



# MediaInfo

Forschungsvereinigung Verbrennungskraftmaschinen e.V.  
FVV | Research Association for Combustion Engines

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## Maximum pressure rise: FVV strengthens hydrogen research

**The Research Association for Internal Combustion Engines (FVV) significantly expands pre-competitive Industrial Collective Research (IGF) on hydrogen-powered combustion engines and fuel cells. Twelve newly initiated projects complement the research already underway and should thus accelerate the implementation of the German and European hydrogen strategy. The aim of the research association is to drive forward the defossilisation of the entire energy chain.**

**Frankfurt/M., 06.11.2020** // The use of renewable 'green' hydrogen as an energy carrier is not limited to fuel cells. It can also be used directly in combustion engines and gas turbines. However, the chemical properties of hydrogen differ significantly from those that characterise fossil fuels. Therefore, technical adaptation or redesign of internal combustion engines, turbomachinery and the related combustion processes is necessary. With a dozen new research projects, the FVV wants to create the scientific basis of advanced combustion technologies for sustainable transport and mobility. A project that will be performed at the Institute for Internal Combustion Engines (IFKM) at the Karlsruhe Institute of Technology (KIT) is exemplary for this. It will investigate the potential of future combustion processes using heavy commercial vehicles as an example. The hydrogen is first blown into the engine's intake manifold and then, after the engine has been modified, directly into the cylinder. This allows the influence of mixture formation on hydrogen combustion to be investigated. The researchers intend to place particular emphasis on the conflict of objectives between high power density and uncontrolled self-ignition of the mixture. In addition, combustion is to be made as efficient and as low-polluting as possible. Prof. Dr. Thomas Koch, director of the research institute, sees hydrogen engines as a great opportunity: "We are capitalising on the existing know-how we already have in Germany and are continuously developing it further - not least through our work for the FVV".

Hydrogen engines are seen as having great potential, especially in commercial vehicles for onroad and offroad operation. But what does the ideal hydrogen powertrain for a heavy-duty truck or an excavator look like? This question is to be answered by another major research project. Cold combustion in the fuel cell as well as hydrogen combustion in the piston engine are potential technology options, but have different advantages and disadvantages depending on the application and duty cycle. Within the project the technical options for different applications and cycles will be simulated and an evaluation matrix will be created. On this basis, future technology roadmaps for commercial vehicle powertrains will be developed and the technical challenges of the new concepts will be

identified. In addition, the combustion behaviour of engines with direct hydrogen injection will be investigated in detail and corresponding three-dimensional simulation models will be created. The FVV is thus laying the foundations for the rapid industrialisation of hydrogen CV powertrains.

In the shipping industry, the introduction of carbonneutral or carbonfree energy sources poses a particular challenge, as very high energy volumes and storage densities are required in long-distance transport. For this reason, the industry is intensively discussing the further processing of renewable hydrogen into ammonia. Liquid hydrogen, on the other hand, cannot be stored permanently due to its low boiling point and is therefore less suitable for transport over long distances. Ammonia, which also serves as the starting material for hydrogen, is better suited for this purpose. At ambient temperature,  $\text{NH}_3$  is already liquid at a pressure of more than 9 bar and is therefore easy to store and transport. However, there are still many open questions regarding its use in large engines. For example, the ignition energy is about 50 times higher than that of methane. In a new project, the FVV therefore intends to investigate both the fundamental suitability of ammonia as a fuel of the future and the boundary conditions for engine combustion. At the same time, a life-cycle analysis will be carried out to compare ammonia with other renewable fuels.

As energy carriers for sustainable air transport, primarily electricity-based liquid fuels are being discussed, but more recently also the direct use of hydrogen. Like all other combustion engines, jet turbines must be adapted to the new fuel, too. "At the FVV, we benefit from the fact that research on stationary gas turbines and aero engines is closely networked," says Dr Dirk Hilberg, Technology Manager at Rolls-Royce Germany and Deputy Head of the FVV's Scientific Advisory Committee. Projects on the influence of hydrogen admixture have already been carried out in the past. "I am convinced that hydrogen and other alternative fuels will decisively determine turbine research in the future", says Hilberg.

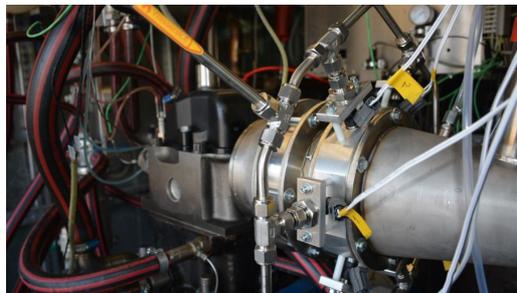
The fuel cell works with hydrogen anyway. Since 2017 the FVV has been concentrating all fuel cell activities in a specific planning group. This group can now demonstrate initial successes: The "generic fuel cell stack", a pioneering project, was completed at the end of September. For the first time, a concept for a manufacturer-neutral test specimen is available. Such a stack, comparable to the single-cylinder units used in engine research, is the basis for pre-competitive cooperation on components and systems, which is of particular benefit to the medium-sized supplier industry. In a follow-up project, a real test device is now to be created on the basis of the concept.

