# Adding the spark to hydrogen

**Empa's engine experts had already promoted and even co-developed the natural-gas turbo engine. As an "encore" of sorts they next want to mix in solar-generated hydrogen, which will save energy and improve engine operation.**

TEXT: Rainer Klose / PHOTO: Empa

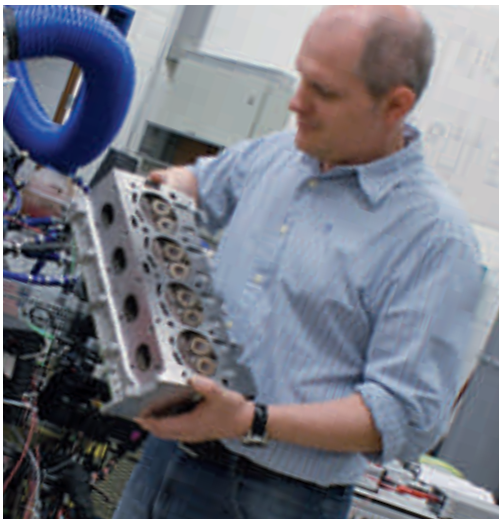
The soundproof test facility in Empa's engine building is a type of torture chamber for internal combustion engines. An engine is bolted down to a yellow steel frame; from it hang hundreds of cables in all colours along with instruments, exhaust hoses and small boxes full of electronic circuits. This is where new engine concepts are being conceived and tested.

### The Empa/ETH natural gas engine

Torturing the engines is done methodologically as part of an ongoing research project. Empa wants to investigate in great detail the interaction of natural gas and hydrogen inside the engine. Research on natural gas engines has a tradition in Dübendorf. Starting in 1999 and going through 2004, the Internal Combustion Engine Laboratory, working in collaboration with ETH Zurich and the automobile industry as part of the Clean Engine Vehicle (CEV) project, converted a VW Polo to operate on natural gas and compensated for the loss of performance with a turbocharger. They were able to show that natural gas and biogas are very well suited as fuels for modern engines, emitting extremely low levels of pollutants. In fact, in 2006 the project team was awarded the Innovation Prize of the German Technical and Scientific Association for Gas and Water. In the meantime, natural gas motors have entered the market, an example being the VW Passat Ecofuel with a supercharged 110 kilowatt (150 hp) 1.4-litre natural gas engine. In 2009, this model was the first car to receive the very strict five-star rating from the ADAC (German Automobile Club) EcoTest.

### How much hydrogen would you like?

Now comes the next step, the hydrogen-natural gas mixture. Initial tests were run in 2005, first on a CEV engine, then on a larger series-manufactured engine. The results to date show that mixing in hydrogen considerably improves ignition performance. This means that mixtures which are difficult to ignite can quickly and reliably be ignited if a small amount of hydrogen is mixed in, whereby there is also a gain in efficiency and a reduction in pollutants. In addition, it's possible to feed more exhaust back into the engine and in this way control engine power. In this case, the throttle can be opened even further so the motor runs with less throttling, in other words more economically.



Project manager Patrik Soltic inspects a cylinder head which is to be used for the hydrogen-natural gas experiment. In the background you can see the Empa test stand for 4-cylinder engines.

The experiments are moving ahead fast. Two series-manufactured vehicles with the latest natural gas drives are placed on Empa chassis dynamometers and are fuelled up with various amounts of hydrogen blended with natural gas. As a first step, the researchers investigate what effect the gas mixtures have when no adjustments are made. In a second step, the vehicle's engine control system is modified to get the most out of existing systems.

At the same time, the basic principles are being further investigated. What are the effects of directly injecting natural gas into a cylinder and hydrogen into the intake manifold? What happens in the reverse case? What changes take place in terms of combustion, exhaust gases and fuel consumption?

### Collaboration with the Competence Centre Energy and Mobility

These fundamental questions about a natural gas/hydrogen engine, however, are not being clarified with something similar to a series-manufactured car engine but in a 250-cc single-cylinder engine mounted on an additional test bench. This engine is provided by the Swiss company Swissauto Wenko AG. Two such engines are set up at the ETH Zurich where the use of alcohol is being studied and rules for their use in hybrid vehicles are being researched. These coordinated research efforts are taking place under the auspices of the Competence Centre Energy and Mobility, a platform in which various institutions of the ETH Domain are working together. "At a later stage, we plan to equip the engine with optical access points so that, based on optical diagnostics, we can study how the formation of the gas mixture and its combustion are influenced by hydrogen", explains Patrik Soltic, head of the Drive Technologies group.

Besides enabling stable, balanced combustion, adding hydrogen has a second big advantage: the opportunity to make use of regenerative energy in an internal combustion engine. "Excess" electricity from solar and wind-driven power plants could be turned into hydrogen through electrolysis and be added to the natural gas or biogas supply, explains project leader Soltic. "In this way we would actually have 'sun in our tank'."

**Link**

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