Periodic Reporting for period 2 - HDGAS (Heavy Duty Gas Engines integrated into Vehicles)

**Periodo di rendicontazione:** 2016-11-01 al 2018-04-30

**Sintesi del contesto e degli obiettivi generali del progetto**

HDGAS's objective was to develop, demonstrate and optimize advanced powertrain concepts for dual-fuel and for pure natural gas operation engines, perform integration thereof into heavy duty vehicles and confirm achievement of Euro VI emissions standards, in-use compliance under real-world driving conditions and CO2 or greenhouse gas targets.

Conclusions of the action:
The positive ignited concept has overachieved the targets in terms of CO2 reductions, especially the lean burn concept as well as the range fulfilment. Due to irregularities of the injectors emissions
compliance with EU VI could only be demonstrated partly. The involved partners are confident that proper working injectors would have ensured emission compliance.

The dual fuel concept has overachieved the target of range before refuelling. However, additional efforts would need to be taken in order to achieve emission compliance as well as the targeted CO2 reductions.

The HPGI concept has fulfilled / overachieved all targets (emission compliance to EU VI, CO2 reduction of 22% and range fulfillment of almost 1200km)

Lavoro eseguito dall’inizio del progetto fino alla fine del periodo coperto dalla relazione e principali risultati finora ottenuti

A new standard for LNG Fueling Coupling (ISO) has been developed and is being reviewed by the ISO group. Investigation on filling process (1d, 3d simulations) as well as on spraybar layout has been done in order to provide valuable input for the development and layout of the tank development.

Definition of system layout, its interfaces and of system requirements has been done. Base tank system with pump compatibility has been developed including Low, medium and high pressure system. Tank and pump systems have been provided to the OEM partners and integrated into the vehicles. A Novel aftertreatment system has been developed for dedicated lean natural gas application which reduces the impact of ageing on the methane oxidation catalyst. Dedicated SCR catalyst has been specified for lean NG application due to exhaust temperature window (higher exhaust temperatures than Diesel) and minimized N2O formation. A sulphur removal strategy has been developed to maintain high efficiency of methane oxidation catalyst.

1D and CFD simulation of stoichiometric and lean burn concepts has been performed. Single cylinder testing has been done in order to select the hardware for the multi cylinder testing. Both concepts have been tested on the multi cylinder engines. All targets have been achieved (GHG reduction of -10%, range of >800km) except the pollutant emissions compliance to EU VI.

Benchmarking was done in order to get an understanding of the performance of current products. A specific dual fuel ECU has been developed. A SPI system has been adapted to the engine and tested and later on a MPI system. Combustion CFD work was done in order to define possible hardware for the single cylinder testing, followed by single cylinder testing in order to select the best hardware for the multi cylinder testing. The multi cylinder tests included a full calibration (steady state and transient) which was finished by supervised testing from TÜV showing emission compliance to EU VI. Also the GHG target of -20 has been reached, actually overachieved. Pems tests have been performed on another vehicle (not HDGAS) with the same technology showing emission compliance also in the vehicle. (-22%) The range requirement of 800km has been achieved with large margin (1172 km).

The procedure for the independent testing for emission compliance has been defined as well as the procedure for GHG reduction demonstration and range calculation. Pems testing was done with a Volvo vehicle with similar specification of the system as HDGAS and showed emission compliance leading to the conclusion that the HDGAS vehicle also would have shown emission compliance. The cost assessment for the main concepts has been developed and are all showing a direct amortization. The payback period for the IVECO vehicle amounts to 1,4 years, the MAN one to 4,6 and the Volvo to 1,7 years. Payback periods below 2 years are usually a qualifier for acceptance at the OEMs

A Final event has taken place in Turin Italy (150 people from 55 companies and 14 different countries attended).
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All the results have been disseminated.

**Progressi oltre lo stato dell’arte e potenziale impatto previsto (incluso l’impatto socioeconomico e le implicazioni sociali più ampie del progetto fino ad ora)**

The European market for NG and Dual Fuel Vehicles is modest in absolute vehicle numbers. The fraction of medium and heavy duty NGVs and DFVs is well below 1% of the total number of vehicles sold in these categories in 2013. However, major opportunity exists to expand the deployment of heavy-duty natural gas (NGVs) and dual fuel vehicles (DFVs). A major advantage of natural gas as a heavy-duty transportation fuel is its relatively low price compared to diesel fuel on an energy-equivalent basis. Data from the Natural and bio Gas Vehicle Association (NGVA Europe17) shows that the EU average price for natural gas was € 0.85 per diesel liter equivalent and € 1.38 for diesel in 2013. Moreover, a large “fuel cost differential” between natural gas and diesel has been forecast over the next two decades. This means heavy-duty fleets should continue to have strong motivation to switch to natural gas.

The recently observed increase in oil price grows the interest in gas powered vehicles. During 2017 several gas engine powered vehicles dedicated for long haul transportation have been launched and with the provided efficiency increase from the HDGAS project those products are able to provide an even higher CO2 reduction. A prerequisite of a higher market penetration of gas powered long haul trucks is a sufficient coverage with LNG. The LNG blue corridor initiative took the infrastructure the next step but more efforts are needed. Gas powered vehicles should not only being considered a s a bridge technology until fuel cell vehicles or PtL is competitive enough it should be considered as an essential part of the final solution. Natural gas is available all over the world providing energy security and blends with biogas can easily be realized enabling an additional reduction of CO2 emissions.

Socio-economic impact and the wider societal implications

The increased know how in gas powered trucks provided by HDGAS secures development of corresponding components and systems within the EU securing employment in the automotive industry. Natural gas powered vehicles emit significantly less pollutants contributing to cleaner air especially in inner cities. It should be considered as an alternative to BEV vehicles in this aspect.

Biogas can also be used as fuel for the developed vehicles providing up to 100% CO2 reductions. Furthermore the production of biogas can be localized thus reducing the dependency to oil/gas producing countries. The localized production of biogas provides additional employment within the EU.