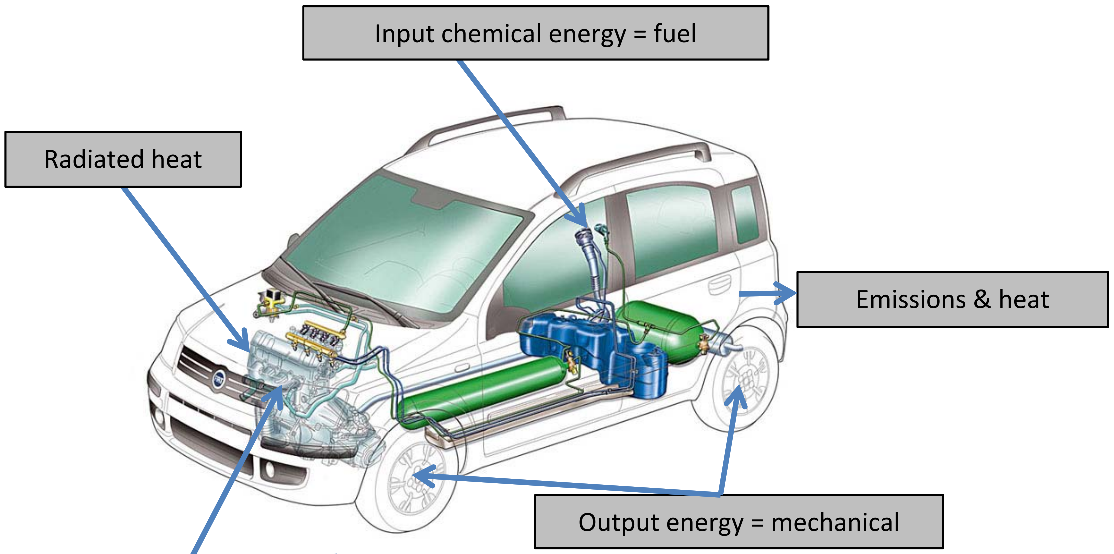
Gas-Only Internal Combustion Engines

H2020 GV-3-2014 Future natural gas powertrains and components for cars and vans

Massimo Ferrera (CRF)

The issue: vehicle emissions

FUEL (C, H, O) + AIR (N_2+O_2) → H_2O + CO_2 + pollutants



Air

Main constituents	%weight
O_2	23
N_2	76

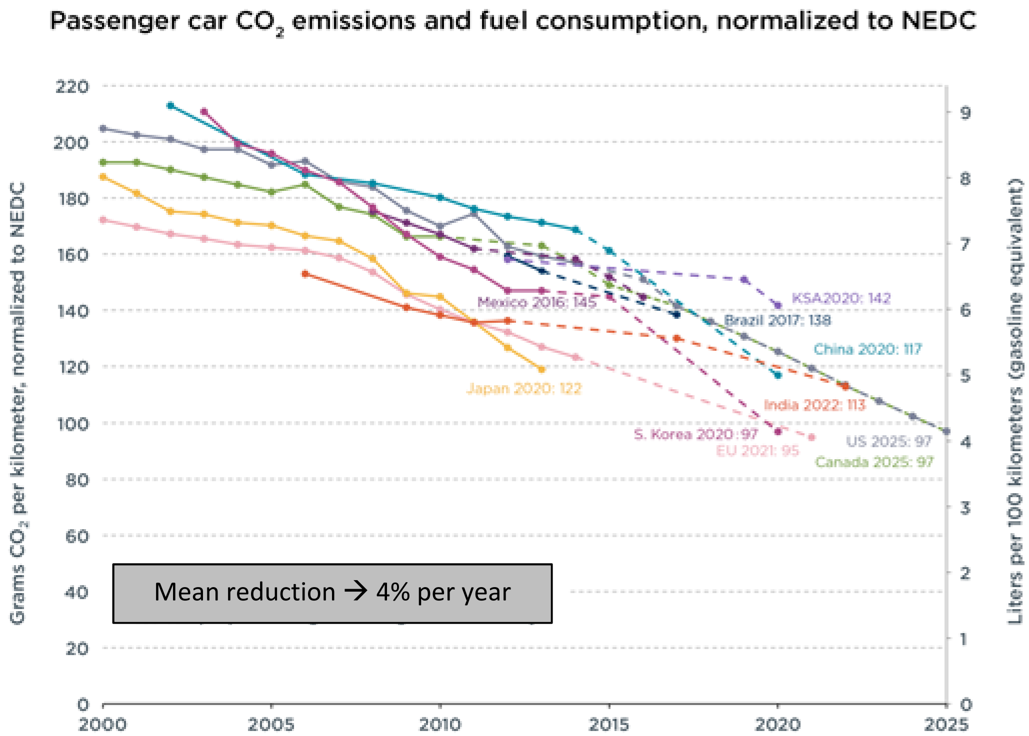
Global impact

Main emissions	%weight
CO_2	18
H_2O	8,5
O_2	0,6
N_2	72

Local impact

Noxious emissions	%weight
CO	0,6
THC	0,1
NOx	0,1
Particle matter	0,1
Not regulated	

