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Particle Reduced, Efficient Gasoline Engines: A First-Year Report on the PaREGEn Project

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Abstract

The PaREGEn project (supported by EC Grant No. 723954) is addressing the research and innovation topic GV-02-2016, "Technologies for low emission light duty powertrains", under the Horizon 2020 framework programme. This project works on the short-term aspects of that call, through the further development of gasoline engines used in mid to premium sized passenger cars. The project is being realized by a sixteen-partner consortium representing all parts of the European Automotive Industry. At the point of the TRA2018, the project will be mid-term: results will be presented in this paper and at the conference relating to the first twelve to eighteen months of progress.

Keywords: Energy Efficiency; Decarbonisation; Emissions; Environmental Impact.

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Nomenclature

CEI	Controlled Electronic Ignition
CER	Cause and Effect Relationship
CFD	Computational Fluid Dynamics
CO	Carbon monoxide
CO_2	Carbon dioxide
CVVL	Continuous Variable Valve Lift
DI	Direct Injection
EC	European Commission
EGR	Exhaust Gas Recirculation
EU	European Union
eIVC	early Intake Valve Closing
FIE	Fuel Injection Equipment
GDI	Gasoline Direct Injection
GPF	Gasoline Particulate Filter
HC	Hydrocarbon(s)
HE	Higher Education (university)
H_2O	Water
IND	Industry
INEA	Innovation & Networks Executive Agency
IPR	Intellectual Property Right(s)
LIF	Laser Induced Fluorescence
MVEM	Mean Value Engine Model
NEDC	New European Drive Cycle
NH_3	Ammonia
NO_x	Oxides of Nitrogen
NVH	Noise, Vibration and Harshness
N_2O	Dinitrogen oxide
OEM	Original Equipment Manufacturer (vehicle manufacturer)
PAH	Poly-Aromatic Hydrocarbon(s)
PEMS	Portable Emissions Measurement System
PN	Particle Number
PWI	Port Water Injection
RDE	Real Driving Emissions
SI-SRM	Spark Ignited engine Stochastic Reactor Model
SME	Small to Medium-sized Enterprise
SUPP	Supplier
SVL	Switchable Valve Lift
SW	Software
T	Task
TC	Turbocharger/d
TRL	Technology Readiness Level
TWC	Three Way Catalyst
TWLNT	Three Way Lean NO_x Trap
vGPS	Virtual Gasoline Particle Sensor
VPR	Volatile Particle Remover
VVA	Variable Valve Actuation
WLTC	World Light-duty Test Cycle
WP	Work Package
0D	Zero-dimensional
3D	Three-dimensional

1. Introduction

Growing road traffic in Europe results in detrimental effects on the environment and public health, to a level that is becoming unsustainable, despite of increasingly stringent emission standards. In particular, carbon dioxide (CO_2) and noxious emissions may not be sufficiently reduced in real driving, whilst some engine technologies may have led to increases in the emissions of nanoparticles that are undetected by current certification procedures. The challenge is to develop a new generation of engine technologies that are truly and significantly more fuel efficient than the best 2015 equivalents under real driving conditions, and to demonstrate pollutant emissions levels compliant with the Euro 6 RDE limits and particle number emissions measured to a 10nm size threshold.

In the "Particle Reduced, Efficient Gasoline Engines" (PaREGEn) project, further development of gasoline engines as used in mid to premium sized passenger cars is being made. With the electrification of the powertrains in smaller vehicles, suitable for zero emissions in urban environments, addressing mid to premium sized cars is especially important: the requirement for clean, efficient and economic engines for cars regularly used for inter-urban and regional transport becomes more urgent as well as more effective to address the societal challenges of air quality, decarbonisation and cost-effective mobility.

Through the use of state of the art development techniques, such as optical single cylinder engines, a range of modelling and simulation tools from 0D to 3D, and the application of novel engine componentry, the optimal trade-off between cleanliness and efficiency is being identified. Of special attention throughout this process is the contribution of such technologies to the reduction of particle numbers, including those particles between 10 and 23nm in size. This learning is being used for the generation of two demonstration vehicles. These demonstrators will have, as their basis, gasoline engines that use engine downsizing as their route to efficiency improvements. Nevertheless, the two approaches to achieving the targets will be different thereafter, using different combustion system, injection (fuel and water), ignition and diluent technologies, different engine air handling systems and different aftertreatment packages. As such, progress within the project is giving insight into the best way forward to meet the requirements for these gasoline engines in all vehicle classes in the coming decade.

