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Prototype vehicle powered by Hydrogen enriched Natural Gas (HCNG, up to 25 Vol.% H_2)

The energy turnaround will produce huge amount of fluctuating renewable excess electricity. Wasting of this renewable energy has to be avoided, therefore chemical storage of excess energy and utilization for mobility is well suited with a high potential for the substitution of fossil fuels. HCNG (hydrogen enriched compressed natural gas) is the cheapest technology (fuel and vehicle) for using fluctuating renewable excess electricity in mobility.

Current CNG vehicles are approved for natural gas with a hydrogen content of maximum 2 Vol.%. For higher blending ratios an adaption of the vehicle is necessary. To investigate the effect of higher blending ratios, a standard natural gas vehicle has been modified to run on HCNG with hydrogen contents of up to 25 Vol.%. To make the refueling possible, Empa's demonstration plant "move" was expanded with a HCNG dispenser specially developed for this project.

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HCNG field test vehicle

Since the vehicle will be fuelled with HCNG with high hydrogen contents, the complete fuel system needs to be designed to withstand the hydrogen-induced embrittlement, caused by the diffusion of atomic hydrogen in the steel, and the higher fuel pressure of 350bar. The following parts have been replaced:

- Gas cylinders and cylinder valves (from steel to carbon fibre compound, H2 approved)
- Fuel lines (from normal steel to noble steel)
- Pressure regulators (approved for H2 and CNG)
- Fuel rail (from normal steel to noble steel)

The fuel system and the vehicle have been re-certified. Equipped with a data logging system, the vehicle is now in its field testing phase as a parcel delivery vehicle in the area of Zürich and will be tested with CNG and HCNG from Empa's refuelling stations at the "move".

