CO_2RE

PROJECT PERIODIC REPORT

Publishable summary

Grant Agreement number: 284909

Project acronym: CORE

Project title: CO2 Reduction for long distance transport

Funding Scheme: Collaborative project

Date of latest version of Annex I against which the assessment will be made:

Periodic report: **1st** **2nd** ☒ **3rd** ☐ **4th** ☐

Period covered: **from 1st July 2013** **to 31 of December 2014**

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Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate) [1]:

  ☐ has fully achieved its objectives and technical goals for the period;

  ☒ has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

  ☐ is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: .....

Johan Engström.....

Date: ....28...../ .....2...../ .....2015.....

For most of the projects, the signature of this declaration could be done directly via the IT reporting tool through an adapted IT mechanism and in that case, no signed paper form needs to be sent

List of Beneficiaries

Project Number [1]	284909	Project Acronym [2]	CORE

List of Beneficiaries

No	Name	Short name	Country	Project entry month[10]	Project exit month
1	VOLVO TECHNOLOGY AB	Volvo	Sweden	1	48
2	CENTRO RICERCHE FIAT SCPA	CRF	Italy	1	48
3	CHALMERS TEKNISKA HOEGSKOLA AB	Chalmers	Sweden	1	48
4	DAIMLER AG	DAI	Germany	1	48
5	FEDERAL-MOGUL BURSCHEID GMBH	F-M	Germany	1	48
6	GOTTFRIED WILHELM LEIBNIZ UNIVERSITAET HANNOVER	LUH	Germany	1	48
7	HONEYWELL TECHNOLOGIES SARL	HTT	Switzerland	1	48
8	INGENIEURGESELLSCHAFT FUER AUTO UND VERKEHR GMBH	IAV	Germany	1	48
9	JOHNSON MATTHEY PLC.	JM	United Kingdom	1	48
10	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	JRC	Belgium	1	48
11	METATRON SRL	MT	Italy	1	48
12	POLITECNICO DI MILANO	POLIMI	Italy	1	48
13	POLITECNICO DI TORINO	POLITO	Italy	1	48
14	Rhodia Operations	RES	France	1	48
15	RICARDO UK LIMITED	Ricardo	United Kingdom	1	48
16	UMICORE AG & CO KG	Umicore	Germany	1	48

Nomenclature

1 Publishable summary

Summary

European wealth, now and in the future, depends on a strong and competitive transport sector. At the same time the transport system of Europe faces significant challenges in order to become sustainable in the long term, and reduce its impact on the environment. With the aim to address these challenges the Collaborative project CORE (CO2 REduction for long distance transport) has started. The consortium consists of 16 partners from truck manufacturers, automotive industries and universities.

Main objective for CORE is to demonstrate a substantial reduction of CO2 emissions through improved powertrain efficiency with technologies having the potential to be implemented in production around 2020.

Main focus areas are improved engine concept featuring variable valve actuation with new turbo system, reduced friction and improved aftertreatment performance, specifically in the low temperature range. In addition, hybridisation and natural gas will be utilised. All achieved results will be evaluated over legislation test cycles and in real life drive cycles. The project will demonstrate three diesel powertrains and one natural gas truck.

The project is in progress nearly according to the plan. After three quarters of the project, novel hardware has been designed and procured. Engines and aftertreatment systems have been assembled and tested. Obtained results show improved efficiency towards the target. The next step is to perform application work and optimise the engine system.

Objectives

The objective is to demonstrate a substantial reduction of CO2 emissions, 15% improved fuel efficiency compared to a EURO V engine and at the same time fulfilling EURO VI emission legislation. By using novel technology combined in flexible engines with a high level of precise control, performance advantages will be achieved with improvements in emissions and fuel consumption. The legislative emission test cycles ETC and the WHTC will serve as the baseline test cycles but, in order to show the improved fuel efficiency and consider the hybrid electric powertrain, specific duty cycles will be used for each application

The target fuel economy improvement of 15% is based on a EURO V state-of-the-art technology operating at the EURO VI emission standard. It is envisioned to achieve 6 to 9% in the sub-projects (see Figure 1) with different engines, powertrains and fuel approaches. The hybridization of the powertrain will contribute with an estimated 3 to 5% fuel economy improvement dependent on the vehicle test cycle through usage of energy recuperation during deceleration events. Additional 2 to 4% of fuel economy improvement is attributed to friction reduction of the combustion engine and energy efficient exhaust gas aftertreatment systems and operation.