Global impact: Green House Gases

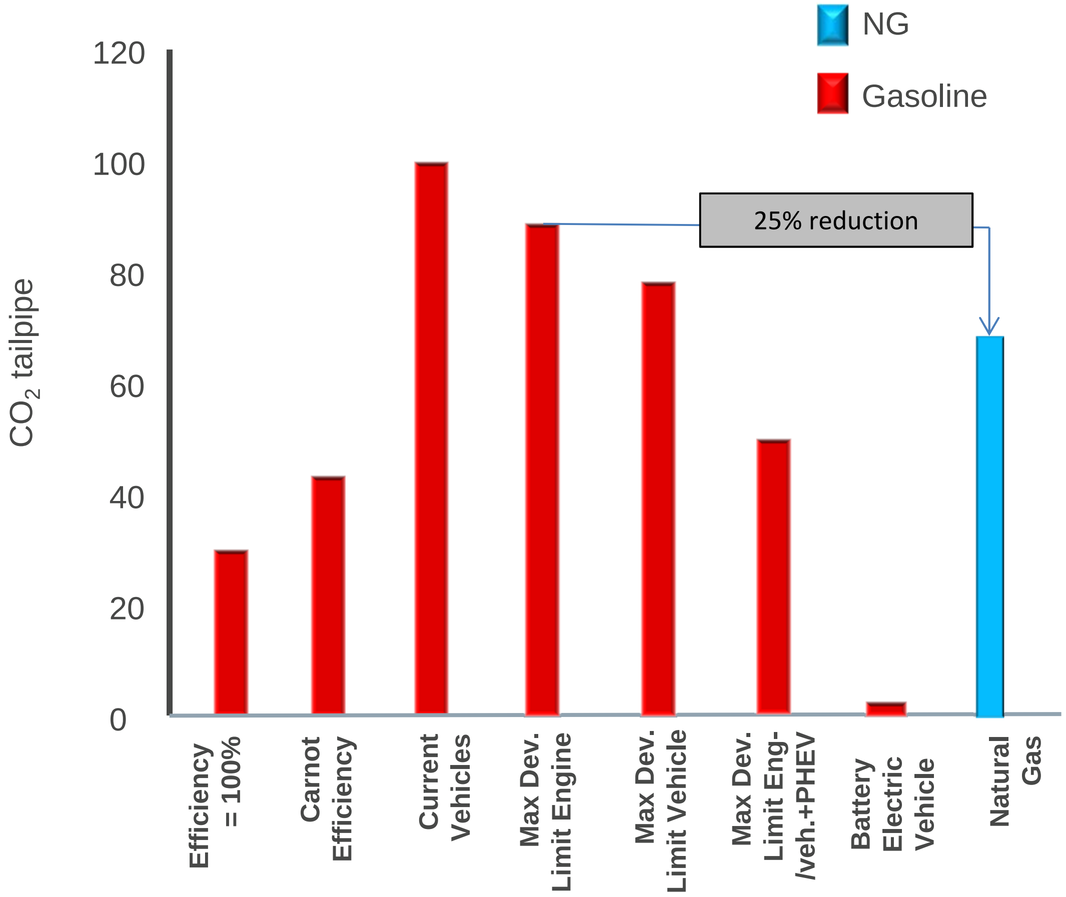


Engine efficiency ~ 30%

VDE Vehicle demand energy

CO_2 is the main GHG. For a given fuel, the CO_2 quantity emitted depends on engine efficiency and vehicle characteristics (weight, rolling resistance, aerodynamics)

CO_2 reduction walk



Electric Vehicles (BEV) and Plug-in Hybrids (PHEV)

Electric vehicle offers CO_2-free emissions

Alternative Low Carbon Fuels

The lowest carbon content fuel, the lowest the CO_2 produced.

