



**CONFERENCE REPORT**  
Engines | Turbomachinery

# FVV Autumn Conference

## 21 Sep - 1 Oct 2020

Digital Conference

# Planning Groups

## 2020 Overview

### ENGINES

	<b>System</b> Dr Peter Riegger (Rolls-Royce Solutions)	<b>1</b>
	<b>Combustion SI</b> Dr André Casal Kulzer (Porsche)	<b>2</b>
	<b>Combustion CI</b> Dr Christian Weiskirch (TRATON)	<b>3</b>
	<b>Strength &amp; Tribology</b> Dr Dieter Eppinger (SEG Automotive)	<b>4</b>
	<b>Engine Dynamics &amp; Acoustics</b> Prof Dr Christoph Brands (Schaeffler Technologies)	<b>5</b>
	<b>Emissions &amp; Immissions</b> Dr Volker Schmeißer (Daimler Truck)	<b>6</b>
	<b>Fuel Cells</b> Dr Volker Formanski (BMW)	<b>7</b>

### TURBOMACHINERY

	<b>Turbomachinery</b> Dr Dirk Hilberg (Rolls-Royce Deutschland)	<b>T</b>
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### Chairpersons of the FVV Scientific Advisory Committee

Dr Ekkehard Pott (Volkswagen) and  
Dr Dirk Hilberg (Rolls-Royce Deutschland)

# How to transform the energy and transport system in the long term while protecting the climate and environment effectively?

The transformation of global energy and transport systems in the direction of renewable energy sources requires a reliable scientific basis, accepted by all, for a complete ›cradle-to-grave‹ assessment of all climate target compliant technologies. In doing so, the complete life-cycle balance of energy carriers, energy storage systems and energy converters must always be considered, and a holistic comparison of the energy efficiency of different powertrain alternatives along the entire value chain is also important. Because protecting both the climate as well as the environment requires a wide range of options.

## Content

1. LIFE-CYCLE ASSESSMENT IN THE MOBILITY SECTOR
2. THE NEW RESEARCH PROGRAMME
3. ALTERNATIVE FUELS | NEW COMBUSTION TECHNOLOGIES:  
FVV STRENGTHENS RESEARCH ON HYDROGEN AS A FUTURE FUEL
4. LIST OF FINAL AND INTERIM REPORTS PUBLISHED

# 1 | Cradle-to-Grave Life-Cycle Assessment in the Mobility Sector - a meta-analysis of LCA studies on alternative powertrain technologies

Be it electric powertrains, hydrogen driven fuel cells or the use of synthetic fuels in combustion engines, a wide range of technologies and fuels are currently being discussed in order to significantly reduce harmful CO<sub>2</sub> emissions from transportation. From a scientific point of view, it is not only the direct emissions generated during operation that need to be considered, but also the greenhouse gases released when manufacturing the vehicles, when producing the energy carriers, when distributing them and – not least – during the recycling processes at the end of the vehicle's life. In order to assess this in a meaningful way, the life-cycle analysis (LCA) approach has become established. One challenge here is that the results of LCA studies are strongly dependent on the assumptions made, producing a correspondingly large spread of results.

In a meta-study performed on behalf of the FVV, the consulting firm Frontier Economics has now for the first time assessed more than 80 individual studies from the last 15 years, which encompass 110 different scenarios and 430 individual analyses. To ensure comparability, the results of all studies were standardised to a car with a total mileage of 150,000 kilometres.

As the study of various life-cycle analyses for cars does not reveal any significant differences between the combinations of combustion engine / synthetic fuels and battery electric powertrain / electricity, the powertrain technology of the future should be decided through technology-neutral competition. In particular, the framework conditions must be designed in such a way that the infrastructural investments necessary for the provision of energy – and which impact the global remaining CO<sub>2</sub> budget – are taken into account.

Dr. Bothe, who conducted the study together with Theresa Steinfort, both Frontier Economics, presented the results at the digital FVV 2020 Autumn Conference at the end of the public information sessions and answered questions from abroad international audience of FVV members and guests.

