Heavy Duty Gas Engines integrated into Vehicles

Project status & results

EGVIA workshop

Brussels, 31 May 2017

PROJECT PARTNERS

Industry:

AVL	www.avl.com	Austria
BorgWarner	www.BorgWarner.com	Germany
BOSCH Invented for life	www.bosch.com	Germany
DAIMLER	www.daimler.com	Germany
dinex ECOCAT	www.dinex.dk	Denmark
FPT	www.fptindustrial.com	Italy
IVECO	www.iveco.com	Spain
MAN	www.MAN.eu	Germany
RICARDO	www.ricardo.com	United Kingdom
SAG	www.SAG.at	Austria
VOLVO	www.volvo.com	Sweden

Research:

Applus IDIADA	www.applusidiada.com	Spain
POLITECNICO MILANO 1863	www.polimi.it	Italy
TNO innovation for life	www.tno.nl	Netherlands
TU Graz	www.tugraz.at	Austria
UNIVERSITY OF EASTERN FINLAND	www.uef.fi	Finland
Hochschule Esslingen University of Applied Sciences For people and technology.	www.hs-esslingen.de	Germany
virtual vehicle	www.v2c2.at	Austria

Service:

UNIRESEARCH	www.uniresearch.com	Netherlands

FACTS & FIGURES

Full name:	Heavy Duty Gas Engines integrated into Vehicles
Acronym:	HDGAS
Duration:	36 months
Start date:	1 May 2015
Total budget:	27 M€
EC Funding:	19.89 M€

The consortium consists of 19 partners from 9 different European countries.

This project has received funding from the European Union's Horizon 2020 Framework Programme for research, technological development and demonstration under grant agreement no 653391.

CONTACTDETAILS

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HDGAS

Heavy Duty Gas Engines integrated into Vehicles

The HDGAS project partners believe in LNG as a real alternative for medium & long distance transport - first as a complementary fuel and later as an adequate substitute for diesel.

www.hdgas.eu

Advanced LNG vehicle fuel system
Exhaust aftertreatment system and emission control

COMPONENT DEVELOPMENT

Low pressure direct injection spark ignited engine with a highly efficient EGR system

Low pressure port injected dual fuel engine

High pressure gas direct injection diesel pilot ignitions gas engine

VEHICLE INTEGRATION

INDEPENDENT TESTING AND OVERALL ASSESSMENT

THE DEMONSTRATION VEHICLES WILL:

- Comply with the Euro VI emission regulations;
- Meet at minimum 10% CO_2 reduction compared to state of the art technology;
- Show a range before fueling of at least 800 km on natural gas;
- Be competitive in terms of performance, engine life, cost of ownership, safety and comfort to 2013 best in class vehicles.

A standardization of the refueling process of LNG trucks

BACKGROUND

The European market for natural gas and dual fuel vehicles is modest in absolute vehicle numbers. 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.

The broader societal challenge is the development of advanced non-hybrid powertrain concepts for heavy duty vehicles (either dual-fuel or optimised for pure natural gas operation), complying with Euro VI emissions standards and meeting the CO_2 or greenhouse gas emissions targets currently under definition.

This will deliver significant air quality improvements, particularly in terms of particle numbers and NO_x in real driving conditions, and will reduce the contribution of heavy duty vehicles to climate change.

OVERALL CONCEPT

The overall objective of HDGAS is to provide breakthroughs in LNG vehicle fuel systems, natural gas and dual fuel engine technologies as well as aftertreatment systems.

The developed components and technologies will be integrated into three demonstration vehicles that are representative for long haul heavy duty vehicles in the 40 ton range.