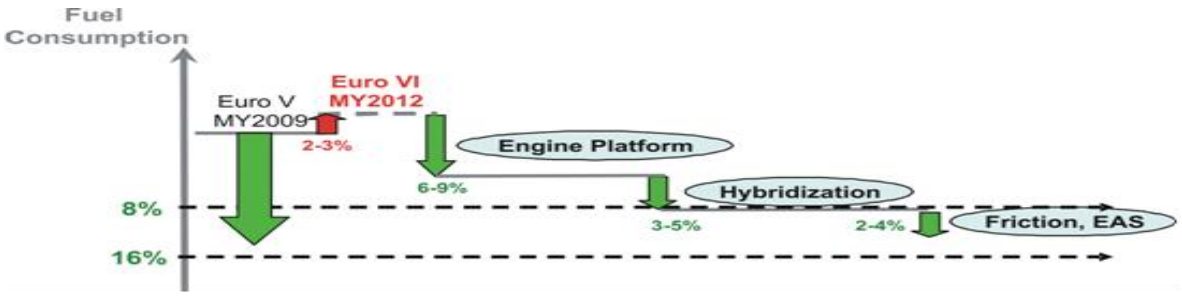

Figure 1: Roadmap toward fuel consumption reduction.

Description of Work and the present main results

CORE is divided into six sub-projects (see Figure 2), three of which focus on different engine and powertrain technologies. Major areas for these are: optimizing the existing Diesel engine: combustion, air management, aftertreatment and controls, decreasing rated engine speed ("down-speeding"), optimizing the powertrain layout (hybrid electric components) and using alternative fuels, namely Liquefied Natural Gas (LNG), combined with variable valve actuation.

These three sub-projects are supported by two projects (shown horizontally in Figure 2) where friction reduction and improvement of low temperature performance of NOx aftertreatment technologies are studied. Accomplished results are adapted on the three engine and powertrain arrangement. Finally in the last sub-project, to ensure knowledge and technology transfer, all results will be assessed by vehicle simulations for final achievement of the fuel economy target.

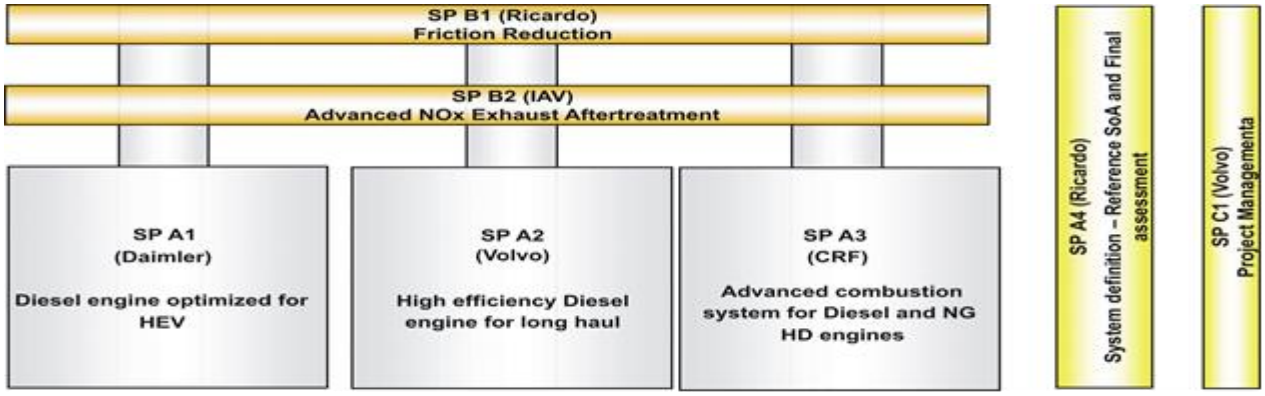

Figure 2: CORE project organisation.

The current status is that improved fuel efficiency has been obtained in all sub-projects. Engine tests show results close to the target for the engine platform. Further engine optimization work is in progress. In the two horizontal projects improved novel hardware has demonstrated results in the target range. The new hardware has been delivered to the engine projects and integration on the engine system is currently on-going. The next step is to perform duty cycle tests with the complete engine systems aiming to fulfil the CORE target. In parallel, the achieved test results will be transferred to SP A4 as a base to simulate the potential improvement of vehicle fuel consumption by packages of CORE technologies using a vehicle simulation programme.

The main results from each sub-project during period, month 19-36, are presented below:

Main Results from SP A1 "Diesel engine optimized for HEV"

- The combustion of the Diesel engine was optimized for downspeeding considering several hardware parameters. Simulation and single cylinder testing was conducted. Improvement of up to 1% in fuel economy was found due to nozzles with higher hydraulic flow.
- The air management of the engine consisting of a 2-stage turbocharger was optimized applying an innovative variable asymmetric turbine to the high pressure turbocharger. A Variable Radial Sliding Turbine (VRST) was designed, procured and tested – several options were considered. An interstage cooling was applied between the compressors.
- The system calibration activities started incorporating combustion and air management system modifications. Steady state testing including optimization of engine settings was done and revealed a downspeeding potential of approximately 3% fuel economy improvement compared to the EUROVI calibration of the conventional engine.
- Compared to the EUROV reference engine a fuel economy improvement of approximately 5-6% is currently envisioned by the work in SP A1.

