What if hydrogen could help decarbonise transport?

The use of hydrogen as a fuel for transport might hold the key for decarbonising our overall energy system, by complementing the generation of electricity from fluctuating renewable energy sources such as wind and solar.


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Twenty-seven years after the signing of the Kyoto Protocol, and possibly around a decade before the earth's climate reaches a tipping point, our transport sector still overwhelmingly runs on fossil fuels, and in particular oil. A growing number of voices call ever more urgently for a fundamental system change.

In the last couple of years, the public debate on decarbonising our transport sector has been dominated by the prospect of battery electric cars, which represent a very promising path towards reducing some of the carbon emitted by transport. As electric cars enter mass production, prices will fall further, and batteries will become increasingly powerful. When electric cars are charged using renewable energy, they can indeed help lower the carbon footprint of the transport sector.

There are, however, a couple of disadvantages that electric cars will not be able to overcome in the near future: battery electric cars will always be much heavier than conventional cars, especially if consumers demand autonomy to a range of several hundreds of kilometres. Equally, recharging batteries will always take much longer than refuelling a car with petrol or gas.

While electric cars seem attractive for users that drive only a few kilometres a day, and who can recharge at times when electricity demand can be fully met by renewable energy sources – wind or solar, depending on the country – they are not ideal for users driving longer distances, who would need to recharge their vehicle in the middle of the day (when electricity is often in high demand and prices typically much higher). And even if battery electric cars succeeded in securing a significant part of the market for private vehicles, in other parts of the mobility sector batteries would simply not be practical. Trucks, trains on non-electrified lines, cargo ships, or aeroplanes will not be able to pack the number of batteries on board necessary to cross the continent, travel the seas, or take passengers up in the air. But what if we used hydrogen gas and fuel cells to produce the necessary electricity on board, rather than storing it in heavy battery packs?

Potential impacts and developments

Instead of storing electrical energy in batteries, large-scale electrolysers allow chemical storage of electrical energy, by using the electricity to split water molecules into hydrogen and oxygen gas. Tanks on-board the vehicles can then be filled with energy-rich hydrogen gas, which can be used to generate electricity in 'fuel cells'. The particular interest of this approach is that vehicles could store large amounts of hydrogen on-board, refuel quickly if necessary, and produce only pure water as an exhaust output.

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The concept of hydrogen-powered fuel-cell cars already attracted much attention following the first oil shock in the 1970s. At that time, the objective was to find a cheaper alternative to oil, and one idea was to use cheap and abundant nuclear energy to produce all the hydrogen we need for our mobility. However, oil prices soon started to stabilise or to fall, and the promise of cheap and abundant electricity from nuclear power plants never became reality. Producing hydrogen with electricity generated by coal or gas-fired power plants is also too expensive, and does not help the climate. In consequence, the idea was relegated to the back burner for many decades.

Today, we still do not have the cheap and abundant sources of electricity that nuclear power once promised, but the electricity market is nonetheless undergoing a fundamental transformation that is attracting new interest to hydrogen technology. As we increasingly switch to fluctuating power sources such as photovoltaic (PV) or wind, the issue of matching supply and demand becomes increasingly cumbersome. As we install ever greater generating capacity to meet electricity demand, even on cloudy days with little wind, we are increasingly frequently in a situation where generating capacity exceeds demand significantly, and where the market prices for electricity fall to zero. This excess electricity could be used to produce cheap hydrogen. And if the price of electricity remains low for several hours a day on average, it will become economically feasible to produce cheap hydrogen in adequate quantities.

In this way, hydrogen generation facilities and wind or PV farms could become a symbiotic couple that boosts each other's business case: The electricity used for producing hydrogen would help stabilise electricity prices when renewable energy is abundant. Wind farms would therefore generate higher returns on investment, which would attract additional investment in wind farms. And, as the number of wind farms increases, electricity generation will more often exceed demand, which means longer periods each day when cheap electricity is available for hydrogen production.

Anticipatory policy-making

Most of the technology for this new era of hydrogen mobility has already been available for many decades. Today, active international cooperation focuses on standardisation and safety aspects. It is already possible to buy anything from bicycles, cars, trucks to trains, ships, and even aeroplanes that are fuelled by hydrogen. While there are still very few production and distribution facilities for green hydrogen in Europe, and prices of hydrogen, vehicles and distribution systems are still relatively high, there is a growing perception that we are about to reach a tipping point, at which greater availability of hydrogen will increase the interest and uptake by consumers, and increasing uptake from consumers will further drive down prices to quickly reach market competitiveness.

In such a situation, even relatively modest political measures and financial investment can help these technologies reach the tipping point faster. Local governments are already stepping up their efforts to promote the production of hydrogen to supply early adopters. Public procurement programmes for hydrogen buses or trains can help industry increase production and drive down the costs of these vehicles. Tax incentives for purchasing fuel-cell vehicles and differentiation between tax rates for hydrogen and petrol would encourage more people to become early adopters, which will in turn drive down prices faster. The European Commission has recently identified hydrogen technologies as one of its six newest strategic and future-oriented industrial sectors in which Europe should aim for global leadership.

Battery electric vehicles will undoubtedly continue to play an important role in decarbonising the transport sector, especially for small and light-weight vehicles used for shorter distances. For heavier vehicles over longer distances, however, hydrogen-powered fuel-cell vehicles seem to be a promising answer. And beyond the transport sector, once the price of hydrogen has fallen sufficiently, hydrogen can help decarbonise other parts of the economy, too, for instance in the iron and steel or cement industries, or be used as a raw material for fertiliser production and other chemical processes.

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