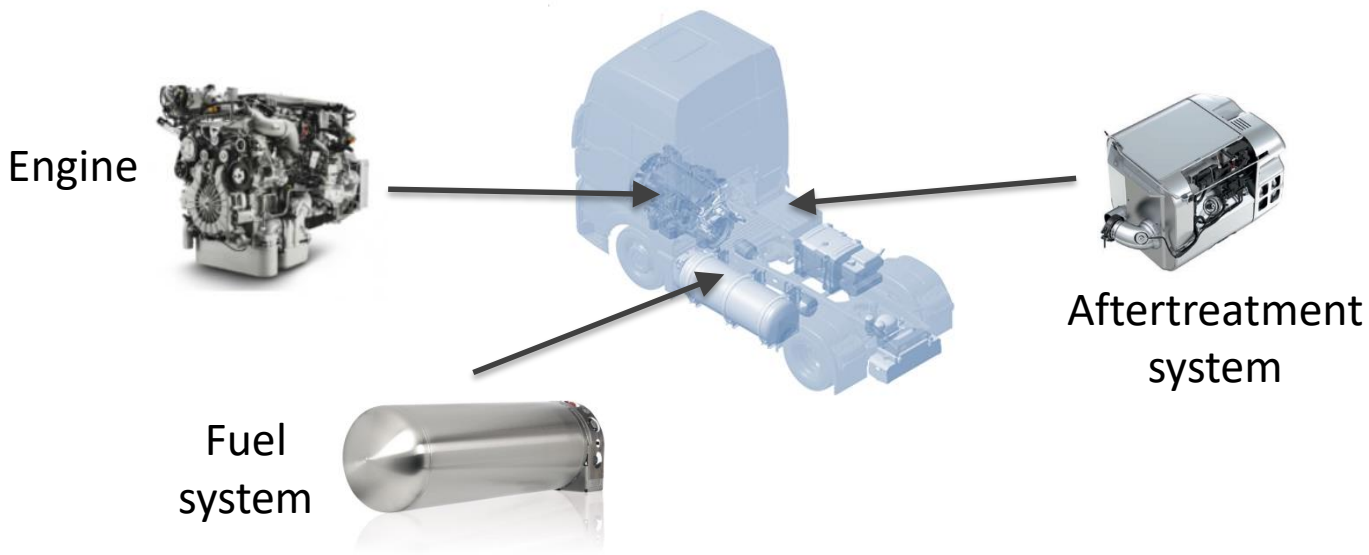
OBJECTIVES AND AIM

The overall objective of the HDGAS project is 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 CO_2 or greenhouse gas targets currently under definition.