2. Project Background

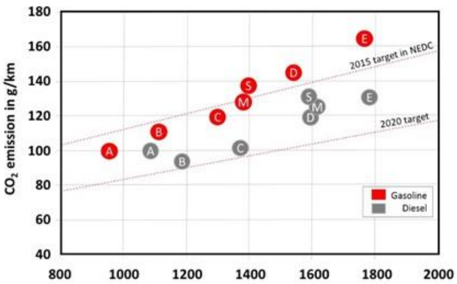


Fig. 1 CO$_2$ emissions by vehicle segment in EU for 2015 (NEDC) passenger cars versus vehicle curb weight (in kg; data source: FEV; M=MPV, S=SUV)

In Fig. 1 an overview of passenger car CO$_2$ emissions versus the vehicle curb weight is given. Globally the gasoline engine remains the dominant passenger car prime mover, with more than 80% of light-duty vehicles using these engines (International Energy Agency (2012)). A comparison of the vehicles in Fig. 1 shows approximately 10% higher CO$_2$ emissions for those with gasoline engines. The difference in the gasoline and Diesel baselines originates from the lower volumetric energy content of gasoline and the somewhat more efficient combustion process of Diesel engines. Improvements in gasoline engines have an intrinsically greater potential to lower the CO$_2$ emissions than improvements with Diesel engines: there are many more gasoline engines and the potential for improvement for gasoline engines is larger than for Diesel engines. Futhermore, those vehicle classes with CO$_2$ emissions farthest away from the 2015 and 2020 targets are those to be addressed within the PaREGEn project, namely D and E class gasoline engined vehicles, which are also those vehicle classes with the higher annual mileages. The challenge for the automotive industry is, therefore, to develop highly fuel efficient (gasoline) engines and to improve exhaust gas aftertreatment systems, in order to meet (forthcoming) EU legislation on emission standards and fuel economy under real driving conditions. At the same time, the European automotive industry has to improve competitiveness in order to successfully maintain substantial market volumes of high quality cars with attractive designs, driving characteristics and fuel economy.

3. Project Objectives

The overall objective of the PaREGEn project is to demonstrate at up to TRL 7 a new generation of gasoline direct injection engines achieving a $\geq$ 15% reduction in CO$_2$ emissions through the optimal combination of advanced engine and robust aftertreatment technologies. Modelling and simulation software will be verified that can improve the design and the control capability of the resulting vehicles. These vehicles will comply with upcoming Euro 6 RDE limits with particle number emissions measured to a 10nm size threshold.

The specific objectives of the work to be conducted within the PaREGEn project can be stated briefly as:

- 1: Establish the solid basis for model-supported engine design and control, based on an in-depth understanding of the Cause and Effect Relationship (CER) of particle formation during the in-cylinder processes;
- 2: Realise robust aftertreatment technology for high performance gasoline engines, which comply with the upcoming Euro 6(c) RDE emission standard;
- 3: Realise the optimal combination of advanced engine componentry for stoichiometric and lean burn gasoline engines by validation on engine test rigs;
- 4: Realise two demonstration vehicles by integrating the advancements in gasoline direct injection engines, aftertreatment systems and control systems;
- 5: Verification of the targeted achievements by independent testing of the demonstrator vehicles.

With Objective 1, an in-depth understanding of the in-cylinder processes and their effect on emissions, with the emphasis on the elucidation of particle formation CER, and the translation thereof into advanced modelling and simulation tools for effective engine development and control, will establish the solid basis for the model-supported design and control. With Objective 2, advanced and robust aftertreatment technology will be realised for two different gasoline engine concepts, in order to comply with the Euro 6(c) RDE emission standard. With Objective 3, advanced engines and engine components will be improved, so as to achieve an optimal combination for the stoichiometric and lean gasoline engines concepts. Essentially, the goal is to achieve minimal emissions in the combustion chamber, to ensure the final clean-up of the exhaust gases, thus to achieve the overall economy and emissions goals. The actual workhorses in the project will be the two multi-cylinder engines on the test benches, as reflected in Objective 3. By reaching Objective 3, the optimization effort in the project will have been successfully demonstrated and validated on the full engine. Objectives 4 and 5 represent the integration of the acquired know-how, engines, engine componentry, models and control strategies into the demonstrator vehicles, together with proof, by means of independent testing, that the tough targets of the call topic have been met.

