

Solar Hydrogen Project at Neunburg vorm Wald, Germany

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Hydrogen losses cut to zero in vehicle refuelling

Filling a sedan car fuel tank with liquid hydrogen now takes only three minutes



As part of the SWB project at Neunburg vorm Wald, Germany, a filling station was built for fuelling test sedan cars with liquid hydrogen, which has a temperature of minus 253 degrees Celsius. From the initial situation, where about 30 percent of the fuel was wasted due to boil-off and the procedure took a full hour, the refuelling technology was progressively improved

to eliminate losses altogether and complete filling of the vehicle fuel tank in less than three minutes.

Hydrogen as a motor fuel

In realistic energy and environmental scenarios for the new millennium it is taken for granted that the automobile will remain the basis for mobility of the individual. However, fuels other than gasoline will increasingly come into play. Hydrogen is a clean alternative. It can be generated electrolytically from water in practically unlimited quantities and about all that is emitted when it is burned is the same starting material, water.

A number of problems still await solution however before hydrogen fuel can be introduced on a full commercial scale. The technology for hydrogen cars is already in place and test vehicles are on the road. What is now needed is economical production of sufficient quantities of hydrogen unaccompanied by emission of carbon dioxide. Investigating the technical potential for achieving this was one of the goals of the SWB project.

Three-stage plan for hydrogen cars

The long-term aim of the hydrogen-powered car could be realized in three stages. The first of these, use of compressed natural gas, has been completed. Standard natural gas cars have been on the market for a number of years now. Natural gas has one great advantage over conventional gasoline or diesel fuel, burning with comparatively little emissions. What is more, it is similar to hydrogen gas in its properties as relevant to use in motor vehicles. Development of the natural gas car accordingly yields technical experience that can be carried over to the hydrogen car.

The second stage is conversion to liquefied natural gas, in other words using the same fuel but requiring a higher standard of technology on account of the low temperature (around minus 160 degrees Celsius) . The energy density of liquefied natural gas is greater than that of compressed natural gas. As a result, a car running on liquefied natural gas can go about 70 percent of the distance attainable with the same tank volume of gasoline. From there it is, technically speaking, a short step to the final stage of the hydrogen car, which uses a more demanding fuel but largely the same technology.

Automated filling systems are needed

As of today, handling low-temperature liquid hydrogen calls for appropriately trained personnel. Systems for automatic refuelling are decidedly advantageous. Further advancement of the fuel storage and filling technology is an important area for development.

The hydrogen car will presumably come to technical maturity within the next decade, but it will likely take much longer for any comprehensive hydrogen energy scheme to become reality. The solar hydrogen plant at Neunburg vorm Wald is one milestone on the road to practical implementation of the goals outlined above. Focal points of the project are the production, storage and utilization of hydrogen, particularly including transport applications and the associated key components of photovoltaic electricity generation, water electrolysis, storage of liquid hydrogen on board of vehicles and refuelling.

New technology revolutionizes refuelling

When the project first got underway, the difficulties in transferring liquid hydrogen from the on-site storage tank to the vehicle fuel tank seemed so daunting as to prohibit its practical use as motor fuel altogether. Finding answers to the problems was a model example of interdisciplinary endeavor involving the energy, gas, control and automobile engineering fields. The aim was to solve the challenges entailed in filling the fuel into a vehicle tank so that the operation could be handled by any normal motorist.

Enough know-how was ultimately acquired in the course of analyzing and optimizing the separate components to allow of revolutionizing the refuelling process. In the early stages, the liquid hydrogen was filled into the vehicle tank from the bottom, requiring the cushion of gas forming above the liquid level to be drawn off simultaneously. With the new design of tank now in use, the liquid fuel is sprinkled into the tank from the top. As the liquid descends, the gaseous hydrogen forming inside the tank condenses on the drops, meaning that it is no longer displaced and therefore is not wasted. Not only was it possible to eliminate fuel losses

altogether with this method of refuelling; the time taken for the operation was cut to just under three minutes.

Robotic hydrogen filling station at Munich Airport

The refuelling system developed and tested under the SWB project laid the ground for the next generation of technology meanwhile taking practical form in the world's first robotic filling station for liquid hydrogen at Munich Airport, Germany. Hydrogen sedan cars are refuelled by a service robot in a few minutes without the driver having to get out of the vehicle. They are deployed within the airport grounds to verify their suitability for everyday use.

This is another example of components finding their way into practical application as a result of a decade's work on hydrogen as an energy medium at SWB.