



# Hydrogen, Fuel of the Future?

*Is hydrogen the ultimate energy source of the future?*

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Recent media reports suggest a new, powerful, clean, and, above all, virtually limitless fuel for the future, namely hydrogen. According to the *Vancouver Province*, in January 1999, a liquid hydrogen car fueling station opened for business in Germany [1]. This March, DaimlerChrysler unveiled a prototype vehicle, NECAR 4, also said to be powered by liquid hydrogen [2].

Indeed, pound per pound, hydrogen carries more punch than our typical gasoline. Indeed, its combustion will result only in water. Indeed, hydrogen, as its compound with oxygen, that is water, can be considered limitless on Earth. So, what then could be the problem with its use as a fuel?

First, let us look at hydrogen as an energy source. Its most common compound in nature, i.e. water, is very abundant, but elemental hydrogen is not. It has to be produced from water, or from fossil materials, by chemical processes such as electrolysis, reduction, or partial oxidation. When reducing water, the process consumes more energy than is present in the produced hydrogen (laws of thermodynamics). Therefore, while we could produce any desirable amount of hydrogen, it has to be done by consuming other sources of energy, whether coal, oil, gas, or hydroelectric power. Overall, this conversion does not provide an energy gain but a loss.

Second, and this is the real crunch, the new wonder fuel needs to be transportable in a car. Notions of "liquid" hydrogen being pumped into a car's "gas" tank are utterly mistaken. In fact, the report in the *Vancouver Province* [1] is wrong as several press releases in Germany clearly show that gaseous hydrogen was fueled [3,4]. In contrast to liquid natural gas, or liquid propane, commonly used in cars or barbecues, liquid hydrogen is very difficult to make, store or transport. Hydrogen boils under atmospheric pressure at  $-253^{\circ}\text{C}$ , a temperature far below that of liquid nitrogen (boiling point  $-195^{\circ}\text{C}$ ) and it has a low heat content, i.e., in contrast with water, it evaporates with little heat or energy input. Also, its critical temperature, above which it cannot be liquefied, is only  $-240^{\circ}\text{C}$ . Therefore, storage and transport of liquid hydrogen requires sophisticated containers with terrific insulation not likely to be possible in a small vehicle. In other words, your tank of liquid hydrogen would long have evaporated before you return to your car from a weekend at the summer cottage. Even with much better insulation than available today, some vaporization would always occur. This would have to be vented safely, far away from any possible source of ignition. Furthermore, because of its very low density of about 0.08, liquid hydrogen takes up about ten times the volume of an equal weight of gasoline. Today's 50 litre gasoline tank would have to be replaced with a 500 litre liquid hydrogen tank.

Another option would be to store the hydrogen in a solid system. Indeed, metals such as palladium and platinum absorb gaseous hydrogen in their structure, at approximately 1 litre of gas (0.1 g) per 10 g of metal. So, for a trip to the cottage you might need the equivalent of 20 kg hydrogen, hence 2,000 kg palladium, at today's price of about \$500 per ounce, a cool \$30,000,000 of palladium. I think there would be a high chance of your returning to your car and finding both the fuel and storage device missing.

An alternate solid hydrogen storage system would be in the form of alkali-hydrides, such as sodium hydride. Such compounds, however, are very moisture sensitive and the slightest air leak would likely result in your finding neither fuel tank nor the mid-size car upon your return from the weekend, but rather a mid-size crater where your car had been.

The third option of storing and transporting hydrogen is as a gas under pressure. Chemical laboratories handle compressed hydrogen routinely in special steel cylinders of approximately 100 lbs. weight and 3000 psi (pounds per square inch) internal pressure, equivalent to the pressure of a water column about 3,000 feet high.

With stringent manufacturing and handling precautions, such compressed gas cylinders are being used in many laboratories. For your weekend trip, you would require approximately ten such cylinders which would take up most of the space in your minivan and weigh about a 1,000 lbs. So, you may have to leave the family and dog at home. On the other hand, in the case of an accident, where a cylinder's pressure control valve might be knocked off, your trip may become quite accelerated as the whole arrangement would likely turn into a booster rocket to blast you right along.

With these options in mind, I think we will continue to use good old-fashioned gasoline for quite some time to come.

## References

1. *Vancouver Province*, page D2, January 15, 1999.
2. [www.daimlerchrysler.com/news/top/t90317\\_e.htm](http://www.daimlerchrysler.com/news/top/t90317_e.htm), March 17, 1999.
3. Pressemitteilung Nr. 1/99, January 13, 1999. Deutscher Wasserstoff-Verband e.V. (DWV), Berlin. Website: [www.dwv-info.de/pm\\_9901.htm](http://www.dwv-info.de/pm_9901.htm), January 19, 1999, 6244 bytes.
4. Hamburger Wasserstoff-Agentur GmbH. Website: [www.hew.de/umwelt/willkommen.html](http://www.hew.de/umwelt/willkommen.html); January 13, 1999, 7832 bytes. ●

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