



# PaREGEN

Particle Reduced, Efficient Gasoline Engines

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## Summary

Within the PaREGEN project, many dissemination activities have been undertaken. Among them are the newsletters. This deliverable summarises the overall dissemination activities with a focus on the newsletters and as follow-up from the D6.1 website, D6.2 and D6.4 Dissemination plans with focus on realisation.

Overall, the PaREGEN project had a good visibility in the second reporting period, as a continuation of the first period and the plans made in D6.2 and D6.4. The results and interesting news have been shared to a large audience, the website was updated frequently and there was a good presence at many different events and exhibitions. A special Final Event was organised together with PEMS4Nano project, this had a good attendance.

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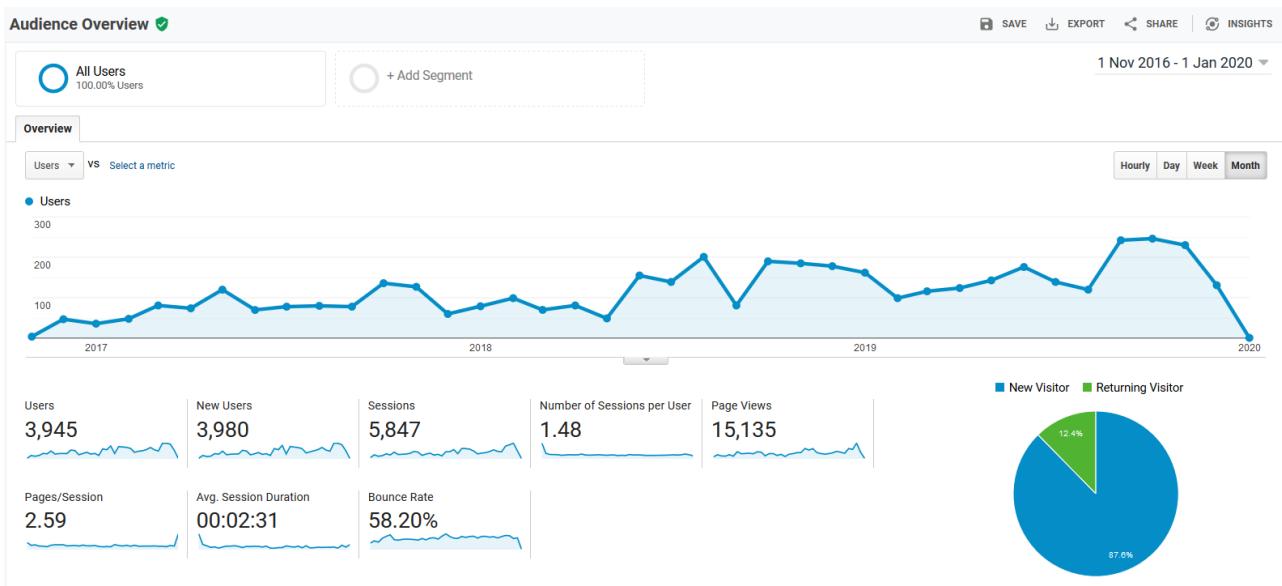
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## 1 Introduction

This deliverable summarises the overall dissemination activities with a focus on the newsletters and as follow-up from the D6.1 website, D6.2 and D6.4 Dissemination Plans, with focus on realisation. Dissemination activities have been crucial for the success of the project and the dissemination was carefully described and planned in advance, see D6.2 and D6.4. Further, the plans and activities were regularly (monthly basis) discussed in the PaREGEN Executive Board meetings.

In this deliverable the newsletters that have been sent out during the project are collated. In the first few months of the project, Uniresearch created the newsletter format and a target group database of contact details. During the project, the information for the database was collected with the support of all partners, this was implemented in the database by Uniresearch and updated regularly. The PaREGEN partners have contributed to the newsletters by providing detailed descriptions of the past/ongoing activities supported with graphical images. There was a possibility to register on the website for the newsletters: see Figure 1-1.1 Users of the PaREGEN website:



**Figure 1-1.1 Users of the PaREGEN website, number per month**

Other activities carried out within this task were the publications of a press releases and papers. In Chapter 5 you can find the list of papers that have been delivered by the partners of PaREGEN in the last period (M19 – M39).

Next to the newsletters, papers and publications that were shared within the last period of the PaREGEN project (M19 - M39), several meetings and events were attended and held. One of these events was our own Final Event of the PaREGEN and PEMs4Nano projects. About 70 guests joined the event to see the results that have been worked on over the past three years. During the two-day event, results were shared in presentations from the PEMs4Nano project, the PaREGEN project and other related projects.

## 2 Newsletters

The newsletters were a way of communicating the results from the project towards the target group. As described earlier, the target group was set-up and the contacts used to share the newsletter with them. The database was accessible via the PaREGEN project partner internal website and was maintained by the project management team (Uniresearch).

As written in the plans: “at least three newsletters will be created in the PaREGEN project, comprising the description of new developments and results. Additionally, at any time when it is regarded relevant, a newsletter will be issued, especially when news results become available”. It can be concluded that this has been achieved, via three technical in-depth newsletters and a series of newsletter related to the combined Final Event with the Pems4Nano project.

**PaREGEN Flyer:** A one-page document providing basic information about the project’s main goals, the technical approach, the expected achievements and a list of project participants in the consortium was planned. This target was also been achieved, by setting up, in Period 1, the general flyer and by updating this flyer during Period 2. In total four updates have been made.



Figure 2-1 PaREGEN Project Flyer

The subsections hereafter describe the newsletters, their content and some statistics.

### 2.1 Newsletter 1

#### 2.1.1 Newsletter 1 statistics

The newsletter was sent out on the 19<sup>th</sup> of October 2017 below you can see the statistics.



Figure 2-2 Newsletter statistics, open and click rates and unsubscriptions, PaREGEN newsletter 1 compared to Uniresearch average campaigns and peers' average.

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To see the full version of the newsletter, please see this link: <https://mailchi.mp/716748f51c2a/paregen-newsletter-1?e=%5bUNIQID%5d>

## 2.1.2 Newsletter 1 content

### Facts and Figures

Full name: Particle Reduced, Efficient Gasoline Engines

Acronym: PaREGEN

Duration: 36 months

Start date: 1st October 2016

Total budget: 11.27 M€

EC Funding: 9.95 M€

EC Contract number: 723954

Website: [www.paregen.eu](http://www.paregen.eu)

### Summary of the project

An international European consortium of 16 large industry and research organisations of various automotive fields of expertise, the “PaREGEN” consortium will demonstrate, at up to TRL 7, a new generation of gasoline direct injection engined vehicles achieving a 15% reduction in CO<sub>2</sub> emissions through the optimal combination of advanced engine and robust aftertreatment technologies.

