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 January 2012** **to 30 of June 2013**

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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.

[1] If either of these boxes below is ticked, the report should reflect these and any remedial actions taken.

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

Johan Engström.....

Date: ....30...../ .....8...../ .....2013.....

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

Publishable summary

Summary

European prosperity now and in the future depends on a strong and competitive transport sector. The long distance transport of goods and services is a significant direct and indirect contributor to European wealth, and its contribution and integration is steadily growing. At the same time the transport system of Europe faces significant challenges in order to become sustainable in the long term, and to decouple its significant positive effects from 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 variable valve application with new turbo system, reduced friction and improved aftertreatment performance, specifically in the low temperature range. In addition hybridisation and liquid 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. First periodic results show improved performance on a component level. Based on these results, concept simulation shows the potential to reach the target. The next step is to procure all component prototypes and assemble the concepts for validation tests.

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 ETC and the WHTC will serve as the baseline test cycles. However, these traditional and legislative emission test cycles do not consider a hybrid electric powertrain. Therefore, new cycles shall be derived from typical customer applications that take the potential of regeneration of energy during deceleration into account.

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.

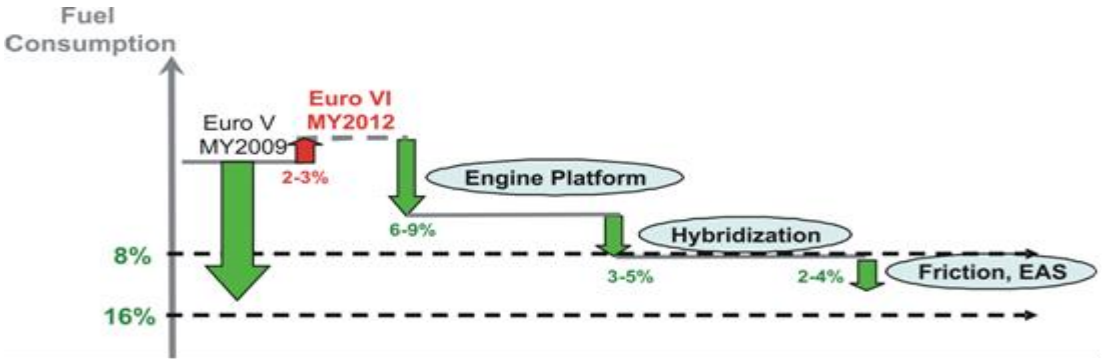
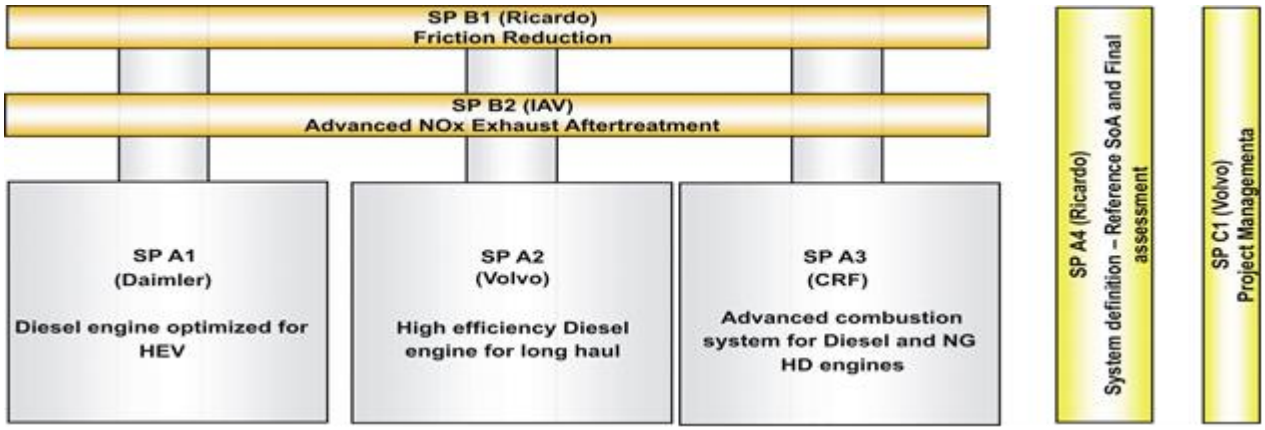


Figure 1: Roadmap toward fuel consumption reduction.

