Hydrogen power in real life

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Since 2009, a hydrogen powered street cleaning vehicle has been undergoing testing on the streets. The project is intended to take hydrogen drives out of the laboratory in order to gain experience on using them under practical conditions. The result: hydrogen as a fuel for municipal utility vehicles saves energy, is environmentally friendly and technically feasible. To make it cost-effective, however, the prices of fuel cells, pressurized storage tanks and electric drives must all drop significantly.

To develop a prototype and then test it right away under everyday conditions of use is not an easy undertaking, and setbacks are practically preprogrammed. The hydrogen powered street cleaning vehicle, which took about 18 months to develop and began trials in Basel in 2009, is no exception. "It became clear relatively quickly that the fuel cell system, which had been developed as a one-of specially for the project, was not yet ready for use in a real-life setting," explains project leader Christian Bach, head of Empa's Internal Combustion Engines Laboratory. "On top of that, the various safety systems kept interfering with each other and bringing everything to a halt."

But because the vehicle achieved its targets both in terms of energy consumption and performance, the project team – which, in addition to researchers from Empa and the Paul Scherrer Institute (PSI), also included the vehicle manufacturer Bucher Schoerling, the electric drive specialist Brusa, the hydrogen manufacturer Messer Schweiz, and the city of Basel Environment and Energy Department as well as the city's cleaning services – decided to replace the fuel cell system initially used with another more mature product, and also to implement a single centralized safety module. The "Fuel Cell System Mk 2" has now been in operation since the summer of last year and has proven to be far more robust: only once has it been necessary to take the vehicle out of service, because of a defective water pump.

But one problem rarely comes alone and sure enough the voltage converter between the fuel cell system and the battery died, then the sensing system for the electric motor drive as well as two cooling water pumps had to be replaced shortly after the vehicle was initially repaired. All these components were, it goes without saying, tailor-made for the vehicle and therefore had appropriately long delivery times. Despite these setbacks, however, for the past three months the vehicle has been running so reliably that the city cleaning services are able to use it on an everyday basis as they would a "normal" vehicle.

Lessons learned from the experience in Basel

The test phase in Basel showed that fuel cells are ready for use under everyday conditions, also – perhaps particularly – in niche applications such as municipal utility vehicles. Their use allows the operator to save a considerable amount of energy, since the vehicle consumes less than half the fuel of its contemporaries. In figures: instead of 5 to 5.5 liters of diesel per hour (equivalent to an energy consumption of 180-200 MJ per hour) the hydrogen powered vehicle needs only 0.3 to 0.6 kg of fuel per hour (that is, 40-80 MJ per hour). And in terms of CO_2 emissions, too, the new vehicle performs about 40% better than a diesel powered equivalent, even when the hydrogen is produced by the steam reforming of natural gas using fossil fuels. If the hydrogen was produced using energy from renewable sources then the CO_2 reduction would be even greater.

During use the novel vehicle has proven to be user-friendly and safe. Refueling was done by the drivers themselves at a mobile, easy-to-use hydrogen fuel station. The refueling stations and garages where the vehicles are parked are fitted with a hydrogen monitoring system, but since it has been in use there has not been a single problem caused by hydrogen leaks. An additional advantage is the fact that the fuel cell powered vehicle is much quieter than a diesel vehicle, both when driving to the area to be cleaned as well as during cleaning itself, even when the suction system and brushes are operating. This leads to a noticeable reduction in noise, particularly for the drivers.

The only disadvantage is that on cold days the waste heat from the fuel cell and the electric motor are not sufficient to adequately warm the driver's cabin – a typical weakness of electrical drives. To counter this, the driver's seat was fitted with a heater unit for use on cold days.

Around the middle of March 2012 the test phase in Basel will draw to an end and the vehicle will be taken to St Gallen for further practical trials. Now that the teething problems have been overcome, the vehicle will undergo further testing in everyday situations in order to gain more operating experience and to allow the ageing behavior of the various components used in the vehicle to be studied.

Currently a vehicle of this kind is about three times as expensive as a conventional one. On the other hand, the costs of fuel cell systems alone have, over the past few years, dropped by a factor of ten, and the end of this trend is not yet in sight.

Provided by EMPA

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