### PaREGEN | Consortium

The consortium consists of 16 partners from 10 different European countries:

Ricardo | Daimler | Jaguar Land Rover | Bosch | FEV | Johnson Matthey | Honeywell | Joint Research Centre (EC) | Uniresearch | IDIADA | Siemens | LOGE | ETH Zürich | Universität Duisburg Essen | RWTH Aachen University | UFI Filters

### Second General Assembly short summary

Held on 21<sup>st</sup> June 2017 – hosted by RICARDO - during this meeting, all work package leaders presented the results achieved within the first nine months of the project and outlined the activities for the next period.

### Upcoming events

Annual EUCAR Conference

14 – 15<sup>th</sup> November 2017

Transport Research Arena 2018

16 – 19<sup>th</sup> April 2018

TRA 2018 is an arena for researchers, companies and public authorities active in the field of transport. It welcomes policy makers and stakeholders framing research and transport policy.

### European Commission

This project has received funding from the European Union’s Horizon2020 research and innovation programme under Grant Agreement no. 723954.

### Introduction by coordinator Simon Edwards

Welcome to the first PaREGEN project newsletter. Whilst the automotive industry has been shaken by many forces for change over the last year, the PaREGEN project has been making good progress towards its targets.

### Advanced Combustion Technologies

One of the main objectives of PaREGEN is to determine the optimal combination of measurement technologies and simulation methods for understanding of cause and effect relationships (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 (based on in-depth understanding of the CER of particle formation); and, secondly, establishing the basis to realize optimal combination of advanced engine componentry for the two demonstrator concepts.

As a first result towards this objective, a software model has been developed to predict the combustion of mixtures of various fuels, which can be used to support the design process of low emission gasoline engines.

### **Advanced Aftertreatment Systems**

An important part of the activities within PaREGEN focus on the development of advanced aftertreatment systems for the two demonstrator engines. For the Daimler stoichiometric gasoline engine, a three-way catalyst system in combination with a gasoline particulate filter is being developed. For the lean burn gasoline engine of Jaguar Land Rover, the development of a lean NOx filter combination is being pursued.

Much of the emphasis of these activities are aimed at the particulate filter, since not much is known about sub 23nm particle emissions and their control for gasoline engines. Johnson Matthey is leading the activities within this part of the project and is collaborating with a specialized company to develop new filter substrates and coating technologies.

### **Daimler and Jaguar Land Rover demonstrator vehicles**

Daimler and Jaguar Land Rover will both develop a new generation gasoline engine within PaREGEN and demonstrate within one of their premium passenger car models with a view to realising the fuel consumption saving equivalent to a reduction in CO<sub>2</sub> emissions of 15% compared to the best equivalent engines in the market in 2016, as well as ensuring the vehicle and engine they are applied to is compliant with EU6c emissions regulations with particulate control down to 10nm.

Since single measures alone are not sufficient, a bundle of integrated technical measures is needed to reach these ambitious targets. This bundle consists of downsized engines, supported by improved fuel injection, air handling and ignition systems, running at higher compression ratios via the controlled application of the Miller Cycle and highly diluted combustion.

### **Target Setting, Tracking and Impact Assessment**

Also, within the scope of PaREGEN is the complete testing, validation and assessment of the demonstrator (sub) systems through physical testing in laboratories. Within this context, a start has been made with the definition of the targets that the two demonstrator engines and vehicles 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 (New European Drive Cycle, World Light-duty Test Cycle and future Real Driving Emissions) are being performed on the chassis dynamometer and/or real road.

## 2.2 Newsletter

### 2.2.1 Newsletter 2 statistics

The newsletter was sent out on the 21<sup>st</sup> of December below you can see the statistics.



**Figure 2-3 Newsletter statistics, open and click rates and unsubscribes, PaREGEN newsletter 2 compared to Uniresearch average campaigns and peers' average.**

To see the full version of the newsletter, please follow this link: <https://mailchi.mp/776a01600de5/paregen-newsletter-3384521?e=%5bUNIQID%5d>

### 2.2.2 Newsletter 2 content

#### Facts & Figures

**Full name:** Particle Reduced, Efficient Gasoline Engines

**Acronym:** PaREGEN

**Duration:** 36 months

**Start date:** 1<sup>st</sup> October 2016

**Total budget:** 11.27 M€

**EC Funding:** 9.95 M€

**EC Contract number:** 723954

**Website:** [www.paregen.eu](http://www.paregen.eu)

#### Summary of the project

An international European consortium of 17 large industry and research organisations in various fields of automotive expertise, the “PaREGEN” consortium will demonstrate, at up to TRL 7, a new generation of gasoline direct injection engined vehicles achieving a 15% reduction in CO<sub>2</sub> emissions through the optimal combination of advanced engine and robust aftertreatment technologies.

#### PaREGEN – consortium

The consortium consists of 17 partners from 10 different European countries:

Ricardo | Daimler | Jaguar Land Rover | Bosch | FEV | Johnson Matthey | Garrett | Joint Research Centre (EC) | Uniresearch | IDIADA | Siemens | LOGE | ETH Zürich | Universität Duisburg Essen | RWTH Aachen University | UFI Filters | University of Brighton

#### Fourth General Assembly

Held on 13<sup>th</sup> and 14<sup>th</sup> December 2018 - jointly hosted by JLR and JM - during this meeting, all partners were present, each work package leader presented the results achieved within the first two years of the project and outlined the activities for the next and last year.

**PaREGEN – Project information**

Follow this link to see the flyer:

[http://www.paregen.eu/download/project\\_flyer\\_newsletters/Uniresearch\\_PaREGEN\\_flyer\\_A4\\_2018.10.01-clean.pdf](http://www.paregen.eu/download/project_flyer_newsletters/Uniresearch_PaREGEN_flyer_A4_2018.10.01-clean.pdf)

**European Commission**

This project has received funding from the European Union's Horizon2020 research and innovation programme under Grant Agreement no. 723954.