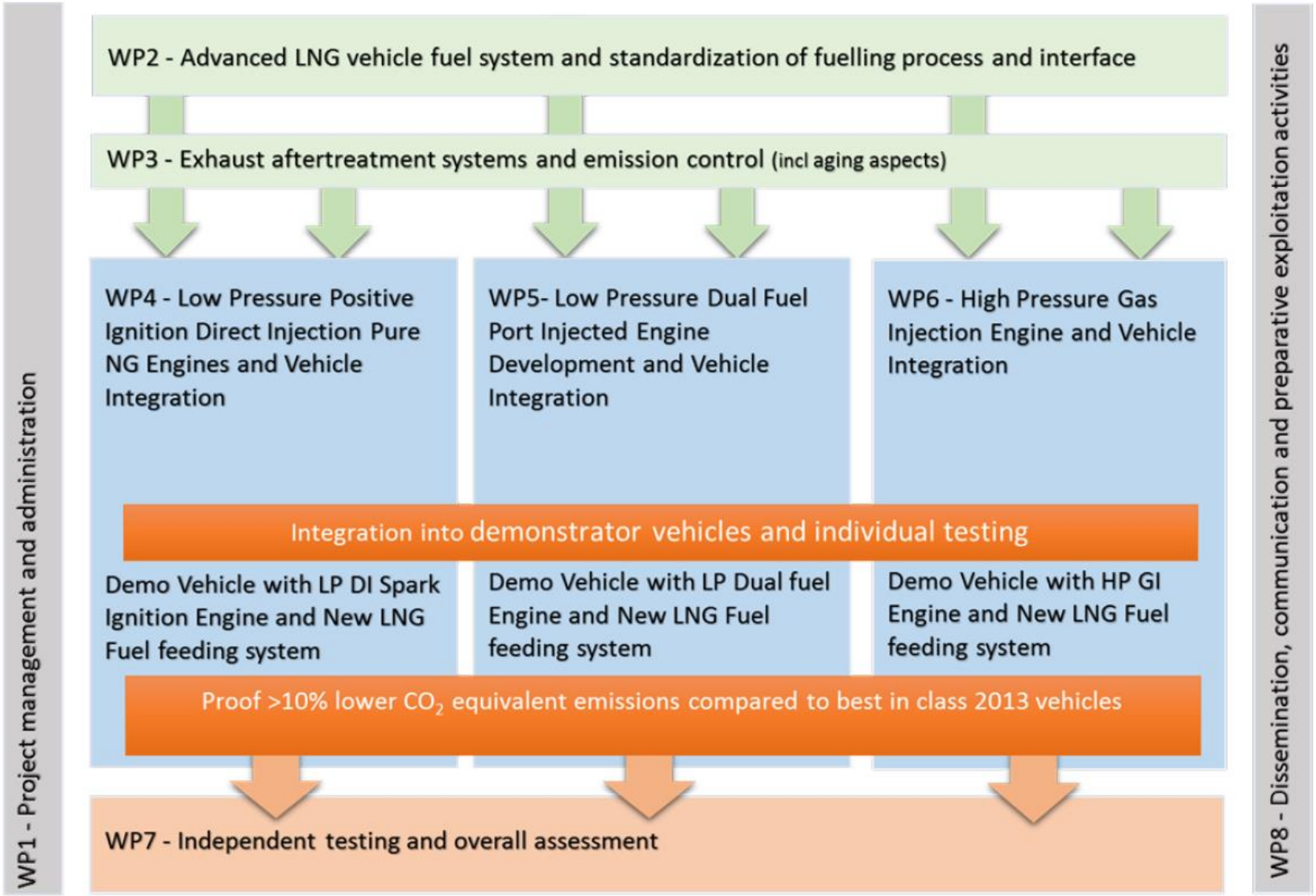
Main objectives

THE DEMONSTRATION VEHICLES WILL:

- Comply with the Euro VI emission regulations;
- Meet at minimum 10% CO_2 reduction compared to state of the art technology;
- Show a range before fueling of at least 800 km on natural gas;
- Be competitive in terms of performance, engine life, cost of ownership, safety and comfort to 2013 best in class vehicles.



Project structure



WP1

Project management and administration

ACHIEVEMENTS

- ✓ Internal communication and consortium management:
  - General assembly meetings with 9 months interval
  - Monthly executive board meetings
  - Web based workspace Project Place®
- ✓ Contractual, administrative and financial project management:
  - Overall project management and coordination with EU commission
  - Periodic discussion and reporting of technical progress
  - Establishment of a quality assurance and risk management process

DAIMLER

WP2

LNG vehicle fuel systems and standardization

OBJECTIVES AT A GLANCE

- Development of LNG tank systems for different engine types:
  - Spark ignited
  - Dual fuel
  - Compression ignited
- Standardisation of fueling interface and process for LNG truck fueling

HIGHLIGHTS

★ Prototype tank systems have been developed and are under procurement

★ Draft standard for LNG refueling interface created at ISO

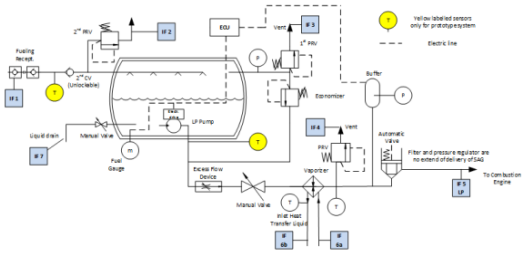
★ Prototype nozzles available

WP2

LNG vehicle fuel systems and standardization

ACHIEVEMENTS

- ✓ Tank system layout defined
- ✓ Prototype tank systems have been developed and are under procurement
- ✓ State-of-the-art thermodynamic simulation of the fueling and defueling process
- ✓ Draft standard for LNG refueling interface created at ISO
- ✓ First prototype fueling nozzles and receptacles have been manufactured