You can view the recorded German presentation [here](#).

The study as well as a briefing paper is available online:

→ [www.primemovers.de](http://www.primemovers.de) | science | taking stock

## 2 | The new research programme

### ENGINES



For the seven planning groups in the research area of engines, the members had submitted 21 new project proposals with a funding volume of 10.9 million euros (27% own funds / 73% external funds).

12 new project ideas with a funding volume of 4.6 million euros will be further developed in discussion groups until the spring conference 2021.

### TURBOMACHINES



In the Turbomachinery Planning Group the members had submitted 7 new project proposals with a funding volume of almost 1.7 million euros (11% own funds / 89% external funds).

4 new project ideas with a funding volume of almost 1.1 million euros will be further developed in discussion groups until the spring conference 2021.

The complete list of planned and ongoing projects is available online on **THEMIS**:

→ [www.themis-wissen.de](http://www.themis-wissen.de) | research programme | project list

## 3 | Alternative fuels | New combustion technologies: FVV strengthens research on hydrogen as a future fuel

Hydrogen can make a significant contribution to climate protection: as fuel for vehicles, raw material for industry or combustible for heating systems. It is a versatile energy carrier which can be used in all sectors and thus assumes a key function in the transformation process of the energy system. With the help of hydrogen, the upcoming tasks of energy distribution, system networking and increasing efficiency can be mastered. In this way, the transformation process will become an ›energy turnaround‹ that encompasses all sectors: electricity, heating, mobility.

The use of renewable »green« hydrogen as an energy carrier is not limited to fuel cells. It can also be burned 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 for advanced combustion technologies for sustainable transport and mobility.

Read more in our [media advisory](#).

A current list of projects on hydrogen research can be found on the next page

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.

Go to the Video »Developing a generic fuel cell stack«

→ [A film by FVV in cooperation with ZSW Ulm](#)

## 3 | 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
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

FVV members may find further information on each individual research project on our THEMIS transfer platform

→ [www.themis-wissen.de](http://www.themis-wissen.de)

# 4 | List of publications

## FVV Spring & Autumn Conference 2020

Due to the cancellation of the Spring Conference 2020, the related final and interim reports were presented at Autumn Conference. An overview of the publication of the contributions in the respective conference proceedings or the scientific series can be found below.

Planning Group	Project number	Project	Duration	Final (AB)/interim (ZB) report	Proceedings	Issue
PG1	1204	Fuels Sensor for Detection of Fuel Condition	15-10-2015 - 31-07-2019	AB	FT20	R593
PG1	1254	Gas Engine Performance	01-12-2016 - 30-11-2019	AB	FT20	R593
PG1	1264	Investigation Twin-scroll Turbines	01-03-2017 - 31-08-2019	AB	FT20	R593
PG1	1265	Controls for High-Load Exhaust Gas Recirculation	01-03-2017 - 31-08-2019	AB	FT20	R593
PG1	1266	Accurate Temperature Management	01-03-2017 - 31-08-2019	AB	FT20	R593
PG2	1202	CNG-DI-Engine at $\lambda=1$ -Operation with Highload-EGR	01-10-2015 - 31-10-2019	AB	FT20	R593
PG2	1233	Modelling of Turbulence II	01-07-2016 - 31-07-2019	AB	FT20	R593
PG2	1256	Water Injection in SI Engines	01-04-2017 - 30-11-2019	AB	HT20	R596
PG2	1263	Near Drop Neighbourhood	01-02-2017 - 31-10-2019	AB	HT20	R596
PG2	1282	Soot Formation at DI Gasoline Engines	01-08-2017 - 30-11-2019	AB	HT20	R596
PG2	1283	Oil Input into Combustion	01-08-2017 - 31-01-2020	AB	HT20	R596
PG2	1286	Wall Heat Transfer in Otto Engines	01-09-2017 - 31-08-2019	AB	FT20	R593
PG2	1317	Spray Diagnostics of Gasoline E-Fuels	01-08-2018 - 31-03-2020	AB	HT20	R596
PG3	1235	Modelling Emissions of Diesel Engine Combustion with Variable Valve Timing	01-08-2016 - 29-02-2020	AB	HT20	R596
PG3	1236	Gas-Diesel-Brennverfahren Gas-Diesel Combustion	01-10-2016-30-09-2019	AB	FT20	R593
PG3	1284	RCCL in Heavy Duty Engines	01-08-2017 - 30-06-2020	AB	HT20	R596
PG3	1287	Diesel Combustion Chamber Insulation	01-09-2017 - 29-02-2020	AB	HT20	R596
PG3	1310	HC/CO Model	01-01-2018 - 31-07-2020	AB	HT20	R596
PG3	1320	Spray Diagnostics of Future Diesel Fuels	01-02-2019 - 31-07-2020	AB	HT20	R596
PG4	1276	Piston Pin Bearing II	01.04.2017 - 31-03-2020	AB	HT20	R596
PG4	1277	Tribological Models of Fluids II	01-04-2017 - 31-03-2020	AB	HT20	R596
PG4	1285	JFTOT Diesel II	01-09-2017 - 30-11-2019	AB	FT20	R593



