

Hydrogen as a pedalling aid

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Filling up with hydrogen instead of electricity: The e-bike relies on the fuel cell.
Credit: Swiss Federal Laboratories for Materials Science and Technology

An e-bike fueled with hydrogen instead of electricity? No, this is not a utopia, but reality: industrial gas specialist Linde has developed a hydrogen pedelec equipped with a compact fuel cell instead of the usual battery. Florian Freund was inspired by the invention for his Matura thesis: He developed a prototype with which the hydrogen e-bike can be refuelled safely at the H₂ filling station on the Empa mobility

demonstrator move.

Florian Freund, a graduate of the Sumatra high school in Zurich, was already interested in energy as a child – from steam locomotives in museums to nuclear energy. But gradually he also developed an awareness of the disadvantages of fossil and nuclear energy technologies, especially the dangers of climate change. This motivated the young researcher to look into alternative energies for his Matura thesis. A topic was quickly found: The power-to-gas and [fuel cell](#) technology should be – and at the end of the work something practical should be created.

Cycling with hydrogen

Fuel-cell vehicles are considered to be the hope of future mobility – and they are already in series production: In the Toyota Mirai, only water vapor comes from the exhaust instead of exhaust gas. At the mobility demonstrator move on the Empa, vehicles can be refuelled with [hydrogen](#) produced by excess solar power. The journey can continue within minutes. A clear advantage over electric vehicles: If their batteries are empty, a longer break is required until they are sufficiently charged again. The same problem is familiar to e-bike riders: As practical as pedaling assistance is in everyday use – longer loading breaks are also required for longer distances. Could hydrogen also help out here?



Credit: Swiss Federal Laboratories for Materials Science and Technology

Vienna-based gas specialist Linde Gas has developed an e-bike prototype that is equipped with a fuel cell and hydrogen tank instead of a battery.

A tank filling of 33 grams of hydrogen gas should allow a range of more than 100 km. When Florian Freund heard about this concept, the practical goal for his work quickly emerged: a new refuelling concept for the hydrogen bike.

The e-bike's [pressure](#) cylinder holds slightly more than 1.3 litres – which corresponds to around 33 grams of hydrogen at the planned cylinder pressure of 340 bar. According to the manufacturer's concept, the bike should be refueled from larger pressure bottles. Freund's idea: Instead of every bicycle owner having to store such a bottle at home, e-bikes could also be refueled at hydrogen filling stations that were actually designed for cars, such as the one at Empa's mobility demonstrator move.

However, this is not so easy: The filling stations are designed to fill the significantly larger tanks of a hydrogen vehicle – with a permanently programmed refuelling program that initially triggers a pressure surge at 440 bar pressure in order to test for possible leaks and to measure the existing pressure in the bottle. Only after this initial pressure surge does the normal refuelling process begin.



A successful project: The prototype connects the filling station with the gas bottle. Credit: Swiss Federal Laboratories for Materials Science and Technology

From model to prototype

After having had to reject some concepts, Freund finally made his breakthrough during a discussion with Empa researcher Urs Cabalzar, who supported the young researcher: "We realized that the first surge of pressure was already enough to fill the bottle – provided the gas no longer flows back into the filling station afterwards," said Freund.

After some development work and with the support of the sponsor, the fluid system specialist Swagelok, this resulted in the prototype: A pressure regulator reduces the pressure surge from 440 to 275 bar. For practical reasons, this value is lower than the possible maximum cylinder pressure of 340 bar – the plug-in coupling used may only be used up to a pressure of 275 bar. A non-return valve installed in the pressure regulator ensures that the gas does not flow back to the filling station. Freund has also considered reinsurance: an overflow valve ensures that the gas is discharged at too high a pressure. Two built-in pressure gauges allow the regulator and the valve to be adjusted and the pressure to be monitored. The user can connect his bottle to the pressure regulator via a hose and a coupling.

After the graduate had completed his prototype and carefully calibrated it, the endurance test was carried out: he connected it to the Empa H2 filling station together with the bottle under the supervision of Urs Cabalzar. And the concept withstood the theory; the system started the refuelling process with the test pressure surge – and in three seconds the bottle was full.

A successful thesis—but is the principle of the hydrogen bike also suitable for everyday use? Florian Freund is – at least for the moment – still somewhat sceptical: "First, hydrogen technology would have to establish itself in regular vehicles in order for fuel cells to become cheaper and the refuelling infrastructure to be sufficiently dense. But then nothing would stand in the way of the new riding pleasure."

Provided by Swiss Federal Laboratories for Materials Science and Technology

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