NG shows the best reduction

A pragmatic answer: methane (1/2)

- CNG reserves greater than oil
- Lowest fuel costs
- Fossil CNG: up to 25% TtW CO2 reduction vs. gasoline with dedicated CNG cars
- Bio-Methane: already available as 2nd generation biofuel (~ 80% less WtW CO_2)
- Power to Gas Methane: ~ 95% less WtW CO_2

A pragmatic answer: methane (2/2)

Right fuel for internal combustion engines

Low emissions:

- No soot
- No NOx issue (also in RDE)

High knock resistant (RON > 120; Methane Number (MN) > 65…70)

- Ideal fuel for boosting and downsizing
- High compression ratio enabler for efficiency improvement and further CO_2 reduction
- High boost pressure enabler (higher downsizing potential) for efficiency improvement by use of smaller engine architecture

GasOn targets to drastically reduce CO2 emissions (20%)

In order to exploit the main benefits of CNG (Compressed Natural Gas), the aim is to develop CNG-only (monofuel) engines able to comply with:

- ❑ **post Euro 6 noxious emissions**
- ❑ **2020+ CO_2 emissions targets**
- ❑ **new homologation cycle and real driving conditions**

with simultaneous improvement of engine efficiency & performance gasoline-like adopting:

- ❑ **Innovative injection, ignition and boosting system concepts**
- ❑ **Advanced exhaust gas after treatment system**
- ❑ **Detecting gas-quality and composition**

GasOn Consortium

CENTRO RICERCHE FIAT (CRF)