HCNG fuel system of the Iveco Daily HCNG

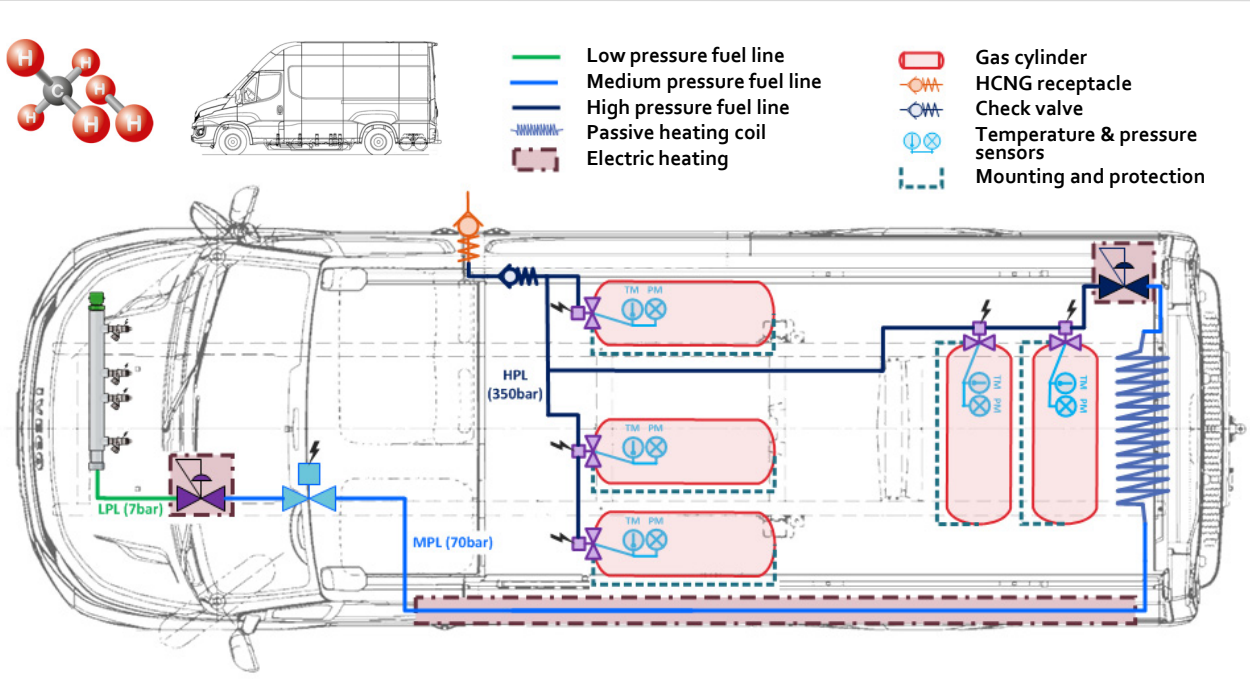

Fig 1: Overview of the system components of the HCNG fuel system

HCNG blending station with dispenser

To find an optimal solution in terms of functionality, safety as well as regarding economic aspects the refuelling process has been simulated using the multi-physics software AMESim. Simulation and evaluation of different HCNG refuelling processes showed that a subsequent-type process should be realized. This enables refuelling to a higher pressure of 350bar, compensating the losses in driving range due to the lower volumetric energy content of the mixture.

From the fuel storage of the "move", the vehicle will be filled up with CNG up to 200bar nominal pressure. In the second stage, the hydrogen is admixed to reach the final nominal pressure of 350bar (max). To ensure that the correct blending ratio is achieved in the vehicles fuel tank, the fuel mass flows and different ambient parameters are used to control the fuelling process at the "move" HCNG dispenser.

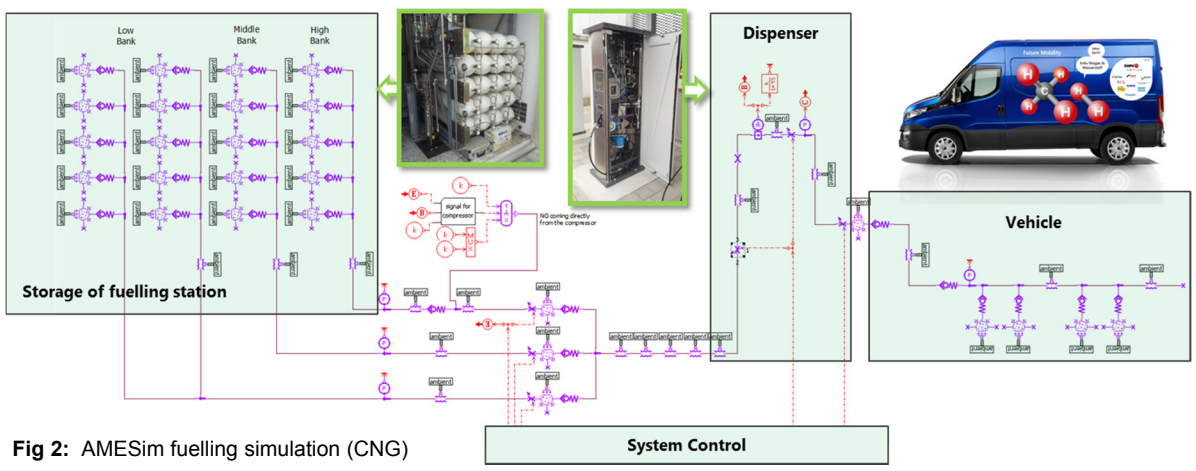

Fig 2: AMESim fuelling simulation (CNG)

Impact on vehicles / energy system

This demonstrator vehicle will show that with minor changes in the fuel system, of which some are already part of the latest state of technology for CNG vehicles, current natural gas vehicles are capable of running with renewable fuel produced with fluctuating excess electricity with lower CO_2 emissions and higher efficiency.

During the start up of the methanation process in a Power to Gas facility a lot of H_2 slip occurs which leads to insufficient gas quality and a lower energy efficiency of the process. If higher H_2 contents in the gas grid would be possible, this gas, normally burnt off at the plant, could also be used in the grid.

The wider usage of hydrogen, as an admixture to natural gas or feeding it to a methanation process, will help to expand the infrastructure for hydrogen production and storage, enabling hydrogen to be an important cornerstone of the energy system and the energy supply for individual mobility.

Partners

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