**Introduction by coordinator Simon Edwards**

Welcome to the second PaREGEN project newsletter. Over the last year, the PaREGEN project has been making good progress towards its targets, as reported several times recently in the public domain and summarized below.

**High-pressure spray assessment**

The aim of this study was to assess Lagrangian-Eulerian CFD models for the simulation of gasoline sprays under non-flashing and flashing conditions. Both conditions can be well reproduced, whilst also maintaining a quite high grid resolution (0.5 mm) in order to be suitable for combustion simulations in a real engine geometry.

**Fuel-film evaporation and combustion**

The aim is to develop optical diagnostics to investigate the impact of evaporating fuel films in combustion: as a source of polycyclic aromatic hydrocarbons (PAH), possible particle precursors and soot. High-speed colour combustion-imaging enables the spray and fuel films to be visualised; the fuel films are illuminated by a green LED, the flame front by chemiluminescence, and the soot by natural incandescence.

**Advanced aftertreatment systems**

The overall aim is to develop a gasoline particulate filter (GPF) to allow vehicles to comply with upcoming Euro 6 RDE limits with particle number emissions measured to a 10nm size threshold. At the same time the demonstrator vehicles will be supplied with complete aftertreatment systems to ensure all other regulated emissions are also suitably controlled.

**Dry dilute combustion demonstrator**

The overall aim is to demonstrate a new generation of gasoline DI engines achieving a  $\geq 15\%$  reduction in CO<sub>2</sub> based on a dry dilute lean burn combustion concept (Jaguar Land Rover).

**Stoichiometric TC-VVA-DI demonstrator**

The overall aim is to demonstrate a new generation of gasoline DI engines achieving a  $\geq 15\%$  reduction in CO<sub>2</sub>. Based on a stoichiometric small TC-VVA-DI engine with water injection (Daimler).

**Target setting, tracking and impact assessment**

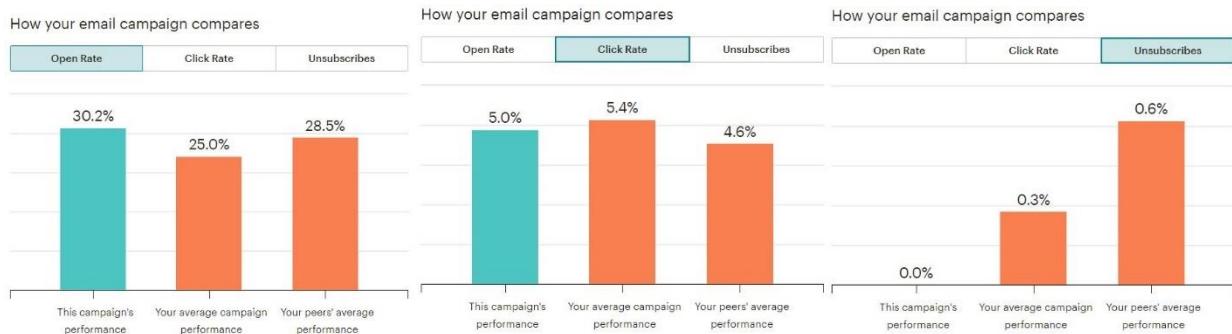
The overall aim is to set the targets, track the developments and conduct the impact assessment for the innovations developed in the demonstrator vehicles.

## 2.3 Newsletter 3 - Final Event

### 2.3.1 Newsletter 3 statistics

To inform every interested recipient, we created four different Final Event newsletters. Here we included different items and shared in every newsletter new information; for example, the agenda, to make sure everyone was informed well and encouraged to join this Final Event.

- 1) The newsletter: “Save the date 12<sup>th</sup> + 13<sup>th</sup> November 2019”, was sent out on the 11<sup>th</sup> of July 2019 and reached 30.2% open clicks online of the 279 recipients.



**Figure 2-4 Newsletter statistics, open and click rates and unsubscribes, PaREGEN newsletter 3 compared to Uniresearch average campaigns and peers' average.**

To see the full version of the newsletter, please follow this link:

<https://mailchi.mp/991838b07503/pems4nano-newsletter-1-august-3515861>

- 2) The newsletter: “Registration has started”, was sent out on the 17<sup>th</sup> of September 2019 and reached 29.6% open clicks online of the 405 recipients.



**Figure 2-5 Newsletter statistics, open and click rates and unsubscribes, PaREGEN registration for final event compared to Uniresearch average campaigns and peers' average.**

To see the full version of the newsletter, please follow this link:

<https://mailchi.mp/16a3c5b0df2d/jointfinalevent-paregen-pems4nano-nov2019?e=%5bUNIQID%5d>

- 3) The newsletter: “Two weeks left to register”, was sent out on the 17<sup>th</sup> of October 2019 and reached 24.4% open clicks online of the 400 recipients.

### D6.3 – Newsletter - PU



**Figure 2-6 Newsletter statistics, open and click rates and unsubscribes, PaREGEN newsletter two weeks left to register compared to Uniresearch average campaigns and peers' average.**

To see the full version of the newsletter, please follow this link:

<https://mailchi.mp/4d5da413d390/jointfinalevent-paregen-pems4nano-nov2019-3708353?e=%5bUNIQID%5d>

- 4) The newsletter: “One week left to register”, was sent out on the 24<sup>th</sup> of October 2019 and reached 25.7% open clicks online of the 416 recipients.



**Figure 2-7 Newsletter statistics, open and click rates and unsubscribes, PaREGEN newsletter one week left to register compared to Uniresearch average campaigns and peers' average.**

To see the full version of the newsletter, please follow this link:

<https://mailchi.mp/5ac5190b8323/jointfinalevent-paregen-pems4nano-nov2019-3708357?e=%5bUNIQID%5d>

- 5) The newsletter: “Looking back at a successful event”, was sent out on the 3<sup>rd</sup> of December 2019 and reached 30.1% open clicks online of the 413 recipients.



**Figure 2-8 Newsletter statistics, open and click rates and unsubscribes, PaREGEN newsletter with all results from the final event compared to Uniresearch average campaigns and peers' average.**

To see the full version of the newsletter, please follow this link:

<https://mailchi.mp/a6e50ace087b/jointfinalevent-paregen-pems4nano-nov2019-3774929?e=%5bUNIQID%5d>

### 2.3.2 Newsletter 3 content

The newsletters created an overall view of how the two day event was going to be. Project and partner information from both project coordinators were shared in every newsletter. Later on, different subjects were being shared, which you can find below.