WP3

Exhaust after treatment systems and emission control

OBJECTIVES AT A GLANCE

- To develop and deliver aftertreatment systems for natural gas applications:
  - Stoichiometric
  - Dual fuel
  - Dedicated lean NG
- Ageing impact study on methane oxidation catalyst
- Calibration of systems to meet Euro VI emissions limits

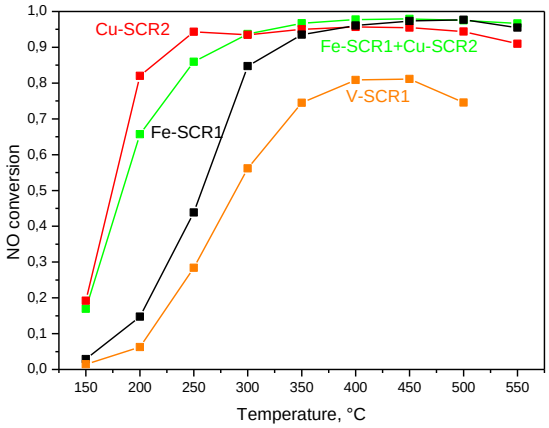
HIGHLIGHTS

- ★ Fundamental studies on synthetic gas reactors performed for methane and NOx control
- ★ Aftertreatment systems specificed and designed
- ★ Aftertreatment systems delivered to partners
- ★ Calibration of aftertreatment system under development

Exhaust after treatment systems and emission control

ACHIEVEMENTS

- ✓ Novel aftertreatment system developed for dedicated lean NG application which reduces the impact of ageing on the methane oxidation catalyst
- ✓ Dedicated SCR catalyst specified for lean NG application due to exhaust temperature window (higher exhaust temperatures than Diesel)
- ✓ Sulphur removal strategy developed to maintian efficiency of methane oxidation catalyst
- ✓ Fundamental studies developed understanding of sulphur poisoning on methane oxidation catalysts
- ✓ 4 scientific papers undergoing publication process



Fundamental studies investigating SCR catalysts for NG applications

Low pressure direct injection spark ignited engine

OBJECTIVES AT A GLANCE

- Development of two versions (stoichiometric and lean burn) of a new direct positive ignition NG engine capable of:
  - > 10% fuel efficiency
  - 10% reduced GHG emissions
  - 10% higher performance in comparison with current engines
  - Vehicle range > 800km

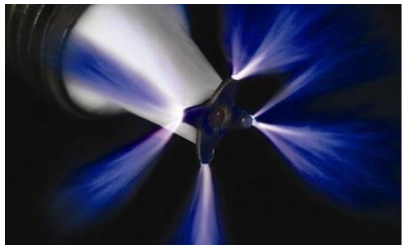
HIGHLIGHTS

★ Single cylinder testing finalized
★ Engine design completed
★ Multi cylinder prototype engines delivered to partners

Low pressure direct injection spark ignited engine

ACHIEVEMENTS

- ✓ 1D and CFD simulation of stoichiometric engine
- ✓ SCE testing of stoichiometric engine
- ✓ 1D and CFD simulation of lean burn engine
- ✓ Design of new components
- ✓ Procurement and construction of prototype engines