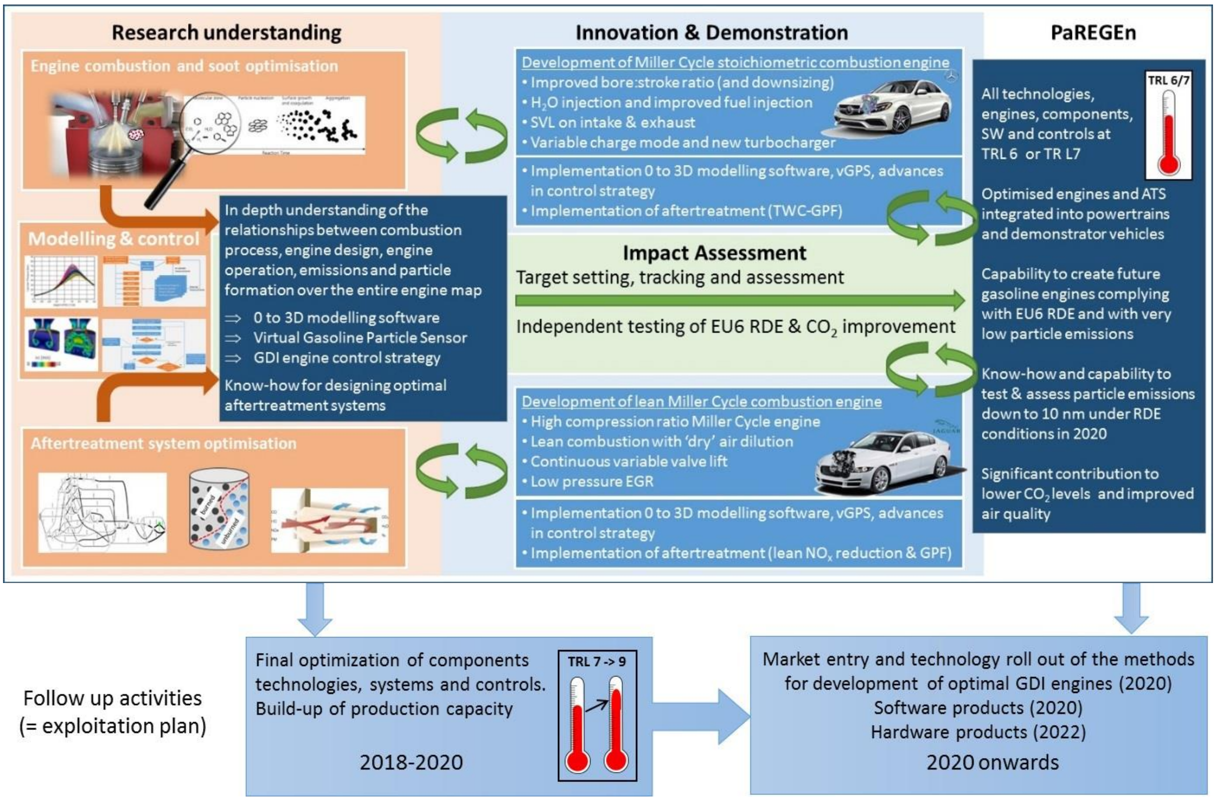


Fig. 2 PaREGEn project overall concept, structure and delineation

4. Project Approach

4.1. Overall Concept

The overall concept, approach and project delineation of the PaREGEn project are depicted in Fig. 2. The overall concept, shown in the large box of Fig. 2, comprises three major elements:

- A *Research for improved understanding element* (orange box) to acquire in-depth knowledge of the relationships between combustion processes, engine design aspects, engine operation, emissions (including CO_2) and particle control over the engine operation map; and to include this understanding in new models, simulation tools and control strategies for future application in engine development and calibration processes;
- An *Innovation and demonstration of new technology combinations element* (light blue boxes), where the developed know-how, software and control strategies are integrated and implemented in two novel optimised gasoline engines together with new engine components; both engines using high compression ratio, the Miller Cycle and highly diluted combustion, but different in dilution methods: water injection with stoichiometric or dry with lean (homogeneous or stratified) combustion;
- An *Independent assessment of their impact element* (green box) to track the progress of the project in reaching the targets and to assess the impact of the project, in terms of reaching the technological goals in these applications and in terms of societal goals: CO_2 reduction (potential) and air quality improvement.

Each of these elements interacts with the others, to ensure that the knowledge gained and technology improvements made can be applied to series production road vehicles in the short-term. The major exploitable results of the PaREGEn project are presented in the dark blue boxes. Below the box, the general outline of the follow-up plan, i.e. further advancing TRLs, in production capacity followed by market entry and commercialization, is presented.

4.2. Work Plan and Project Consortium Membership

The project is divided into two different types of activities: 'horizontal' and 'vertical'. The 'horizontal' type (Work Packages (WP) 1, 2, 5, 6 and 7) relates to generic and collaborative activities that are key to realising synergies through the project and achieving the goals of research, evaluation and dissemination (they also include the overall project management activities). The 'vertical' type relates to specific component and demonstrator vehicle development plus validation activities: these are discrete in their nature (WPs 3 and 4). All WPs are led by industry partners. The project WPs, the leader and collaborating partners in each and the tasks planned within each WP are shown in Fig. 3. The full list of the project consortium membership is given in Table 1.