Main Results from SP A2 "High efficiency Diesel engine for long haul"

- Procurement of new prototype 2-stage turbocharger. Hardware has been delivered and performance tests are completed.
- Procurement of a variable valve system. This has been delivered and mounted on the engine.
- Selection of DPF based on data evaluation and carry out ash accumulation test
- Model-in-the-loop simulations with good performance in terms of fuel consumption, as well as emission restrictions, by controlling adequately the valve actuation.
- Transient engine simulations in relevant cycles showing improved BSFC.
- Assembly of complete engine and first performance test, steady state operation. This first results show good potential to reach the BSFC target, specifically at high load, however more work is required at lower load.

Main Results from SP A3 "Advanced combustion system Diesel and NG HD engines"

- Development of numerical combustion model in 1D GT-Power for Diesel and CNG engines equipped with Variable Valve Actuation (VVA) system to evaluate different camshaft profiles, turbo-matching, Miller cycle effects supporting the subsequent CRF test bench activity.
- Modelling the VVA system effect as a way to speed up the activation of SCR system in order to improve CO2 reduction and to achieve best solution about package, flow conditions and skin temperature in Diesel engine. Testing of thermal management strategies to obtain the best compromise between BSFC reduction and ATS efficiency.
- VVA strategies analysis to obtain CNG catalyst thermal improvement; evaluation of lay-out influence and measures of conversion efficiency performed on test bench; detection of critical THC emission areas.
- Power curve profiles modelling; definition of specific VVA strategies in entire engine map and other engine parameters calibration at test bench, for both engines.
- Steady state points and homologation cycles (ETC and WHTC) on test bench performed to verify CO2 reduction and emission level for both engines; reference truck tested in JRC to define the reference for LNG/CNG demonstrator;
- End of activity of design and development of LNG pressure regulator; installation on vehicle and first check; components for LNG fuelling system procurement.

Main Results from SP A4 "Final Assessment"

- Method for evaluating fuel consumption benefits using the V-SIM program was agreed.
- Initial fuel consumption results for the Volvo heavy truck were presented at the CORE meeting in Milan in October 2014.

Main Results from SP B1 "Friction reduction"

- A method was developed which improved repeatability of fuel consumption measurement.
- The Phase 1 components reduced engine fuel consumption at key points by between 0.4% and 1.1% compared with the baseline.
- A 25% reduction in oil viscosity reduced motoring FMEP by 3-5% but fuel consumption in firing conditions was not reduced. The reduction in hydrodynamic friction with the LV oil was offset by the increase in friction in mixed and boundary lubrication.

Main Results from SP B2 "Advanced NOx Exhaust Aftertreatment"

- Cu-zeolite SCR technology has been selected as a CORE deliverable, due to its low-temperature performance, sulphur poisoning tolerance, and potential to substantially improve the SCR system performance in transient operation. The Gen3 Cu-SCR catalyst has been tested, and delivered to partners in SP B2 and to SP A1.
- The reaction kinetic model of the SCR catalyst has been developed and prepared for the transfer to sub-projects A1 and A3. The system simulation study has been completed, showing that the developed SCR technologies enable meeting Euro VI emission requirements in WHTC simulation, as well as in a typical PEMS cycle.
- Vehicle simulation study has been completed to demonstrate the SCR and SCR/DPF technology performance in various on-road driving cycles.
- The mechanism of the ammonium nitrate (AdBlue additive) reactions on Fe-zeolite catalyst has been investigated, and its effect on the SCR system performance has been modelled, showing the potential for future system improvements.
- The AdBlue dosing strategy in the IAVs DCU model has been calibrated for the Gen3 SCR catalyst formulation.
- The development of the AdBlue processor in WP26 has been terminated, the available funds distributed to high-priority tasks in WPs 24-26.

Expected Results and Impact

The CORE project is designed to have a direct impact on the next generation of heavy duty transport vehicles enabling them to run more energy efficiently while meeting future emissions standards. By developing three advanced heavy duty engine systems adapted to the OEM´s widely used vehicle configurations, and providing these on an industrial scale and commercial basis, the CORE project will have an impact on the rate of emissions from the next generation European long distance surface transport. Up-to-date achieved results at the sub-technology level have already influenced and supported powertrain development inside the OEMs.

The project has a public website, which is available at: http://co2re.eu/
On this site public reports, demonstration activities and other information will be published along with project news.