WP5

Low pressure port injected dual fuel engine

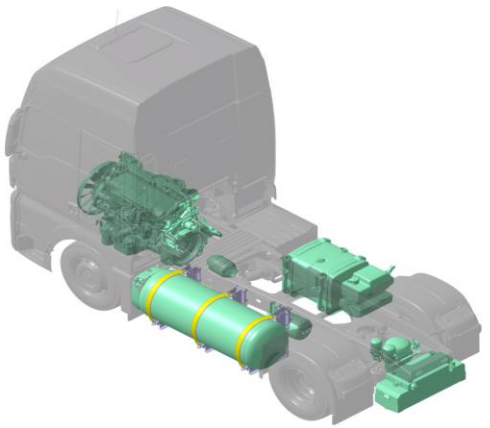
OBJECTIVES AT A GLANCE

- Development of a low pressure port injected dual fuel engine capable of:
  - 15% substitution increase compared to 2013 state of the art dual-fuel HD engines
  - 10% reduced GHG emissions compared to present diesel vehicle
  - Exhaust emissions meeting EU VI
  - Diesel-like performance and drivability
  - Vehicle range > 800km
  - Vehicle to operate in pure diesel mode

HIGHLIGHTS

★ New closed-loop injection system developed and implemented

★ Methane oxidation catalyst installed and calibrated



Low pressure port injected dual fuel engine

ACHIEVEMENTS

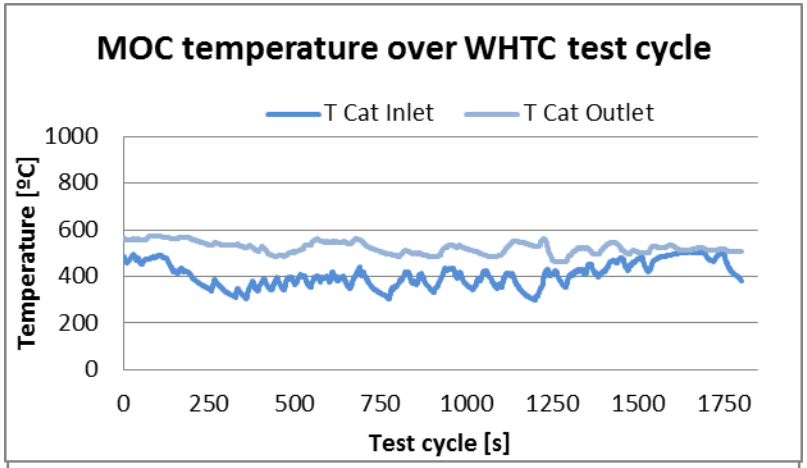
Engine:

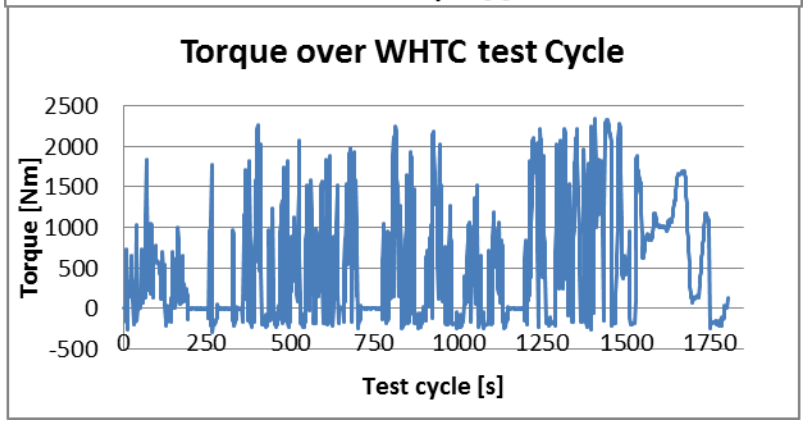
- ✓ Investigations and simulations of gas flows, injection and combustion concluded
- ✓ New closed-loop injection system developed and in implemented
- ✓ Prototype engine is running in dual fuel operation on the test bench

WHTC test cycle		
GER [%]	Aver. Power [kW]	Methane [g/kWh]
65	73.1	0.462
Methane emmissions limit according R49.06		0.485