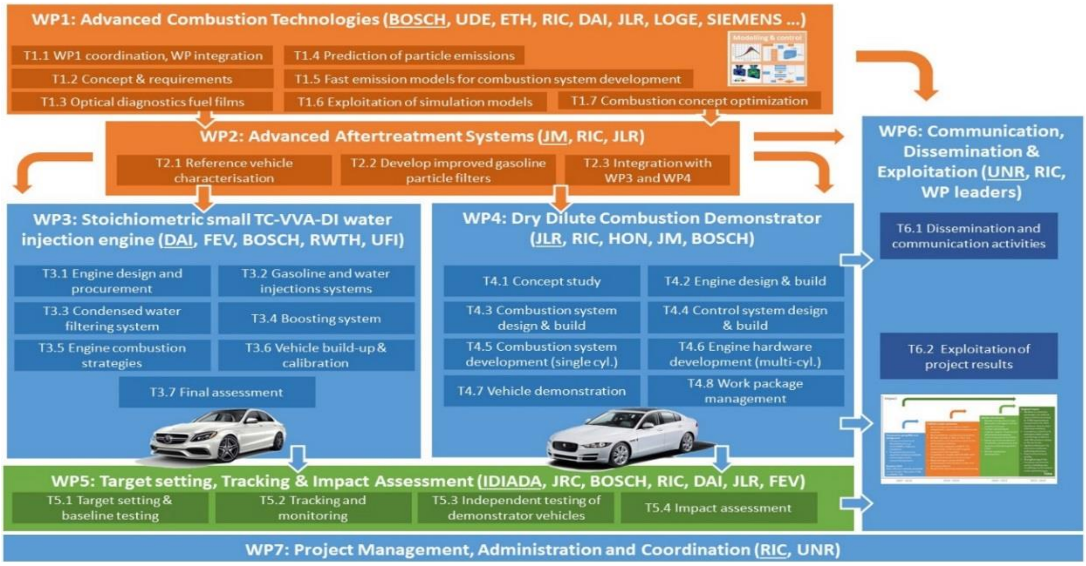


Fig. 3 The PaREGEn project work plan

Table 1. PaREGEn project consortium membership

Partner Number	Partner Name	Partner Code	Partner Country	Organisation Type
1	Ricardo UK Ltd	RIC	UK	IND-SUPP
2	Daimler AG	DAI	DE	IND-OEM
3	Jaguar Land Rover Ltd	JLR	UK	IND-OEM
4	Robert Bosch GmbH	BOSCH	DE	IND-SUPP
5	FEV GmbH	FEV	DE	IND-SUPP
6	Johnson Matthey plc	JM	UK	IND-SUPP
7	Honeywell, Spoll. S.R.O.	HON	CZ	IND-SUPP
8	JRC - Joint Research Centre	JRC	IT	RESEARCH
9	Uniresearch BV	UNR	NL	IND-SME
10	IDIADA Automotive Technology SA	IDIADA	ES	IND-SUPP
11	Siemens Industry Software SAS	SIEMENS	FR	IND-SUPP
12	Lund Combustion Engineering LOGE AB	LOGE	SE	IND-SUPP
13	Eidgenoessische Technische Hochschule Zuerich	ETH	CH	HE
14	Universitaet Duisburg - Essen	UDE	DE	HE
15	Rheinisch-Westfaelische Technische Hochschule Aachen	RWTH	DE	HE
16	UFI Filters	UFI	IT	IND-SUPP

5. Results Achieved To Date

At the time of writing, September 2017, the PaREGEn project has been running for just under a year. Progress has been in accordance with the original objectives, plan and organization: this is reported in this section.

5.1. Work Package 1 (Advanced Combustion Technologies)

The overall aim of this WP is to determine the optimal combination of measurement technologies and simulation methods for understanding the CER of particle emissions, with a focus on a model supported design and calibration approach to get closer to the optimal combination of engine and robust aftertreatment technologies. Two main activities have been initiated: establishing the solid basis for model-supported design and control of the in-cylinder processes; and, secondly, establishing the basis to realize optimal combination of advanced engine componentry for the two demonstrator concepts.

An optical flow bench has been revised to represent the geometry used within WP3: basic tests for the PWI and water wall-films characterization are planned. To support WP4, the application of the CEI system is being undertaken on a single cylinder engine, such that the ignition system can be assessed, in terms of spark current and discharge behaviour at the lean operating limit.

In order to support in-cylinder measurements of the fuel film, suitable tracers and their calibration procedure for LIF measurements with film thickness between 10 and 300µm have been devised. The first engine measurements, looking at the fuel film thickness on the piston surface have been made and appear plausible. The effects of the injection pressure on the distribution of the film thickness on the piston surface have been assessed, see Fig. 4: increasing injection pressure from 50 to 100 bar did not decrease wall wetting, but further increase to 200 bar did.

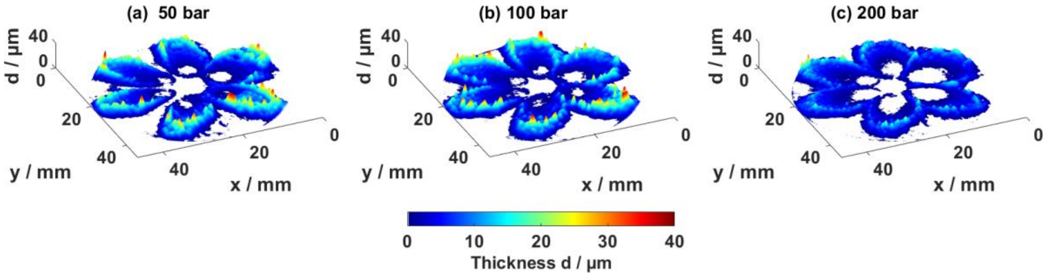


Fig. 4 The effect of injection pressure on measured piston surface film thickness distribution

Numerical simulations of the fuel spray droplets, vapour concentration, combustion effects and emissions are being advanced and correlated with the quantitative images from various experimental results. Gasoline chemical kinetics simulation software has been developed to include over 400 different species and over 5000 difference reactions; this is available for application at various levels of detail both in the 3D and 1D simulation tools being used for the analysis and the development of the vGPS. Experimental conditions, that give a reproducible flash boiling effect, for example, or ignition of the fuel vapour have been defined. High speed combustion imaging using the chemiluminescence of the premixed flame together with LIF imaging of the unburned fuel vapour, are helping to understand the areas of likely high soot formation and concentrations from the wall-film fuel evaporation after the flame front has passed, see Fig. 5.