However, the FVV does not focus exclusively on hydrogen-powered energy converters, but also researches the operation of combustion engines with other renewable energy sources. Increasing the efficiency of combustion engines, for example through hybrid concepts, also plays an important role in the association's research portfolio. "We always look at the complete life-cycle balance of energy sources, storage systems and converters," says FVV Managing Director Dietmar Goericke. "A holistic comparison of the energy efficiency of different powertrain alternatives along the entire value chain is also important to us. The transformation of the energy and transport system needs a reliable scientific basis for the evaluation of all technologies that meet the climate target".

## Images

1 | iStock / audioundwerbung

2 | KIT



Hydrogen test bench at the Institute of Internal Combustion Engines (IFKM | KIT).

### Hydrogen Research in the FVV | Newly planned/started projects:

Planning Group	Project number	Project	Status/ Duration
PG1	M0920	<b>Carbon-neutral Long-haul Heavy-duty Powertrains 2050 II</b> Study on CO <sub>2</sub> emissions, energy consumption and costs of long-haul heavy-duty trucks with SOFC, H <sub>2</sub> -ICE, efficiency-optimised hybrid concept considering future energy supply for 2050	Planned
PG1	M3320	<b>New Hydrogen Storage Concept</b> Based on New Technologies and Materials	Planned
PG1	1384	<b>H<sub>2</sub> in the Gas Network</b> Development of a market ramp-up on the basis of scenarios for increasing the hydrogen concentration in the gas network and presentation of solution approaches in the gas industry and the automotive industry for maintaining CNG engine integrity as well as its economic evaluation	01.01.2020 - 31.12.2021
PG2	M0220	<b>DI Hydrogen Combustion Process</b> High-efficient combustion process for hydrogen-based fuels	Planned
PG2	M0820	<b>High-efficiency H<sub>2</sub> SI Engine with Direct Injection</b> Thermodynamic potential of monovalent DI turbo-charged H <sub>2</sub> SI engine for passenger cars and light-duty vehicles	Planned
PG3	M1020	<b>Hydrogen Combustion and Comparison SI/CI Concepts</b> Study of hydrogen combustion characteristics and comparison between SI and CI combustion concepts for HD applications	Planned
PG3	M1120	<b>NH<sub>3</sub> Combustion Process for Large Engines</b> Experimental and numerical analysis of combustion processes for ammonia as a carbon-neutral fuel	Planned
PG3	M3120	<b>Comparison of Future Hydrogen Powertrains for Commercial Vehicles</b>	Planned
PG3	M4020	<b>Ammonia as a Future Fuel</b> Life-cycle analysis of NH <sub>3</sub> as a carbon-neutral fuel	Planned

Planning Group	Project nummer	Project	Status/ Duration
PG3	1405	<b>Closed-cycle Hydrogen CI Engine</b> Potential analysis of a hydrogen CI engine within a closed working gas circuit	01.09.2020 - 31.10.2021
PG4	M0119	<b>Gaseous H<sub>2</sub> Inhibitors</b> Influence of inhibitors in hydrogen, in particular oxygen, on the mechanical properties of steels	Planned
PG4	M0420	<b>Base Engine Components for H<sub>2</sub> ICEs</b> Investigation of the impact of different Hydrogen combustion processes on wear and durability of engine component systems	Planned
PG5	M3820	<b>Combustion Noise H<sub>2</sub> Piston Engine</b> Combustion noise excitation of H <sub>2</sub> piston engines in comparison to Gasoline and Diesel	Planned
PG5	M3920	<b>NVH Fuel Cell</b> Challenges and solutions towards NVH behaviour of fuel cell-driven vehicles	Planned
PG6	M0720	<b>Near-Zero Emission Concept for H<sub>2</sub> SI Engines</b> Ultra-low emission concept of monovalent Direct Injection turbo-charged H <sub>2</sub> Otto engine for passenger cars and light-duty vehicles	Planned
PG6	M2420	<b>High-temperature H<sub>2</sub>-DeNO<sub>x</sub> for H<sub>2</sub> DI Otto Engines</b> High-temperature NO <sub>x</sub> reduction via H <sub>2</sub> in the exhaust of monovalent H <sub>2</sub> direct injection SI engines	Planned

#### Caption Planning Groups (PG):

Planning Group 1 »System«

Planning Group 2 »Combustion SI«

Planning Group 3 »Combustion CI«

Planning Group 4 »Strength & Tribology«

Planning Group 5 »Engine Dynamics & Acoustics«

Planning Group 6 »Emissions & Immissions«

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## About FVV

FVV | The Research Association for Combustion Engines is a globally unique network of companies, research & technology performers (RTD) and funding bodies. In the context of pre-competitive Industrial Collective Research (IGF), manufacturers of automotive engines, industrial engines, fuel cells and turbomachinery as well as their suppliers and service providers work together with universities and other research establishments on cutting-edge technologies. The aim is to make internal combustion engines, hybrids, turbomachines and fuel cells cleaner, more efficient and sustainable – for the benefit of society, industry and the environment.

Combustion engines and fuel cells facilitate individual mobility, transportation, energy supply and industrial added value. The innovative power of the industry and its economic success make a significant contribution to social prosperity. As a non-profit organisation, the FVV supports the development of its members - small, medium and large companies - and the promotion of young scientists through pre-competitive industrial collective research.

The FVV is a member of the German Federation of Industrial Research Associations (Arbeitsgemeinschaft industrieller Forschungsvereinigungen - AiF), the leading national organisation for applied research and development for SMEs. It has invested more than 500 million euros in 1,200 research projects since it was founded in 1956.

More information can be found at [www.fvv-net.de/en/](http://www.fvv-net.de/en/)