been identified and targeted projects with a wide variety of thrusts have been initiated in these areas. "FCTRAC", for example, is developing a fuel cell tractor including refueling facilities and testing it for real life suitability. The "HyTruck" project, on the other hand, focuses on the development of an emission-free fuel cell drive train for commercial vehicles, and "Renewable Gasfield" is planning to construct a plant for green hydrogen production through PEM electrolysis with subsequent methanation and feeding into the gas grid. In Austria innovations from research are also increasingly finding their way into practice. In 2023, for example, the Zillertalbahn in Tyrol between Jenbach and Mayerhofen will become the world's first narrow-gauge railway line to be converted to hydrogen.

EU planning to invest billions

At the European level Austria is not alone in its hydrogen efforts: other countries - especially Germany, France and the Netherlands - are also pushing ahead with development, and Brussels, too, has recognized the signs of the times: in its "Green Deal," the European Commission has presented strategies for hydrogen and for energy system integration. Plans exist for a strong, gradual expansion of electrolysis capacities up to 2030 according to which hydrogen is to gain further importance and be used on a large scale by 2050 in sectors where decarbonization is difficult. By 2030, a total of 430 billion euros is to be invested in the ramp-up of this green technology of the future, with the public sector contributing 145 billion euros. This is intended to promote applications as well as production, infrastructure and storage, and create up to 140,000 new jobs.



There are many application areas for hydrogen: Experts see great medium-term potential, especially in logistics and heavy-goods transport.
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Water – the coal of the future

There are many areas of application for hydrogen. In the medium to long term, for example, the gas could replace coal in steel production and supply industrial and commercial applications that require high temperatures. There is also great potential in the area of mobility - not so much in individual transport which is currently being converted to electromobility with battery technologies, but rather in logistics, local and long-distance passenger transport, and heavy-goods transport. Attempts have also been underway for some time to equip aircraft and ships with such drives. As an energy storage medium, hydrogen can play a key role in the conversion of the energy system to (partly fluctuating) renewable energy sources. Thus, Jules Verne's version could actually become reality: Hydrogen in water would then be used as a fuel and become an entirely unimagined source of heat and light. It would then indeed be the "coal of the future" and, in conjunction with other alternative strategies, could actually become an important component of the new energy world, while also linking the previously separate energy markets for electricity, heat and transport.

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