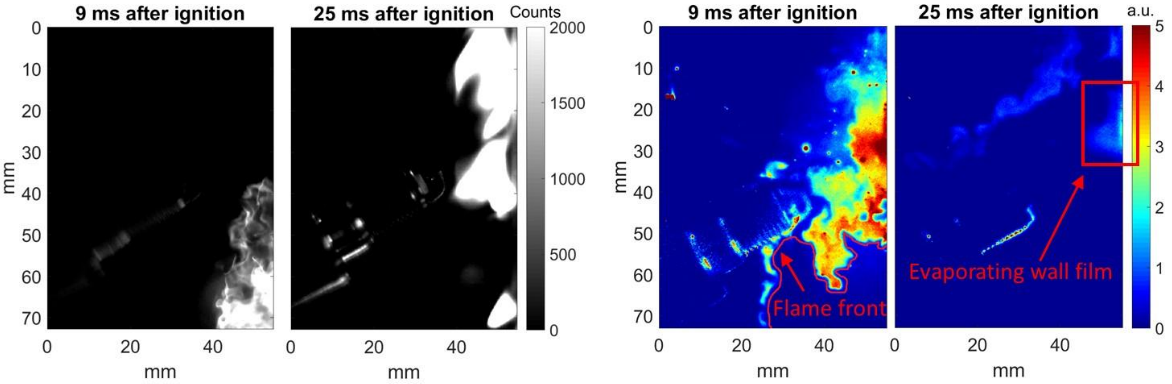


Fig. 5 Images of (a) Chemiluminecense of the combustion; and (b) LIF of the vapour under equivalent conditions

Over the coming months, engine data with a new generic six-hole fuel injector, suitable for simulation model training and validation, will be collected; the water injection and advanced ignition system testing on the single cylinder engines will be progressed including the visualization of PAHs and wall-film (water, fuel) distributions. This will be supported by the determination of fuel film thickness and quantification of vapour phase above the fuel film. In simulation, the multi-phase model will be characterized and the optimal CFD-grid size for valid flash-boiling simulation investigated; the spray-wall interaction analysis and its correlation with soot particle formation will made; and a 3D-CFD of the single-cylinder engine will be used to evaluate the new models in a real-world application. The SI-SRM model training, based on engine data, and further development of a wall-film mode and of engine maps for the SI-SRM-AMESIM coupling will be undertaken. In parallel, the capabilities of the MVEM to simulate the engine emissions in a full vehicle context over RDE cycles will be extended.

5.2. Work Package 2 (Advanced Aftertreatment Systems)

In this WP, a TWC+GPF combination is being developed (for WP3) and a lean NO_x filter combination (for WP4). A primary aftertreatment system concept has defined for WP4, including:

- a TWLNT for both stoichiometric performance and lean NO_x conversion;
- an option of a heated catalyst for improved light-off performance;
- a GPF, giving additional CO and HC conversion and high filtration efficiency; plus
- a Selective Catalytic Reduction (SCR) catalyst, for lean NO_x conversion with ammonia (urea) dosing.

Much of the emphasis of WP2 is aimed at the particulate filter, since not much is known about sub 23nm particle emissions and their control. WP1 is providing background input to this. New filter substrates and coating technologies are being developed. Vehicle testing has and is being performed to screen the filters according to determined drive cycles. Since conventional equipment does not permit sub 23nm particle measurements (especially not in a PEMS configuration), Cambustion DMS500 equipment has been used for the initial particle characterisation. However, further equipment is being used during WP5, see below, and, in future, Horiba will make equipment available following development as part of the PEMS4Nano project (see http://www.pems4nano.eu/), and measurements on the same development basis vehicle will be made by Ricardo as part of the DownToTen project (see http://www.downtoten.com/). To enable the development of the NO_x aftertreatment systems, synthetic gas rigs are being used to replicate exhaust conditions measured in WP4.

To date, several new GPF washcoats have been investigated, many of which provide a significant back-pressure improvement over a reference formulation. Cold-flow and soot-loaded backpressure analyses have been completed and filtration efficiency testing has been undertaken on an engine dynamometer test bed using a Euro 5, 2 litre, 4 cylinder, DI, turbocharged engine. Several formulations show improvements over the reference with respect to 10 to 23nm particle filtration efficiency, see Fig. 6 and 7: all development have shown a very high filtration in this size range, relative to other particle sizes.

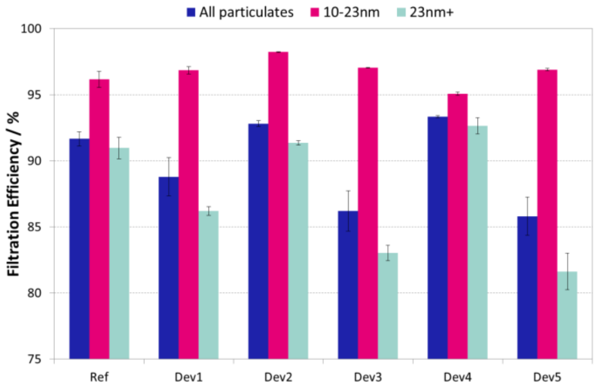


Fig. 6 The results of particle filtration efficiency measurements during several development iterations of the GPF

