Particle Reduced, Efficient Gasoline Engines

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Summary

The PaREGEn project aimed to achieve the optimal combination of innovative direct injection gasoline engines and robust aftertreatment technologies capable of meeting upcoming Euro 6 RDE limits for E and D class vehicle types (by way of the Mercedes E180 and Jaguar XE gasoline variants). Regarding the Mercedes E180, this was fitted with a new stoichiometric gasoline direct injection engine together with the aftertreatment system, comprised of a three-way catalyst (TWC) and a gasoline particle filter (GPF). The Jaguar XE adopted a dilute combustion system and a new boosting system (Variable Nozzle Turbine and electrical compressor), together with a complex aftertreatment system that will be suitable for both stoichiometric and lean combustion modes; in addition, a higher energy ignition system and optimized fuel injectors suitable for lean engine operation mode were implemented.

Whilst the PaREGEn project developed high TRL versions of the engine technology and aftertreatment systems for these two specific vehicle types, this technology was devised with the view to be incorporated into a much wider array of gasoline engines, potentially covering the entire European new gasoline engine vehicle fleet and including many hybrid vehicles. As a result, the potential impact of this new engine technology on CO_2 and particle number emissions (including the ability of effectively reducing sub 23 nm particle emissions) is substantial at a European level. With this technology now demonstrated, it is important now to consider the impact of bringing these innovations to the market, for the automotive industry and society.

The aim of the work with Task 5.4, as reported in this deliverable D5.4, was to evaluate the importance of the PaREGEn results relative to vehicles already on the market, evaluate the results against future trends and evaluate the potential impact of the PaREGEn project results in terms of CO_2 and particle emissions. Additionally, some PN 23nm emission factors for EU SULEV were detailed.

Looking at the present in order to quantify this potential impact, a 2015 best-in-class vehicle equivalent with respect to the size and maximum engine performance for each baseline vehicle was found at the beginning of the project and it is presented with the corresponding CO_2 value (in grammes per kilometre) was developed to provide a reference of the demonstrator vehicle's improvements. This reference was obtained by gathering information from different sources, such as the results obtained from the tests performed on the baseline vehicles, European emissions standard limits of the Euro 6 (d), technical information about the baseline vehicles, vehicle databases from 2015 containing the different vehicle brands with the corresponding value of CO_2 emissions and also from information about the vehicle market segmentation. The EEA Vehicle Database was the main vehicle database selected and used as a reference for this work. The Vehicle Certification Agency Vehicle Database and other websites were used to confirm the data obtained from the EEA Vehicle Database. Since the two baseline vehicles belong to different segments, one best-in-class vehicle for each baseline vehicle was defined.

Looking to the future, a modelling tool was used to study different scenarios for the introduction of the PaREGEn technologies in the European vehicle fleet, to deliver direct emissions reductions in the short- and long-term futures (years 2030 and 2050, respectively). Modelling tools have been widely used in the analysis of current and possible future EU policies on transport emissions for the European Commission (EC), industry and other interested parties. The Sibyl software modelling tool from EMISIA was used in the work reported here because it was considered as a good option that uses the emission factors from COPERT (which is the EU standard vehicle emissions calculator), includes a full stock model for all European modes of transport and can estimate the CO_2, air pollutant and fuel efficiency impacts of different vehicle technologies. Therefore, the potential impact of the PaREGEn project based on a selected series of scenarios, was formulated by considering different fleet projections of the new technology developed and being introduced

to the European vehicle fleet (EU-28). This was feed into the software to simulate and evaluate the impact on CO_2 and PN emissions, over the period 2020-2050.

The scenarios considered are, specifically:

- Scenario 1. The new PaREGEn technology is implemented in every new production vehicle for the Mercedes E-Class and Jaguar XE models equipped with petrol engines from 2022 on.
- Scenario 2. This scenario includes the deployment from Scenario 1, and additionally every new Daimler and JLR petrol vehicle will be implemented with the same technology. In this last case, its implementation is progressive along the years 2022-2025 and, then, constant from 2025 on.
- Scenario 3. Additionally to the previous Scenario 1, every new petrol vehicle from all brands (including Daimler and JLR petrol vehicles) will be implemented with the same technology. In this case, its implementation will be progressive along the years 2022-2030 and, then, constant from 2030 on.
- Scenario 4. Additionally to the previous Scenario 3, every new hybrid vehicle equipped with a petrol engine being either HEV, MHEV or PHEV from all brands (including Daimler and JLR petrol vehicles) will be implemented with the same technology. In this case, its implementation will be progressive along the years 2022-2030 and constant from 2030 to 2050.

Regarding the CO_2 emissions results, the overall impacts of the four scenarios relative to the baseline, can by summarised. Whilst Scenarios 1 and 2 achieve modest overall CO_2 emissions savings at the European level (from 0.012 to 0.435 $MtCO_2$ in the 2050 projection, although these would clearly be an important contribution for the two manufactures' fleet values), Scenarios 3 and 4 (which see all new gasoline vehicles – Scenario 3 – and additionally all hybrid vehicles equipped with petrol engines – Scenario 4) achieve much larger and more significant CO_2 emissions savings, at almost 10 $MtCO_2$ in the best case with Scenario 4.

Analysing the results of the simulation in more detail, the relative reduction of CO_2 emission for the total fleet (TF) for road transport and the passenger cars (PC) was done. Considering the total fleet (TF), only Scenarios 3 and 4 have a significant impact on CO_2 emissions reduction. In the 2030 projection, Scenario 3 has a 0.52% reduction of emissions, whilst for Scenario 4, the reduction is 0.68%. Looking at the 2050 projection, the total CO_2 saving increases to 0.81% and 1.52% are reached for Scenarios 3 and 4 respectively. Considering only the passenger cars (PC), there is a significant reduction in CO_2 emissions for both Scenario 3 and Scenario 4. In 2030, the reduction for Scenario 3 would be 1.18% whilst for Scenario 4 the saving increases up to 1.54%. The projection to 2050 shows even more significant CO_2 emissions reduction: 5.03% and 9.40% for Scenario 3 and Scenario 4, respectively. This is a significant contribution to achieving the EC's long-term decarbonisation targets in the road transport sector and illustrates the potential of the engine technology developed in the PaREGEn project.

As with the CO_2 emissions, the reduction of PN emissions from a European perspective for Scenario 1 is negligible even for the 2050 projection. However, in 2050, if the PaREGEn technology is applied to all the entire Daimler and Jaguar Land Rover fleet, a slight reduction is seen for Scenario 2 (around 2%, compared to the baseline). Regarding the other two scenarios (Scenario 3 and Scenario 4), much larger emissions savings are seen, as expected (the new aftertreatment and petrol engine technologies are implemented to all the petrol vehicles and hybrid vehicles with petrol engines). Specifically, for the 2030 projection, there is a 1.11% and 1.59% reduction for Scenarios 3 and 4 respectively, while the long-term 2050 projection shows 32% and 73% PN emissions reduction, respectively.

Appendix A – Acknowledgement

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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
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14	UDE	UNIVERSITAET DUISBURG-ESSEN
15	RWTH	RWTH AACHEN UNIVERSITY
16	UFI	UFI FILTERS SPA
17	UOB	UNIVERSITY OF BRIGHTON
18	GARR	GARRET MOTION CZECH REPUBLIC S.R.O.

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