#### Joint Final Event - Showcasing the result

On behalf of the partners in PaREGEN and PEMs4Nano, two Horizon 2020 projects, we would like to invite you to the Joint Final Event on November 12<sup>th</sup> & 13<sup>th</sup> 2019. The final event will be hosted by Applus IDIADA in Santa Oliva near Barcelona, Spain.

Our programme will allow you to take a close look at the latest developments. You will be able to see new gasoline combustion engine technology in action in a vehicle on a chassis dynamometer. During a test drive you can see 10 nm particle emissions being measured in real-time. State-of-the-art simulations will allow you to dive into the fundamental mechanisms behind these technologies. There will be various product demonstrations in an extensive exhibition. And any question you may still have, will be answered during the technical presentations, which may include live scientific measurements.

Get active and join us; we are looking forward to meeting you there!

#### Health effects of air pollution from a toxicological perspective - effects of source specific emissions (Nov. 13<sup>th</sup> - 09:00 AM)

- Prof.dr. Flemming R. Cassee – RIVM

Much of the discussion on health effects due to exposure to air pollution is focussed on particulate matter. This is regulated in the EU based on size mass, i.e. PM10 and PM2.5, assuming that all PM is equally toxic. Much of the research has been focused on tailpipe emissions from road traffic but more recently emphasize is also given to wear particles such as emitted from tyres and brakes...

#### Presentation of 10 nm PEMS technology

- Prof. Dr. Marcus Rieker – Horiba

The partners in PEMs4Nano have succeeded in developing portable emissions measurement systems (PEMS) to measure particles that are 10 nm or larger. A catalytic stripper has been developed and optimized to robustly and reliably detect solid particles for the sub-23 nm regime...

#### Presentations on low CO<sub>2</sub> Engines and Vehicle Technology

- *Various presenters - PaREGEN*

Within the PaREGEN project, new engines have been developed for mid to premium sized vehicles. These engines have been found to have significantly better fuel economy (up to 15% compared to baseline) whilst the vehicles are still able to achieve better than the most stringent passenger car emissions regulations in Europe to date...

#### Presentations on understanding the cause and effect relationships behind particle emissions

- *Various presenters – PaREGEN*

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Knowing how and why particle emissions arise in gasoline engines is key to being able to control them at source in future vehicles. New techniques to look in-cylinder and see the precursors to these particle emissions have been devised within the PaREGEN project...

### **PaREGEN**

During the **PaREGEN** presentations, the technologies introduced into the two demonstrator vehicles to achieve the ambitious fuel economy and emissions targets will be described in detail: hardware and software will be on show in the exhibition. In addition, the new understanding of the cause and effect relationships for particle formation in-cylinder will be given: in full colour, in real-time!

### **PEMs4Nano**

During the day PEMs4Nano will talk about the emission measurement system for sub-23 nm particles that they have developed. In addition, a Model Guided Application (MGA) has been developed as well. The talks will go deeper and more become more detailed about the detailed physico-chemical and advanced statistical algorithms models, which are combined to model the particulate emissions. These models help to optimize the emissions measurement system.

## **2.4 Newsletter – final newsletter**

### **2.4.1 Newsletter 4 Content**

This newsletter will be sent out in January 2020, as final message from the PaREGEN project, with all latest results included. The following subjects will be addressed:

#### **Combustion research**

The results related to the development of the cause and effect relationship of particle formation (mostly from WP1), with the focus on the final results (links will be provided to the public final reports).

#### **Demo 1 + demo 2**

During the PaREGEN project two demonstrators were produced, one at Daimler and one at Jaguar Land Rover. Since the remaining report on these subjects have been delivered, we wish to provide a short summary of the outcome of the work in the newsletter. We will ensure that the summaries of these deliverables are uploaded on the PaREGEN website, and we will make a link to the location in the newsletter.

#### **WP5 results**

Uniresearch will update the website of the PaREGEN project, including the WP5 results. These will be shared in the newsletter, including a link to the website.

#### **Final Event recap**

The Final Event took place on the 12<sup>th</sup> and 13<sup>th</sup> of November 2019. After the event, Uniresearch send out a newsletter to all those who were invited. Within this section, we will make a brief recap on the Final Event including a link to the website, where all posters and presentations can be found.

#### **Zenodo publications**

In 2018 and 2019 publications that were connected to the PaREGEN project were shared on ZENODO. ZENODO is a general-purpose open-access repository developed under the European OpenAIRE program. It allows us to deposit data sets, research software, reports and any other research related digital artefacts. In total PaREGEN has uploaded 9 different reports on this tool. Within the last newsletter, we will mention these reports and link readers to the ZENODO website.

### 3 Press release

#### 3.1 Purpose of the press release

The press releases that were shared within this project specified the projects' overall aims and objectives. To increase the visibility and support of the PaREGEN project, the press releases were to help the impact generation of the PaREGEN project and its results.

In total we sent out three press releases, in the table below you can see in which months the press releases were published and which partner contributed.

Number	Name	Partner	Publishing Month
1	PaREGEN project on path to better gasoline fuel efficiency and reduced particle emissions	Ricardo & Uniresearch	M08
2	Ricardo to share insights on low emissions and hybrid research projects at TRA, Vienna	Ricardo	M19
3	Ricardo to share insights into next generation ultra-clean and high-efficiency engines	Ricardo	M32

#### 3.2 Press release 1

This press release was published on the 17<sup>th</sup> of May 2017 by Uniresearch. The overall purpose of this document was to introduce the PaREGEN project and the coordinator.

PaREGEN project on path to better gasoline fuel efficiency and reduced particle emissions - Global engineering, environmental and strategic consultancy

PaREGEN project on path to better gasoline fuel efficiency and reduced particle emissions - Global engineering, environmental and strategic consultancy

the optimal trade-offs between cleanliness and efficiency are being identified for such next-generation gasoline engines.

The results of this work will be used for the creation of two demonstration vehicles, which will be powered by gasoline engines yet to be introduced to the market. It is intended that the two vehicles will use contrasting approaches to achieving the project targets, they will use different new combustion systems, fuel injection and diluent technologies (e.g. lean operation or water injection), ignition systems, engine air handling systems and aftertreatment packages. Progress on the project is already offering insights into the best way forward in meeting emissions and efficiency requirements for comparable gasoline engines over the coming decade.