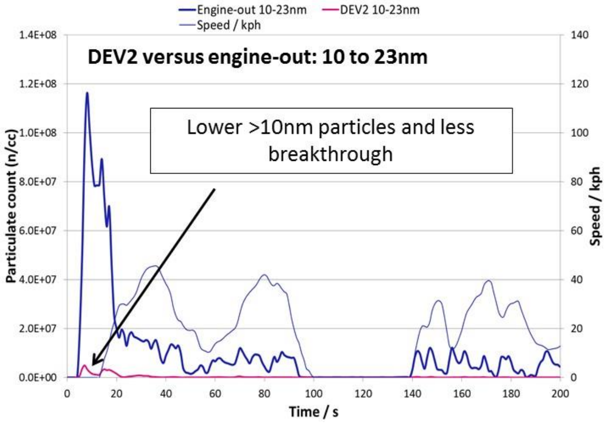
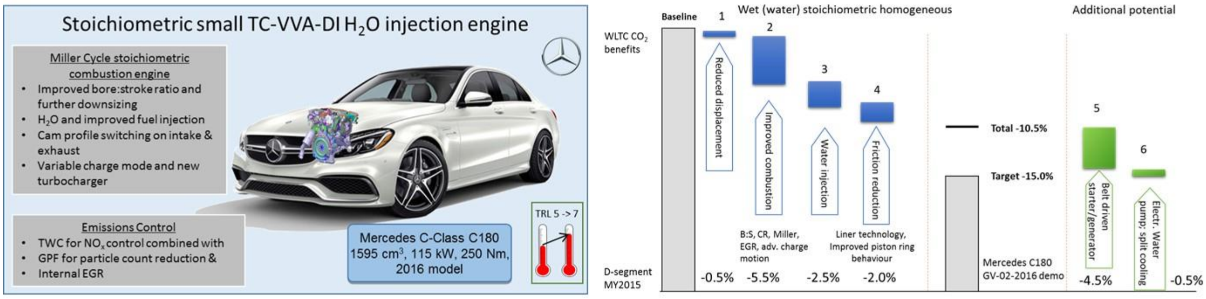


Fig. 7 Example results during transient testing, showing improved particle filtration in the 10 to 23 nm size range with one of the GPF developments

5.3. Work Package 3 (Stoichiometric small TC-VVA-DI water injection engine)

To enable a stoichiometric engine operation mode, which in turn reduces raw engine-out soot emissions and combustion temperatures, leading to lower raw NO_x emissions and knock mitigation, the benefits of water injection will be investigated by means of both engine and vehicle tests. Two different water injection strategies are available, port or direct injection. Both technologies will be investigated on the engine test bench to judge the potential and risks of each and decide on the appropriate strategy. The wet dilution strategy also requires the investigation and specification of viable water harvesting from exhaust gas and filtering technologies: first investigations will be carried out with special attention to the risks for combustion efficiency due to unwanted by-products. As a second means of dilution, internal EGR will be combined with water injection as a strategy. These efforts to minimise fuel consumption, NO_x and soot emissions under real driving conditions will be complemented by the integration of a particulate filter into the exhaust aftertreatment system.


Stoichiometric small TC-VVA-DI H_2O injection engine

Miller Cycle stoichiometric combustion engine
- Improved bore:stroke ratio and further downsizing
- H_2O and improved fuel injection
- Cam profile switching on intake & exhaust
- Variable charge mode and new turbocharger

Emissions Control
- TWC for NO_x control combined with
- GPF for particle count reduction &
- Internal EGR

Mercedes C-Class C180
1595 cm^3, 115 kW, 250 Nm,
2016 model

Fig. 8 CO_2 reduction waterfall proposed for the WP4 demonstrator vehicle

These technology (thermodynamic) applications need to be controlled, for which an optimal strategy will be developed, in terms of the DI, boosting and flexible variable valve technologies plus water injection. In parallel to the investigations, a demonstrator vehicle will be built-up, which will present the finally selected technology packages. From the initial concept study, a potential route to the targeted fuel consumption reduction has been proposed, see Fig. 8. However, the totally realizable CO_2 reduction will be calculated considering all investigations in WP3, WPs1 and 2, and former EU or other publicly funded projects, by means of vehicle longitudinal dynamics simulation.

To date, the 1D gas exchange concept phase simulation for the multi-cylinder engine has been carried out to define and start the procurement of a beneficial double scroll turbine turbocharger system. The multi-cylinder engine has been designed and procurement is underway. The water harvesting and filtering concept has been defined. Various designs of injector and spray targeting geometries have been proposed and discussed, both for the fuel and for the water injection: the final designs have been fixed, injector samples are ordered. A single cylinder engine, to study the fuel and the water spray interaction, has been designed, procured and supplied to WP1.

5.4. Work Package 4 (Dry Dilute Combustion Demonstrator)

WP4 seeks to advance the state-of-the-art on lean burn engine technology by combining advancements in fuel injection technology, boosting technology and Continuously Variable Valve Lift (CVVL) technology in a high compression ratio engine operating on the Miller Cycle (Miller (1956)). As mentioned above, the fine sub 23nm particles are also a special focus, these must be addressed in the context of lean stratified combustion, which is likely to generate more in-cylinder particulate matter than homogeneous charge combustion, and in the context of RDE, which may exacerbate the particulate problem because of greater transient behaviour of the engine. The Dry Dilute Combustion Demonstrator will make advancements against these challenges via improved DI FIE with higher injection pressures than are currently used in gasoline engines, a variable geometry turbocharger with higher boost pressures in the lower speed ranges (especially under reduced loads), and CVVL to realise the Miller Cycle with eIVC, whilst also taking advantage of the higher expansion ratio. In addition, the virtual sensor models developed in WP1 will be implemented for further improvements in combustion control.