## 4 | List of publications

### FVV Spring & Autumn Conference 2020



Planning Group	Project number	Project	Duration	Final (AB)/interim (ZB) report	Proceedings	Issue
PG5	1306	Prediction Diesel Roughness with TPA	01-06-2018 - 31-12-2020	AB	HT20	R596
PG5	1361	Acoustic Transmission Loss in Turbochargers II	01-07-2019 - 31-05-2020	AB	HT20	R596
PG6	1271	EAS-Clogging	01-04-2017 - 31-08-2019	AB	FT20	R593
PG6	1294	2030+ Requirements on Emission Control Systems - MD/HD	01-02-2018 - 31-07-2020	AB	HT20	R596
PG6	1315	Oxygen Storage	01-07-2018 - 30-06-2020	AB	HT20	R596
PG7	1296	Cooling Fuel Cells	01-01-2018 - 30-09-2019	AB	FT20	R593
PG7	1298	Fuel Cell System Simulation - Membrane Water Management	01-01-2018 - 31-01-2020	AB	FT20	R593
PG7	1366	Generic Fuel Cell Stack	01-09-2019 - 30-06-2020	AB	HT20	R596
PGT	1217	Crack Behaviour of Welded Joints	01-01-2016 - 30-09-2019	AB	FT20	R594
PGT	1258	Thermally Extended Rotordynamic of Turbochargers	01-01-2017- 30-09-2019	AB	HT20	R596
PGT	1269	Mistuning with Aerodynamic Coupling II	01-07-2017 - 31-12-2019	AB	FT20	R594
PGT	1288	Lifing Methods, Multiaxial and Anisothermal (LEBEMAN)	01-09-2017 - 31-08-2020	ZB	FT20	R594
PGT	1326	Stress Relaxation Behaviour II	01-04-2018 - 31-03-2021	ZB	FT20	R594
PGT	1330	Metal-graphite Composites for Plain Bearings (MeGraV)	01-09-2018 - 31-08-2020	ZB	FT20	R594
PGT	1331	Aeroelastic Cascade DELTA	01-06-2018 - 31-01-2021	ZB	FT20	R594
PGT	314 V	Damage Tolerance on Plain Bearings	01-10-2016 - 30-06-2019	AB	FT20	R594
Board	1365	Cradle-to-Grave Life-Cycle Assessment in the Mobility Sector	01.08.2019 - 31.05.2020	AB	----	R595



**FUNDING ORGANISATIONS**

Federal Ministry for Economic Affairs and Energy  
Federation of Industrial Research Associations

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Mechanical Engineering Research Federation  
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