17 May 2017

Home page / News and media / Press releases / PaREGEN project on path to better gasoline fuel efficiency and reduced particle emissions

- Particle Reduced, Efficient Gasoline Engines (PaREGEN) project focuses on the twin challenges of improving the fuel efficiency of next-generation gasoline engines while controlling emissions of particles as small as 10 nm
- Ricardo coordinating the research initiative as part of a 16-partner consortium, representing all sectors of the European automotive industry

While powertrain electrification offers significant opportunities to reduce vehicle emissions in the urban environment, the gasoline engine is likely to continue to play a significant role in passenger cars – both in conventional and hybrid powertrains – for many years to come. This is particularly the case for mid- to premium-sized passenger cars that are used for longer-distance journeys. Furthermore, in parallel with efforts to improve the efficiency and reduce the CO<sub>2</sub> emissions from such vehicles, there is growing recognition that a potential engine development challenge exists in the form of particle emission numbers below the current 23 nm diameter size measurement threshold.

The PaREGEN project has, therefore, committed to achieve a 15 percent CO<sub>2</sub> reduction along with real driving emissions targets, and aims to assess the emissions of particles as small as 10 nm from mid- to premium-sized passenger cars. Through the use of state-of-the-art development techniques, such as optically accessed single cylinder engines, a range of modelling and simulation tools and the application of novel engine componentry,

"Ricardo is pleased to be coordinating and working as part of the 16-member PaREGEN consortium, including key automotive industry partners such as Daimler, Jaguar Land Rover, Bosch, Johnson Matthey, IDIADA, FEV, Honeywell, LOGE AB, Siemens Industry Software and UFI Filters." commented Ricardo global technology director, Simon Edwards. "Ensuring that the next generation of gasoline combustion engines makes advances in fuel efficiency and CO<sub>2</sub> reduction, whilst also limiting nanoparticle emissions, is an imperative for the automotive industry. I am pleased that we will be welcoming all members of the PaREGEN consortium to the second General Assembly of the project, to be hosted at the Ricardo Centenary Innovation Centre at Shoreham-by-Sea, UK, in June, when we will review the first nine months' progress and confirm plans for the coming year."

<https://ricardo.com/news-and-media/press-releases/paaren-project-on-path-to-better-gasoline-fuel-efficiency-and-reduced-particle-emissions/> [16-2-2019 08:39:48]

Figure 3-1 Press release of PaREGEN, by Ricardo

### 3.3 Press release 2

This press release was published on the 19<sup>th</sup> of April 2018 by Ricardo. The overall purpose of this document was to highlight the insights on low emissions and hybrid research projects at TRA, Vienna, that Ricardo would be presenting.

#### PRESS RELEASE

9 April 2018

##### Ricardo to share insights on low emissions and hybrid research projects at TRA, Vienna

In a total of six papers co-authored with its research partners, Ricardo will share some of the results of four key automotive powertrain research projects at the forthcoming Transport Research Arena Vienna 2018, to be hosted from 16<sup>th</sup> to 19<sup>th</sup> April

Transport Research Arena (TRA) 2018 is a European forum for researchers, companies and public authorities active in the field of transport, as well as policy makers and stakeholders framing research and transport strategy. In TRA's scientific and technical sessions, a broad spectrum of research and innovation activities will be discussed, ranging from basic research findings on application-oriented engineering to the socio-economic impacts of policies and standards.

In the paper *Particle Reduced, Efficient Gasoline Engines: A First-Year Report on the PaREGEN Project*, Ricardo will share the mid-term results of this important European research initiative. The seventeen-partner PaREGEN project is committed to achieve a 15 percent CO<sub>2</sub> reduction along with real driving emissions targets, and aims to assess the emissions of particles as small as 10 nm, based on mid- to premium-sized gasoline powered passenger cars. Through the use of state-of-the-art development techniques, such as optically accessed single cylinder engines, a range of modelling and simulation tools and the application of novel engine componentry, the optimal trade-offs between cleanliness and efficiency are being identified for such next-generation gasoline engines.

In the second paper, *IMPERIUM – IMplementation of Powertrain Control for Economic and Clean Real driving emission and fuel ConsMption*, opportunities are identified for powertrain optimization from the control strategy point of view; specifically, through modelling the physical behaviour of the truck and identifying the opportunities for control optimisation using additional, look-ahead mission-related information. The



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powertrain configuration gives the possibility to achieve hybrid vehicle functionality, such as regenerative braking, acceleration assistance and limited EV operations, while not detracting from the vehicle packaging and being a lower cost solution appropriate for rapid market uptake. Initially the powertrain has been developed with a state of the art electrical machine, rated at up to 15kW when running at 48V. However, an advanced electrical machine and power electronics have been developed, which demonstrate almost a 25kW rating within the same practical package.

The final paper co-authored by Ricardo, together with Concawe and Shell Global Solutions, is entitled *Comparison of real driving emissions and chassis dynamometer tests on emissions of two fuels in three Euro 6 diesel cars*. This paper documents recent research work commissioned by Concawe to build understanding of the emissions performance of late Euro 6 diesel passenger cars with different aftertreatment systems over various regulatory chassis dyno cycles and RDE on-road testing. The project compares emissions of these vehicles on two extreme fuels when run under comparable road load conditions, and also aimed to ascertain if there were any detectable fuel effects.

Ends

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IMPERIUM consortium consists of major European actors to provide a 100 percent European value chain for the development of future powertrain control strategies for trucks: they are committed to achieve a fuel consumption reduction of 20 percent, while keeping the vehicle within the legal limits for pollutant emissions.



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A further three papers co-authored by Ricardo to be presented at TRA 2018, relate to the twenty-five partner European COMPetitiveness in Commercial Hybrid and AutoMotive PowertrainS (ECOCHAMPS) project. The project has developed efficient, compact, low weight, robust and cost-effective hybrid powertrains for both passenger cars and commercial vehicles. The improvements are an increased functionality, improved performance, comfort and safety, and emissions levels better than Euro 6/VI.

The paper *ECOCHAMPS – Project Targets, their Tracking and the Evaluation of the Demonstrator Vehicles built to date*. The paper also looks towards the development of current and future CO<sub>2</sub> declaration methods for hybrid heavy-duty commercial vehicles, supporting the deployment of next-generation propulsion technologies for decarbonizing freight transport.