Truck:

- ✓ Vehicle nearly ready for engine integration





WP6

High pressure gas direct injection engine

OBJECTIVES AT A GLANCE

- To develop and demonstrate a new Heavy Duty Methane Gas engine and vehicle, based on a High Pressure Direct Gas Injection (HPGI) with:
  - Exhaust emissions meeting EU VI
  - > 20% reduction of greenhouse gas emissions compared to present diesel engine
  - Same engine power, torque and drivability as diesel engine
  - > 90% substitution of diesel in real driving cycle
  - > 800 km driving range

HIGHLIGHTS

★ Prototype injector developed and performance proven by tests

★ Single- and multi-cylinder engines designed and procured

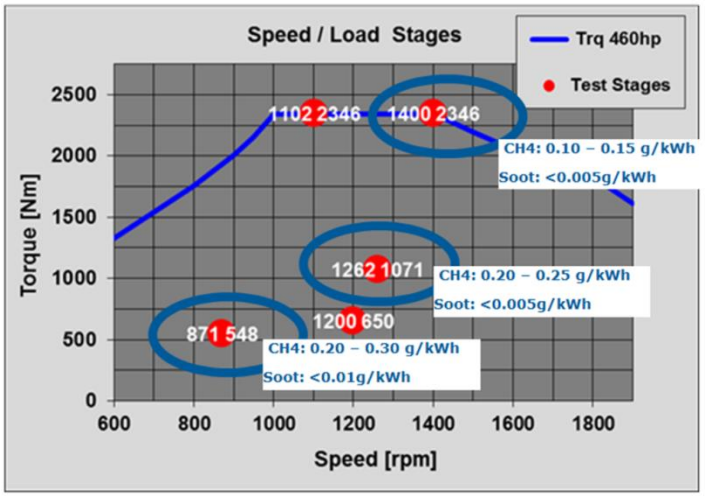
★ Combustion system optimization by CFD

★ Vehicle under development with:
  - device to mitigate all methane boil-off
  - low friction LNG pump and improved control

High pressure gas direct injection engine

ACHIEVEMENTS

- ✓ Summary of results from engine tests:
  - Fuel efficiency better than diesel
  - Soot emissions close to zero
  - Methane emissions engine-out meeting EU VI
  - > 90% substitution of diesel



WP7

Independent testing and overall assessment

OBJECTIVES AT A GLANCE

- Independent assessment of the achieved results compared to state of the art from 2013:
  - GHG and CO2
  - Driving range
  - Emission compliance on test bed and on road
- Cost assessment

HIGHLIGHTS

★ Testing procedures defined

★ Baseline testing performed

★ First target testing planned in June 2017 (engine)

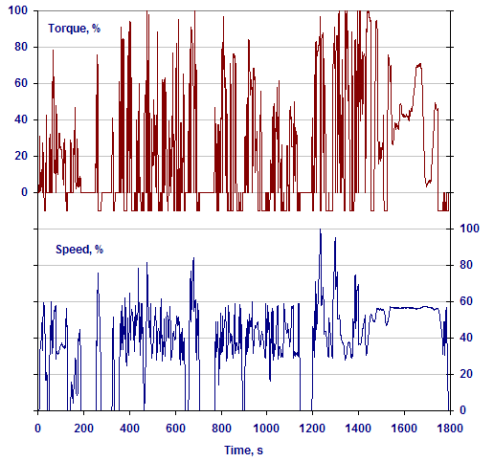
Independent testing and overall assessment

ACHIEVEMENTS

- ✓ Testing procedures and necessary documentation defined for

  1) Emission compliance:
  - Test method (test bed and on road)
  - Test cycles
  - Fuel
  - Emission components