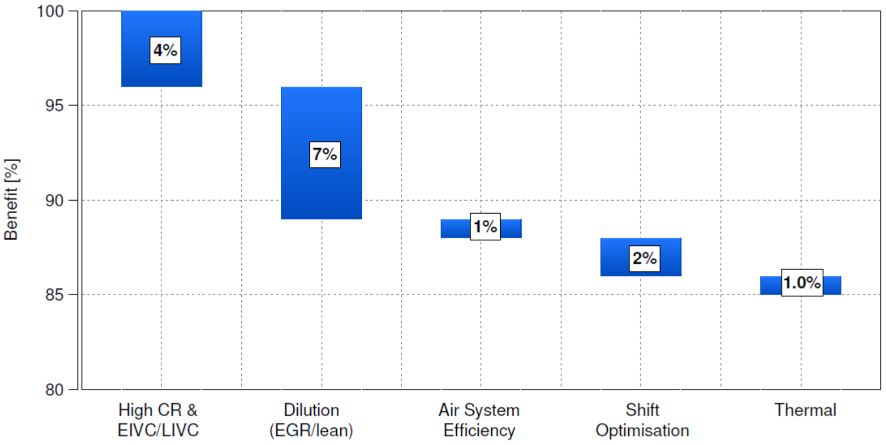


Fig. 9 Fuel consumption reduction “waterfall” for the WP5 demonstrator vehicle

To date, the concept study for this demonstrator engine and vehicle been completed. A 15% fuel consumption saving over the baseline vehicle has been targeted, with the savings versus the engine and vehicle technology distributed as in Fig. 9. The vehicle will have uncompromised brake torque and power, that is 320Nm between 1200 to 4000rev/min and 200PS between 4500 to 6000rev/min. The emissions will be compatible with EU6c + PN control to 10nm over the NEDC, WLTP-L and WLTP-H testing on the chassis dynamometer. The demonstrator vehicle will have driveability and NVH suitable for management reviews.

5.5. Work Package 5 (Target Setting, Tracking and Impact Assessment)

WP5 has started with the definition of the targets that the two demonstrator engines and vehicles (developed in WPs 3 and 4) will have to fulfil. Baseline vehicle measurements for the two demonstrator vehicles are on-going. As an independent assessment, several testing activities according to regulations (NEDC, WLTC and future RDE) are being performed on the chassis dynamometer and/or real road. The general arrangement for the chassis dynamometer vehicle tests is shown in Fig. 10; the measurement equipment used for the assessment of particle numbers and unregulated emissions (e.g. NH_3, N_2O and formaldehyde) is highlighted. The Horiba MEXA 2000SPCS allows standard PN measurement at > 23nm; the AIRMODUS Condensation Particle Counter is an additional PN measurement for particles > 7nm. This was installed such that it uses the VPR and dilution from the MEXA, hence PN > 23nm and PN > 7nm measurements could be made continuously and concurrently. The TSI EEPS was used to generate maps of the particle size and number distribution during the transient test cycles, as shown, by way of example in Fig. 11. Correlation between real road RDE measurements and replicated RDE measurements on the chassis dynamometer has been undertaken.

The tracking will be performed during WP3 and W4 through witnessing the engine testing on the bench. Then, WP5 will perform a complete testing, validation and assessment of the systems developed in the WP3 and WP4 through physical testing of the vehicles within the laboratory, with the objective to ensure the correct operation of the subsystems integrated into the demonstration vehicles. Finally, the WP will assess the impact of the PaREGEn project: as such, the work is first intended to collect the impact based on direct input from testing results and then evaluate their relative importance based on the fuel consumption of the existing European vehicle parc.