The paper, *European Competitiveness in Commercial Hybrid and Automotive Powertrains (ECOCHAMPS): A Modular System and Standardization Framework (MSF) and the Development of MSF-conform Components*, presents work relating to the pre-standard Modular System and Standardization Framework (MSF), which is also a focus of ECOCHAMPS. While there are existing standards for drivetrain components and electrically driven auxiliaries of light-duty vehicles such as hybrid passenger cars, no such similar standards exist for heavy-duty vehicles. This paper focuses on the MSF approach, the development of MSF-conforming drivetrain components and auxiliaries, the results from the component integration into the demonstrator vehicles and the outlook for the final demonstrator vehicle assessment.

The penultimate paper, *European Competitiveness in Commercial Hybrid and Automotive Powertrains (ECOCHAMPS): Effective Passenger Car Hybridisation via a 48V DCT*, gives results from the overall development and testing of the demonstrator vehicle and advanced electrical system. In this vehicle, the powertrain is fitted with an electrical machine directly coupled to a double clutch transmission (DCT). As such, the

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Ricardo plc is a global, world-class, multi-industry consultancy for engineering, technology, project innovation and strategy. Our purpose is to providing outstanding value through quality engineering solutions focused on high efficiency, low emissions, class-leading product availability and robust strategic implementation. With a culture of delivering excellence and value through technology, our client list includes the world's major transportation original equipment manufacturers, supply chain organizations, energy companies, financial institutions and governments. Guided by our corporate values of respect, integrity, creativity & innovation and passion, we enable our customers to achieve sustainable growth and success. Ricardo is ranked in the top 100 of the Corporate Social Responsibility Index, which identifies global companies that demonstrate strong environmental, social and governance (ESG) practices. For more information, visit [www.ricardo.com](http://www.ricardo.com).

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**Figure 3-2 Second press release, by Ricardo**

### 3.4 Press release 3

This press release was published on the 25<sup>th</sup> of February 2019 by Ricardo. The overall purpose of this document was to highlight the insights into next-generation ultra-clean and high-efficiency engines that Ricardo would be sharing at a forthcoming conference in the UK.

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premium-sized passenger cars that demonstrate a fifteen percent reduction in CO<sub>2</sub> emissions under Euro 6d RDE legislation, and control of particle number emissions measured down to 10 nanometres.



#### PRESS RELEASE

25 February 2019

#### Ricardo to share insights into next-generation ultra-clean and high-efficiency engines

**At the prestigious Future Powertrain Conference 2019 (FPC2019), to be hosted in Birmingham, UK, on 27-28 February, Ricardo will present some of its exciting research work which focuses on future high fuel efficiency and low emissions gasoline engine technology for mass market passenger cars**

Whether used in conventional or hybrid-electric powertrains, the gasoline engine is likely to remain a dominant source of motive power for passenger cars for many years to come, particularly in the mid- to premium-size vehicle sectors. A key challenge, therefore, is to develop a new generation of gasoline engine technologies that are significantly more fuel efficient under real driving conditions than today's products, and which meet future emissions legislation while offering competitive performance and affordability.

In the presentation *A New Generation of Lean Gasoline Engines for Premium Vehicle CO<sub>2</sub> Reduction*, part of the 'Electrified Engines' session of FPC2019, Ricardo will outline some of the results to date of the company's work on the PaREGEN (Particle Reduced, Efficient Gasoline Engines) project. Supported by the EU Horizon2020 framework programme, PaREGEN is a seventeen-partner research activity which, through the use of state-of-the-art development techniques and the application of novel engine componentry, is identifying the optimal trade-off between cleanliness and efficiency in the next generation of gasoline engines. In particular, the project seeks to develop the capability for designing future gasoline engine technologies for mid-

Ricardo and its partners in the PaREGEN project are developing a two-litre turbocharged, direct-injection gasoline engine, with a lean-homogeneous combustion system matched to a lean- and stoichiometric-capable exhaust aftertreatment. As will be related in the presentation, initial vehicle-based tests have shown that the engine technology package is able to realize a substantial reduction in fuel consumption and to switch successfully between stoichiometric and lean operating modes in a range of conditions. While work remains to be done in the PaREGEN project, these initial results provide significant confidence that the consortium is on track to achieve the prescribed fifteen percent reduction in CO<sub>2</sub> emissions, meet Euro 6d RDE emission thresholds and deliver particle reduction down to 10nm.

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 The PaREGEN project has received funding from the European Union's Horizon 2020 Programme for research, technological development and demonstration under Grant Agreement no. 723954.

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**Figure 3-3 Third press release, by Ricardo**

## 4 Final Event

The PaREGEN and PEMs4Nano Joint Final Event took place on November 12<sup>th</sup> & 13<sup>th</sup>, 2019. The Final Event was hosted by Applus IDIADA in Santa Oliva near Barcelona, Spain and co-organised by Uniresearch.

In the morning, the director of IDIADA welcomed both projects on their premises, where later on presentations and exhibitions were given. Below you can find the listing of and links to the presentations that were held during the Final Event. The posters can be found on this page: <https://paregen.eu/posters/>



**Figure 4-1 The two PaREGEN demonstrator vehicles at the final event at IDIADA (left) and the groups picture at the final event with all project partners and invited guests**

This two-day event allowed the attendees to take a close look at the latest developments. They were shown new gasoline combustion engine technology in action on a chassis dynamometer. During a test drive, 10 nm particle emissions were being measured in real-time. State-of-the-art simulations allowed the visitors to dive into the fundamental mechanisms behind these technologies. There were various product demonstrations in an extensive exhibition.

During the PaREGEN presentations, technologies were introduced that have been applied to the two demonstrator vehicles to achieve the ambitious fuel economy and emissions targets. The hardware and software that was used was shown near the Exhibition Area and on the chassis dynamometer. In addition, the new understanding of the cause and effect relationships for particle formation in-cylinder were given in full colour and in real-time. Below you can find a listing of and the links of these presentations.