Description of Work and the present main results

CORE is divided into six sub-projects, three focusing on different engine and powertrain technologies. Major areas for these are: optimizing the existing Diesel engine: combustion, air management, aftertreatment and controls, decrease rated engine speed ("down-speeding"), optimizing the powertrain layout (hybrid electric components) and using alternative fuels as liquefied natural gas (LNG) combined with variable valve actuation.

These three sub-projects are supported by two cross projects where friction reduction and improvement of low temperature performance of NOx aftertreatment technologies are studied. Accomplished results are adapted on the two 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.



Current status of achieved results shows a good potential towards the targets of improved fuel efficiency. Performed engine simulation and first engine tests in steady state operation indicate fuel improvements close to the target for the engine platform. Major contribution to obtain this improvement is derived from new matched high efficient turbosystem in combination with variable valves. For the aftertreatment system, low temperature performance of the SCR system has been improved by novel coating and, for the particulate filter, lower backpressure is obtained by new design. Nevertheless, challenging work remains in order to fully reach the targets in all steps, and to prove these figures in a transient duty cycle operation on the engine concept level. Main results from each sub-project are presented downwards:

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

- Simulation result for fuel efficiency improvement achieved by downspeeding in the simulated cycle (PEMS cycle) is 2% that is lower than expected.
- Simulation result for fuel efficiency improvement caused by hybridization is 8% that is higher than expected.
- The combination of downspeeding and hybridization (10% fuel efficiency potential) meets the target improvement of 7-11%
- 2-stage turbocharger prototype with asymmetric high pressure turbine and variability of both volutes is available and could be tested successfully

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

- Define and design of a new high performance 2-stage turbo.
- Decision to select AMS VVA system for the Volvo CORE engine
- Define and select a novel DPF with has shown improved performance on component level
- Created a 1D gas exchange model of the Volvo CORE engine
- 1-cylinder engine test with software in the loop (turbo), best point on target or better, steady state operation
- Simulation result for fuel efficiency of the Volvo CORE engine in ESC show the potential of 5% fuel improvement compared to EURO V

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

- Diesel and CNG prototype engines with a specific designed variable valve actuation system;
- Guidelines for iEGR management combined with EIVC
- CNG engine: 2-10% efficiency improvement; lower exhaust temperatures on power curve; possible higher low end torque;
- GT Power model for gas injection optimization;
- Proto A and Proto B LNG pressure regulator realized

Main Results from SP B1 "Friction reduction"

- Initial predictions for changes to piston and ring design, and the use of coatings may give improvements in motored frictional mean effective pressure of about 12% at 1000 rpm and 9% at 2000 rpm
- Predictions for no existing design constraints indicate motored frictional mean effective pressure may be reduced by about 19% at 1000 rpm and 26% at 2000 rpm
- Piston design changes include piston clearance increase from 120 µm to 140 µm, dimensional changes to piston rings and coating change from AV13D to AV19D

Main Results from SP B2 "Advanced NOx Exhaust Aftertreatment"

- Exhaust system design and performance data (boundary conditions) delivered
- DeNOx system models with SCR and SDPF as NOx reduction catalysts, and AdBlue and gaseous NH_3 as reductants, along with reductant control strategy.
- The sensitivity study found DeNOx efficiency improvement from improved low-temperature SCR catalyst activity, ammonium nitrate (AdBlue additive) dosing, and SCR coating on DPF substrate. No improvement found from gaseous ammonia injection on the DeNOx efficiency in WHTC.
- The first version of Ce-Zr mixed oxide formulation (CORE1), with performance not exceeding reference SCR technology (Cu-zeolite).
- Promising initial results from the development of new Cu-zeolite formulation.
- Samples of both reference and CORE1 catalyst formulations on wall-flow filters.
- Higher cell density found to improve efficiency and storage capacity of SCR catalysts.
- Three potential concepts of AdBlue processor identified, one evaluated experimentally, but requires extensive development. Another concept was chosen for further development.
- Impact of AdBlue additive (ammonium nitrate) on Fe-zeolite SCR catalyst was evaluated experimentally, kinetic model is created.

Expected Results and Impact

CORE project is structured to have a direct impact on the next generation of heavy duty transport vehicles to run more energy efficiently and meet future emissions standards. By developing three advanced heavy duty engine systems adapted to three by the OEM´s widely used vehicle configurations, and providing these on an industrial scale and commercial basis, the CORE project will have significant impact on the rate of emissions from next generation European long distance surface transport.

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.