  2) Target fulfillment:
  - GHG / CO2
  - Driving range
  - Performance



WP8

Dissemination, communication and preparative exploitation activities

ACHIEVEMENTS

- ✓ Elaboration of a dissemination plan
- ✓ Participation at international conferences and workshops
- ✓ Creation and publication of :
  - project website
  - regular newsletters
  - flyer
- ✓ Elaboration of an exploitation plan

Dissemination, communication and preparative exploitation activities

- Publication of **results**

☑ under 'latest news' &

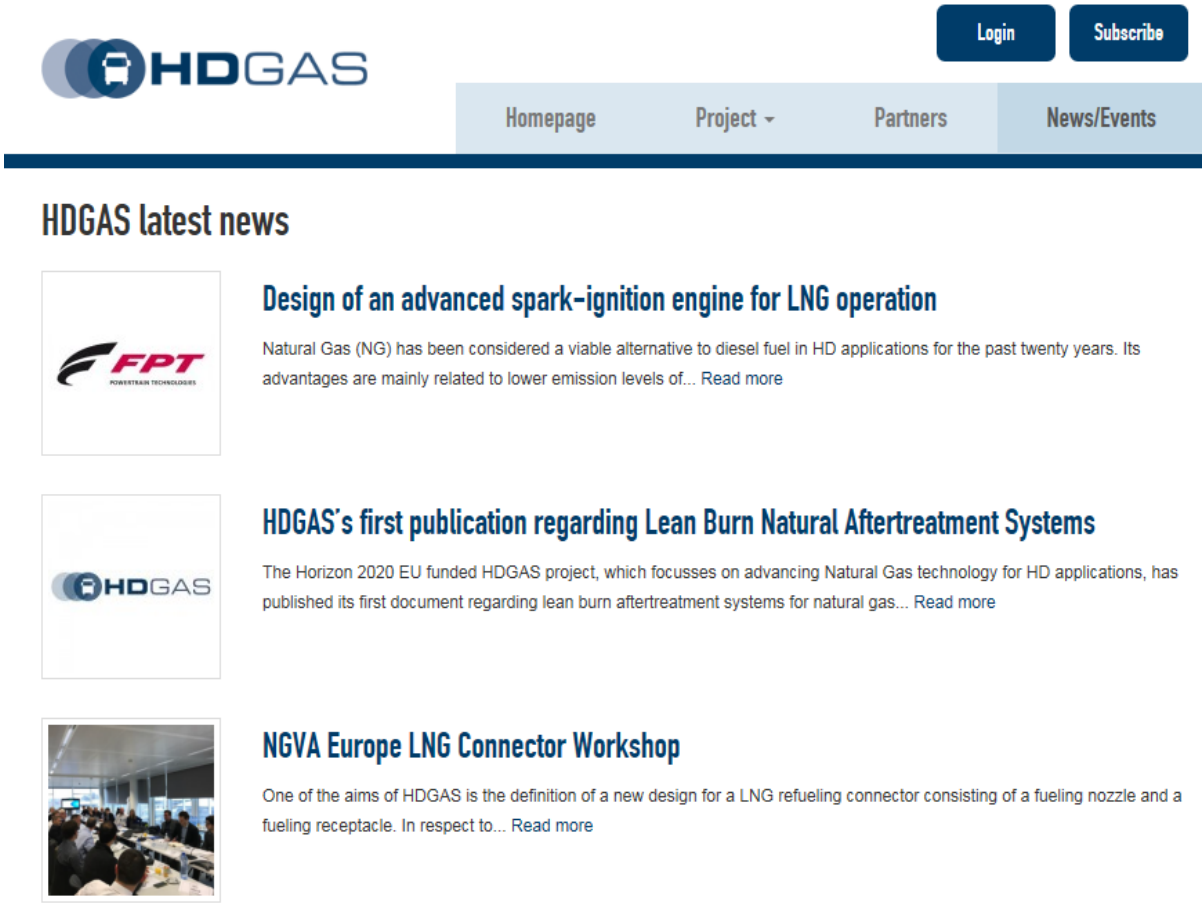
☑ in newsletter

-> please subscribe !