### Presentations of PaREGEN & PEMs4Nano

- Welcome by IDIADA by Miquel Maureso – IDIADA
  - Link:<https://paregen.eu/wp-content/uploads/2019/11/1.1-1-Welcome-PaREGEN-PEMs4Nano-1.pdf>
- Independent evaluation of PaREGEN and PEMs4Nano results By Susanna Paz & Antonio Pérez – IDIADA
  - Link:<https://paregen.eu/wp-content/uploads/2019/11/1326I8R.pdf>
- Keynote speaker Flemming Cassee – RIVM
  - Link:<https://paregen.eu/wp-content/uploads/2019/11/2.1-1-Cassee-PEMS4NANO-PAREGEN-Final-Event.pdf>

### Projects related to PaREGEN & PEMs4Nano

- DiePer by Herwig Ofner – AVL
  - [https://paregen.eu/wp-content/uploads/2019/11/1.5-14-PaREGENPEMs4Nano\\_FinalEvent\\_dieper\\_Ofner.pdf](https://paregen.eu/wp-content/uploads/2019/11/1.5-14-PaREGENPEMs4Nano_FinalEvent_dieper_Ofner.pdf)
- EAGLE by Christof Schernus – FEV
  - [https://paregen.eu/wp-content/uploads/2019/11/1.5-15-EAGLE\\_PaREGEN\\_FinalEvent.pdf](https://paregen.eu/wp-content/uploads/2019/11/1.5-15-EAGLE_PaREGEN_FinalEvent.pdf)
- DownToTen by Andy Ward – Ricardo
  - [https://paregen.eu/wp-content/uploads/2019/11/1.5-16-DownToTen\\_Any-Ward.pdf](https://paregen.eu/wp-content/uploads/2019/11/1.5-16-DownToTen_Any-Ward.pdf)
- SURREAL-23 by Apostolos Tsakis – CERTH
  - <https://paregen.eu/wp-content/uploads/2019/11/1.5-17-SURREAL-23-overview.pdf>
- UPGRADE by Jeremy Gidney – Johnson Matthey
  - [https://paregen.eu/wp-content/uploads/2019/11/1.5-18-UPGRADE\\_S.-Zandiri\\_Particle-emissions-from-GDI-combustion-system\\_final.pdf](https://paregen.eu/wp-content/uploads/2019/11/1.5-18-UPGRADE_S.-Zandiri_Particle-emissions-from-GDI-combustion-system_final.pdf)

### Presentations of PaREGEN

- Introduction to the project by Simon Edwards – Ricardo
  - Link: <https://paregen.eu/wp-content/uploads/2019/11/1.1-3-PaREGEN>Welcome-and-Brief-Introduction-from-the-project-officer-read-by-Simon-min-1-2.pdf>
- Project overview by Simon Edwards – Ricardo
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/1.2-5-PaREGEN\\_Project-Overview\\_Simon-Edwards-min-1.pdf](https://paregen.eu/wp-content/uploads/2019/11/1.2-5-PaREGEN_Project-Overview_Simon-Edwards-min-1.pdf)
- Stoichiometric small TC-VVA-DI water injection engine by Normann Freisinger – Daimler
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/1.2-6-PaREGEN\\_DAI\\_WP3\\_Normann-Freisinger.pdf](https://paregen.eu/wp-content/uploads/2019/11/1.2-6-PaREGEN_DAI_WP3_Normann-Freisinger.pdf)
- Dry Dilute Combustion by Niall turner – Jaguar Land Rover & Andy Lane – Ricardo
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/1.2-7-Final-Event\\_PAR\\_Presentation\\_WP4\\_published.pdf](https://paregen.eu/wp-content/uploads/2019/11/1.2-7-Final-Event_PAR_Presentation_WP4_published.pdf)
- Advanced Combustion Technologies by Andreas Manz – Bosch
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/2.2-2-PaREGEN\\_introWP1\\_Andreas-Manz.pdf](https://paregen.eu/wp-content/uploads/2019/11/2.2-2-PaREGEN_introWP1_Andreas-Manz.pdf)
- Advanced Combustion Technologies by Sebastian Kaiser – UoD
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/2.2-3-PaREGEN\\_WP1\\_Sebastian-Kaiser.pdf](https://paregen.eu/wp-content/uploads/2019/11/2.2-3-PaREGEN_WP1_Sebastian-Kaiser.pdf)
- Application of optical diagnostic techniques in a single cylinder engine by Jan Niklas Geiler – Bosch
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/2.2-4-PaREGEN\\_WP1\\_Jan-Geiler.pdf](https://paregen.eu/wp-content/uploads/2019/11/2.2-4-PaREGEN_WP1_Jan-Geiler.pdf)
- Gasoline combustion modelling using detailed, reduced and tabulated chemistry by Fabian Mauss – LOGE
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/2.2-5-PaREGEN\\_WP1\\_Fabian-Mauss.pdf](https://paregen.eu/wp-content/uploads/2019/11/2.2-5-PaREGEN_WP1_Fabian-Mauss.pdf)
- CRFD By Yuri Wright – ETH
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/2.2-6-PaREGEN\\_FinalEvent\\_PresentationCRFD\\_VGPS\\_ETH\\_SIEMENS\\_ForDistribution-klein.pdf](https://paregen.eu/wp-content/uploads/2019/11/2.2-6-PaREGEN_FinalEvent_PresentationCRFD_VGPS_ETH_SIEMENS_ForDistribution-klein.pdf)
- Looking to the Future by Simon Edwards – Ricardo & Cor van der Zweep – Uniresearch
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/2.5-17-PaREGEN-Project-Looking-to-the-Future-Simon-Cor\\_FINAL.pdf](https://paregen.eu/wp-content/uploads/2019/11/2.5-17-PaREGEN-Project-Looking-to-the-Future-Simon-Cor_FINAL.pdf)

- Looking to the Future by Marco Mammetti – IDIADA
  - Link: [https://paregen.eu/wp-content/uploads/2019/11/2.5-18-PaRPEMs\\_FinalEvent\\_Future\\_Marco-Mammetti.pdf](https://paregen.eu/wp-content/uploads/2019/11/2.5-18-PaRPEMs_FinalEvent_Future_Marco-Mammetti.pdf)
- Looking to the Future by Christof Schernus – FEV
  - Link: <https://paregen.eu/wp-content/uploads/2019/11/2.5-19-20191113-FutureOutlook-Schernus.pdf>

## 5 Dissemination achievements

In the second period of the PaREGEN project, multiple papers were written and shared. You can find them listed below.

### 5.1 Papers and publications

In total 17 publications have been achieved, of which at least 3 publications are peer reviewed and made Green open access. You can find the publications in appendix A.