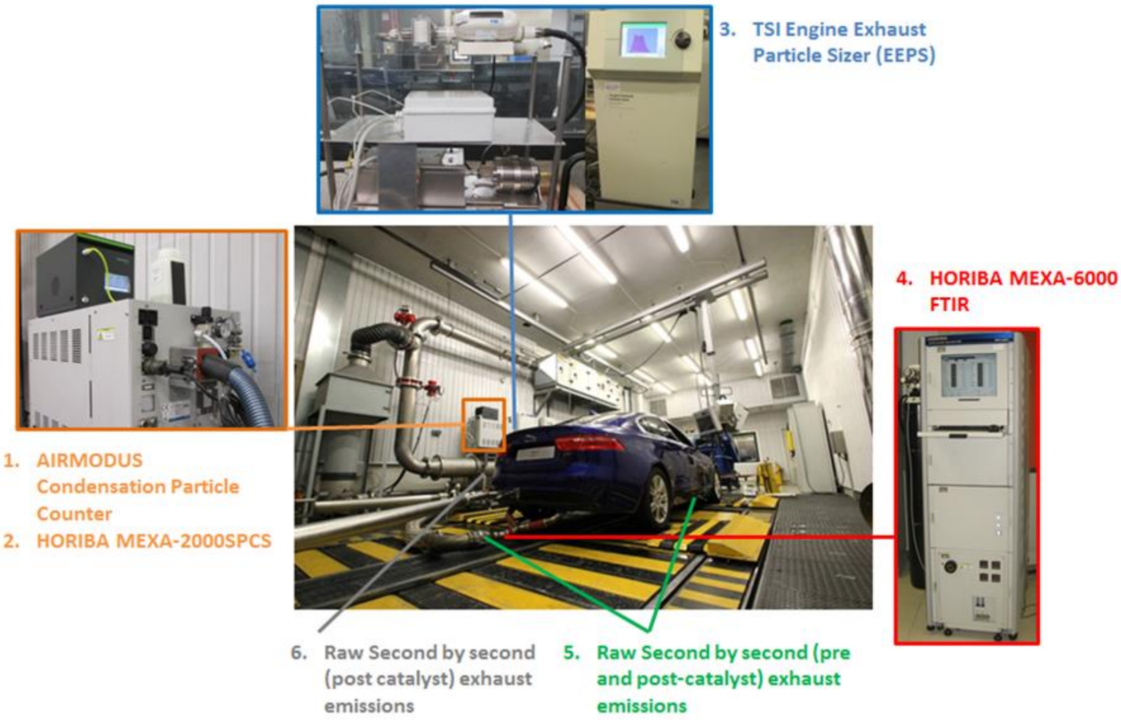


Fig. 10 The WP4 baseline vehicle on-test at IDIADA, showing some of the measurement equipment used

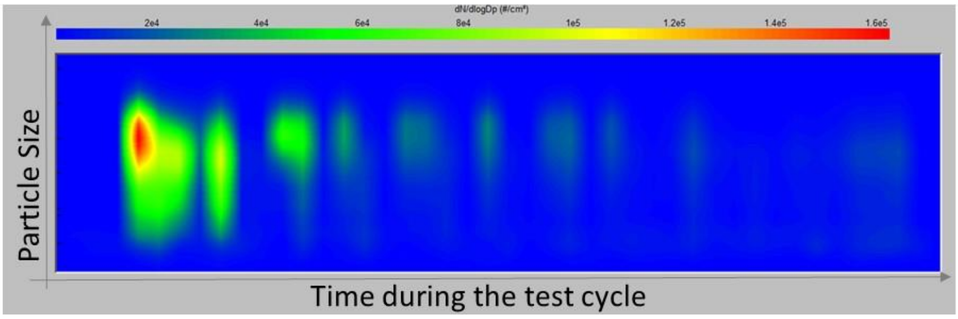


Fig. 11 Example measurements of particle size and number (on the colour scale) over a transient test

5.6. Work Package 6 (Communication, Dissemination and Exploitation)

WP6 is ensuring the appropriate and effective communication of the project and its results to relevant stakeholders, the commercial automotive community in general and to pave the way to exploitation of the PaREGEn project results. As such, a project identity and website have already been created (see www.PaREGEn.eu), a project flyer has been distributed, a press release issued announcing the start of the project (see https://ricardo.com/news-and-media/press-releases/paregen-project-on-path-to-better-gasoline-fuel-ef) and an initial dissemination plan plus contacts database created. The project is planned to be presented at EUCAR and technical papers submitted, see for example, Geiler et al. (2017).

5.7. Work Package 7 (Project Management Administration and Coordination)

WP7 focuses on the efficient execution of the PaREGEn contract, the maintenance of the consortium agreement and the protection of the IPR of the consortium. Further, the technical coordination of the PaREGEn project and liaison with the EC, via INEA, is included in this WP. The organizational structure, decision making mechanism and management procedures (including financial tracking) have been enacted: at the time of writing two project General Assembly meetings have taken place. The project milestones, MS0 Project Start, MS01 Concepts Defined have been completed and the MS02, Reference Vehicles Tested is to be completed very soon. Seven project deliverables have been submitted, public summaries of which are available via the project web site. In particular, a Risk Management and a Change Management process are in place and active. Through the coordinator, the PaREGEn project is interacting with other projects supported under the same call.

6. Future Work and Expected Impact

The PaREGEn project is currently one year into a three-year activity. Over the next two years the component, engine and aftertreatment technologies, now specified in concept, will be evaluated on the engine test bed and, if effective, fitted into two demonstrator vehicles for independent evaluation. The simulation tools currently in development will be validated through further experiment and the learning transferred into the control systems of the future vehicles. The step thereafter is market introduction: it is the full intention that the innovative technologies developed will be applied by others in the industry to ensure the maximum impact from the project. A roadmap to implementation of the technologies has been devised and is supported by more detailed plans relating to how the supply industry, for either the hardware or the simulation tools and techniques, will feed into this implementation.

The project PaREGEn has committed to achieve a 15% CO_2 reduction along with real driving emissions targets. If successful and adopted across all light vehicle classes, these short-term gasoline engine developments are projected to reduce the European vehicle parc CO_2 emissions by about 2.0 Mtonnes CO_2 in 2025 and up to 10 Mtonnes CO_2 together with around a 10% reduction in PN >10 nm in 2030. In addition to improving the European competitiveness, one of the most valuable contributions from this project will be that the new modelling and simulation tools to benefit engine design, development and control in general long after the project is completed.

7. Conclusions

In PaREGEn, further development of gasoline engines used in mid to premium sized passenger cars is being made. The project is currently one year into its three-year plan and is progressing accordingly, with the technology developments showing good progress towards achieving the overall project objectives and expected impact.

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