- **Publishable summaries**

☑ under 'results'

☑ regular updates



WP8

HDGAS

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Homepage Project Partners News/Events Results

Results

On this page the public available documents from the project can be downloaded.

- Public reports
  - HDGAS-D2.1-System Layout Of LNG Tank System-Daimler-Public Summary (397.4 KiB)
  - HDGAS-D3.1-Output From Catalyst Model-UEF-Public Summary (392.1 KiB)
  - HDGAS-D3.2-Catalyst Specs-DINEX-Public Summary (366.5 KiB)
  - HDGAS-D4.2-CFD Simulations-RICARDO-Public Summary (345.6 KiB)
  - HDGAS-D4.3-New Engine Components' Design-FPT-Public Summary (347.4 KiB)
  - HDGAS-D4.4-Prototype Of New FPT Cursor 13 Pure NG LPDI Engine-FPT-Public Summary (338.2 KiB)
  - HDGAS-D5.1-Baseline Engine Performance-Idiada-Public Summary (350.5 KiB)
  - HDGAS-D5.2-Dual Fuel Performance Evaluation-Idiada-Public Summary (353.1 KiB)
  - HDGAS-D5.3-MPI Low Pressure Dual-fuel Functional Operation-IDIADA-Public Summary (353.4 KiB)
  - HDGAS-D6.1-Prototype Injectors For SCE And ECU-Bosch-Public Summary (499.8 KiB)
  - HDGAS-D8 1-Project Website Public And Partner Restricted Part-UNR-Final (1.3 MiB)
  - HDGAS-D8.2-Flyer-UNR (1.3 MiB)
  - HDGAS-D8.3-Dissemination Plan-initial-UNR (895.3 KiB)
  - HDGAS-D8.4-Exploitation Plan-UNR-2016 (490.7 KiB)

advanced-spark-ignition-engine-for-lng-operation/

News

Design of an advanced spark-ignition engine for LNG operation
April 7, 2017

HDGAS's first publication regarding Lean Burn Natural Aftertreatment Systems
April 7, 2017

NGVA Europe LNG Connector Workshop
April 7, 2017

Performance evaluation Dual Fuel trucks available on the market
May 10, 2016

MPI low pressure Dual Fuel functional operation with a new open engine management system
April 15, 2016

Events

Transport Research Arena 2018
16/04/2018 - 19/04/2018
Vienna
NGV Corridors

Outlook and risk mitigation

WP2: Advanced LNG vehicle fuel system

WP3: Engine aftertreatment system

Low pressure direct injection spark ignited EGR engine

WP4

Low pressure port injected dual fuel engine

WP5

High pressure gas direct injection diesel pilot ignition engine

WP6

WP7: Independent testing and overall assessment

WP2: Tank and fuel systems have been developed and are under procurement for vehicle integration. Integration of a new partner as supplier for high pressure gas system and reduction of gas pressure from 500 to 300 bar will secure a proper operation in the vehicle

WP3: Methane conversion efficiency and catalyst ageing are being considered as main challenge. New catalyst compositions will make a major contribution being emission compliant without major fuel efficiency penalties by applying targeted thermal management

WP4: The stoichiometric SI engine is considered as straight forward technology with no concerns in terms of emission compliance. With several new technologies being implemented, major steps reducing fuel consumption will be realized. The goal of reaching 10% reduction still remains challenging.
The lean burn version should easily reach the targets connected to improved efficiency while compliance with emission level of methane is the main challenge

WP5: Dual fuel engines offer great flexibility to its operators while the LNG network still needs improvements in terms of coverage. Reaching the 10% of CO2 reduction has been achieved already. Being emission compliant in all conditions still remains as the main challenge

WP6: HPGI offers high CO2 reduction potential (>20%) as well as no major concerns in terms of emission compliance. System complexity and cost are areas to be in focus

END
of
PRESENTATION

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