### 5.2 Press releases

- [1] PaREGEN project on path to better gasoline fuel efficiency and reduced particle emissions
- [2] Low emissions and hybrid research projects at TRA Vienna
- [3] Next generation ultra clean and high efficiency engines

### 5.3 ZENODO

To maximise the dissemination of the papers of the PaREGEN project, we used the Zenodo community to share our findings. Zenodo allowed us to share, curate and publish our papers to others than just the PaREGEN partners. The citation information is also passed to DataCite and onto the scholarly aggregators. The papers we published on Zenodo are the following:

- [4] Edwards S., Verhagen E. (2018). [Particle Reduced, Efficient Gasoline Engines: A First-Year Report on the PaREGEN Project](#) DOI; 10.5281/zenodo.1483250
- [5] Geiler J. N., Grzeszik R., Quaing S., Manz A., Kaiser S. A., (2017) [Development of laser-induced fluorescence to quantify in-cylinder fuel wall films](#) DOI; 10.1177/1468087417733865
- [6] Edwards S., (2018) [PaREGEN; Particle Reduced, Efficient Gasoline Engines - Workshop Presentation](#) DOI; 10.5281/zenodo.3459091
- [7] Edwards S., (2018) [PaREGEN; Particle Reduced, Efficient Gasoline Engines - ERTRAC ECGVI EC #H2020RTR18](#) DOI; 10.5281/zenodo.3459269
- [8] Jüngst N., (2018) [Multi-diagnostic imaging of evaporating fuel wall-films in combustion as a source of PAH and soot](#) DOI; 10.5281/zenodo.3546086
- [9] Jüngst N., Kaiser S., (2019) [Visualization of soot formation from evaporating fuel films by laser-induced fluorescence and incandescence](#) DOI; 10.5281/zenodo.3546100
- [10] Jüngst N., Kaiser S., (2019) [Experimental and numerical analysis of evaporating fuel films](#) DOI; 10.5281/zenodo.3546124
- [11] Jüngst N., Kaiser S., (2018) [Imaging of Fuel-Film Evaporation and Combustion in a Direct-Injection Model Experiment](#) DOI; 10.4271/2019-01-0293

## 6 Discussion and Conclusions

Overall, the PaREGEN project had good visibility in the second reporting period, in line with and as a continuation of the first period and the plans made in D6.2 and D6.4.

The results and news have been shared to a large audience, the website was updated frequently and there was a good PaREGEN presence at many different events and exhibitions. And a special Final Event was organised, together with PEM4Nano project with a good attendance.



Figure 6-1 The PaREGEN stand at the Vienna Motor symposium 2019 ([The 40th International Wiener Motor Symposium 15th - 17th May 2019](#))

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## 7 Deviations

There were no deviations compared to the plan.

## Appendix A – References

- [1] Edwards S., Verhagen E. (2018). [Particle Reduced, Efficient Gasoline Engines: A First-Year Report on the PaREGEN Project](#) DOI; 10.5281/zenodo.1483250, TRA2018 Vienna
- [2] Osbome R., Lane A., Turner N., McWilliam L., Hinton N., Geddes J., Gidney J., Cleeton J., Atkins J., Morgan Rob., (2019) A New-Generation Lean Gasoline Engine for Reduced CO<sub>2</sub> in an Electrified World, Vienna Motor Show
- [3] Frapolli N., Boulouchos K., Wright Y. M., Geiler J. N., Manz A., Kaiser S. (2019) Large Eddy Simulations and Tracer-LIF Diagnostics of wall film dynamics in an optically accessible GDI research engine, ICE2019 14th SAE Capri
- [4] Edwards S., Manz A., Gidney J., Freisinger N., Turner N., Perez A., v.d. Zweep C. (2020) Particle Reduced, Efficient Gasoline Engines: A final report on the PaREGEN project, TRA 2020 Helsinki (to be published, April 2020)
- [5] Lane A., Developing the Next Generation of Gasoline Engine Technologies for Reduced CO<sub>2</sub> in an Electrified World, Future Powertrain Conference 2019 UK
- [6] Osbome R., Lane A., Turner N., McWilliam L., Hinton N., Geddes J., Atkins P., Morgan R. (2019) Multi-Cylinder Engine and Vehicle Development of a New Lean Gasoline Concept, 28th Aachen Colloquium Fahrzeug- und Motorenmechanik
- [7] Edwards S. (2018). Particle Reduced, Efficient Gasoline Engines, Thessaloniki workshop (Presentation)
- [8] Edwards S. (2018) Particle Reduced, Efficient Gasoline Engines, EAGLE workshop High Efficiency Hybrid Powertrains (presentation)
- [9] Edwards S. (2019) Particle Reduced, Efficient Gasoline Engines, EGVI-ERTRAC-EC Results from H2020 road transport projects, 2019 (presentation)
- [10] Edwards S. (2018) Particle Reduced, Efficient Gasoline Engines, TAP Conference Thessaloniki, Greece (presentation)
- [11] Barro C., Boulouchos K. (2019) A Virtual Gasoline Particle Sensor (vGPS) for Direct Injection Spark Ignition Engines, ETH-Conference: Combustion generated nanoparticles (presentation)
- [12] Edwards S. (2019) PaREGEN Overview for the FVV Water Recovery Workshop.
- [13] Edwards S. (2019) Particle Reduced, Efficient Gasoline Engines, EGVI - ERTRAC conference Brussels, 2019 (presentation)
- [14] Rieker M., Edwards S. (2018) Einladung zum Forschungskolloquium Effizienzsteigerung von Verbrennungsmotoren, PaREGEN at FH Frankfurt Research Colloquium (presentation)

## Appendix B – Acknowledgement

The author(s) would like to thank the partners in the project for their valuable comments on previous drafts and for performing the review.

Project partners:

#	Partner	Partner Full Name
1	RIC	RICARDO UK LIMITED
2	DAI	DAIMLER AG
3	JLR	JAGUAR LAND ROVER LIMITED
4	BOSCH	ROBERT BOSCH GMBH
5	FEV	FEV EUROPE GMBH
6	JM	JOHNSON MATTHEY PLC
7	HON	HONEYWELL, SPOL. S.R.O.
8	JRC	JOINT RESEARCH CENTRE – EUROPEAN COMMISSION
9	UNR	UNIRESEARCH BV
10	IDIADA	IDIADA AUTOMOTIVE TECHNOLOGY SA
11	SIEMENS	SIEMENS INDUSTRY SOFTWARE SAS
12	LOGE	LUND COMBUSTION ENGINEERING LOGE AB
13	ETH	EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZUERICH
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17	UOB	UNIVERSITY OF BRIGHTON
18	GARR	GARRET MOTION CZECH REPUBLIC S.R.O.



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