Ford

RENAULT

FEV

AVL

IFP Energies nouvelles

cea

RICARDO

EMPA Materials Science & Technology

DELPHI Innovation for the Real World

SCHAEFFLER LUK INA FAG

Continental

PIERBURG

POLITECNICO DI TORINO

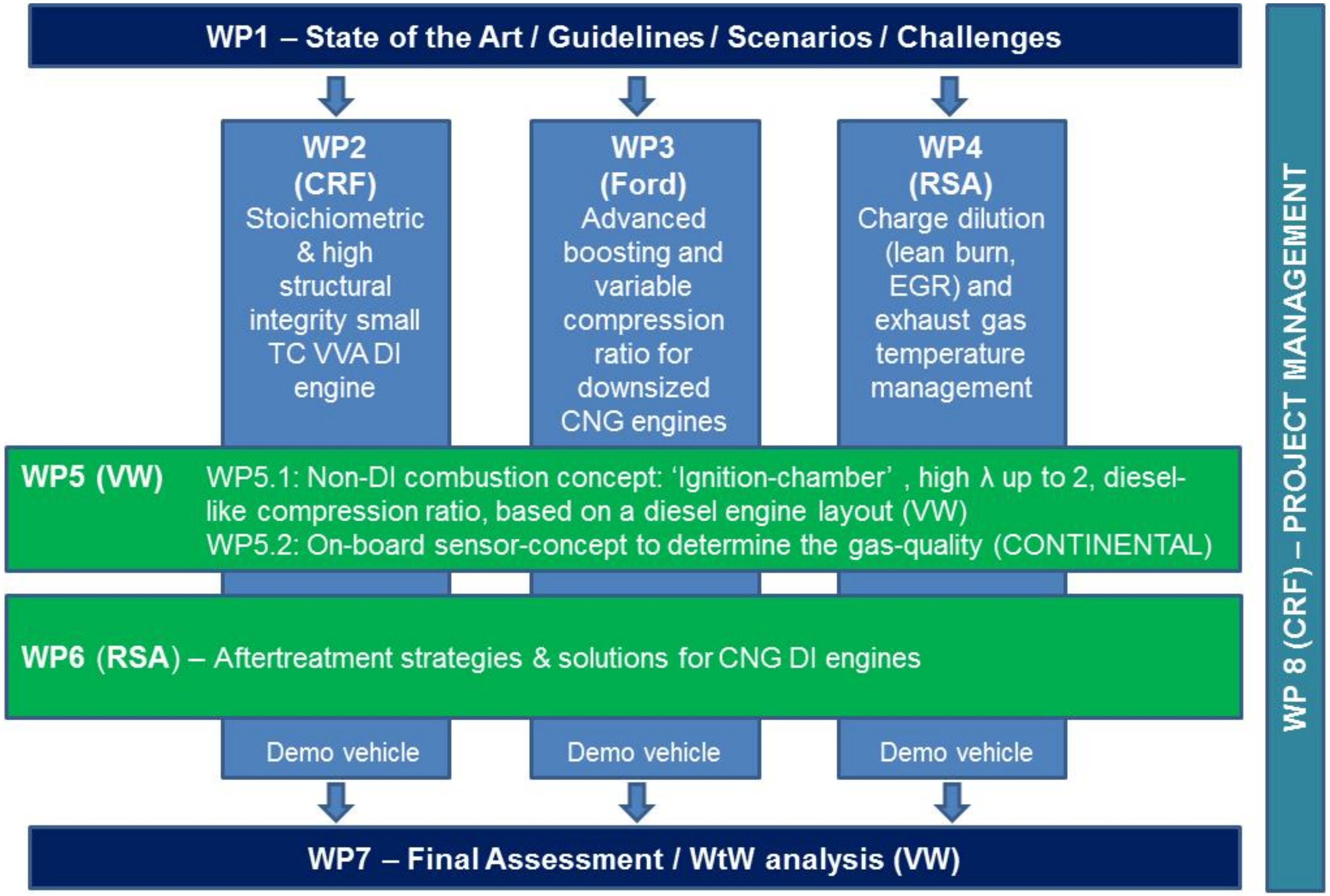
Universidad Politecnica Valencia

ETH zürich

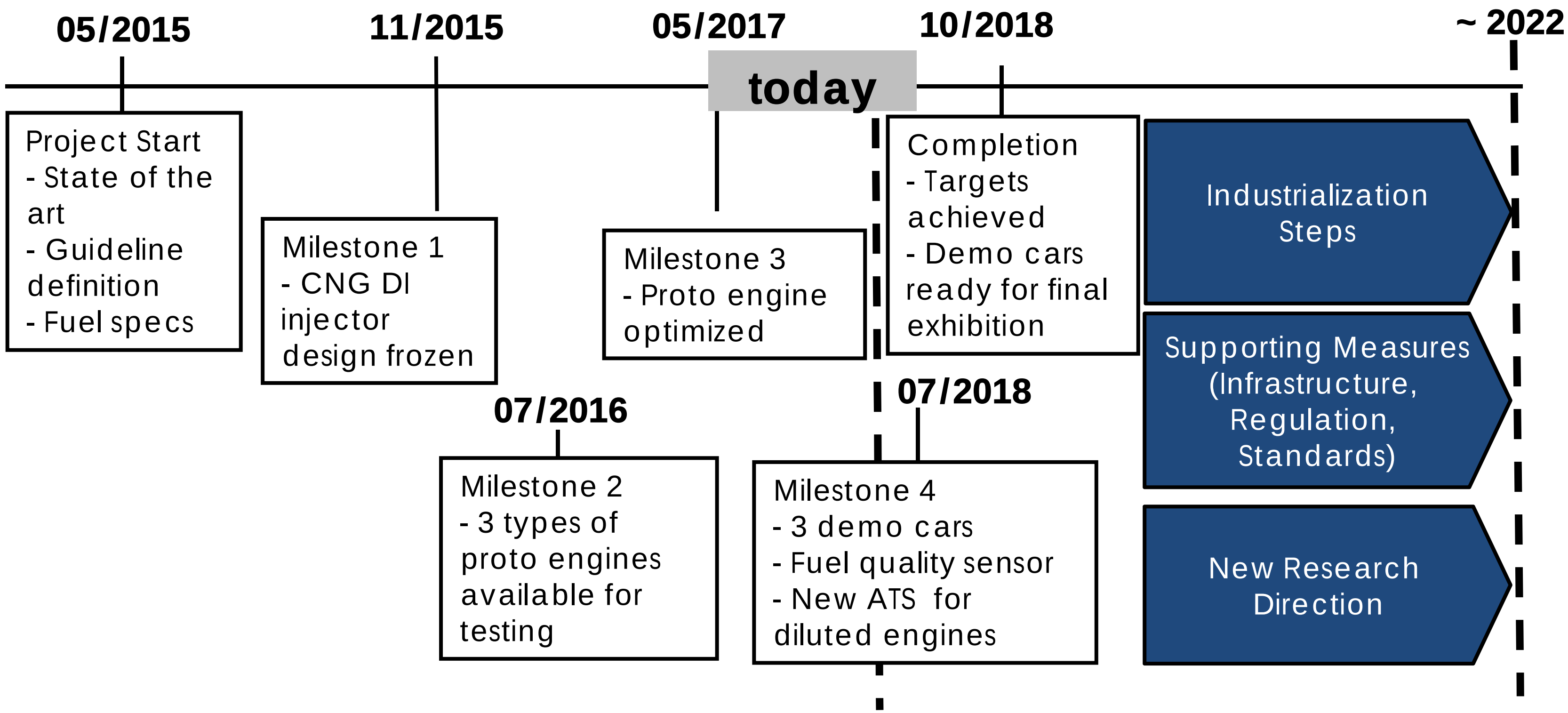
Poznan University of Technology

Czech Technical University in Prague

GasOn Structure



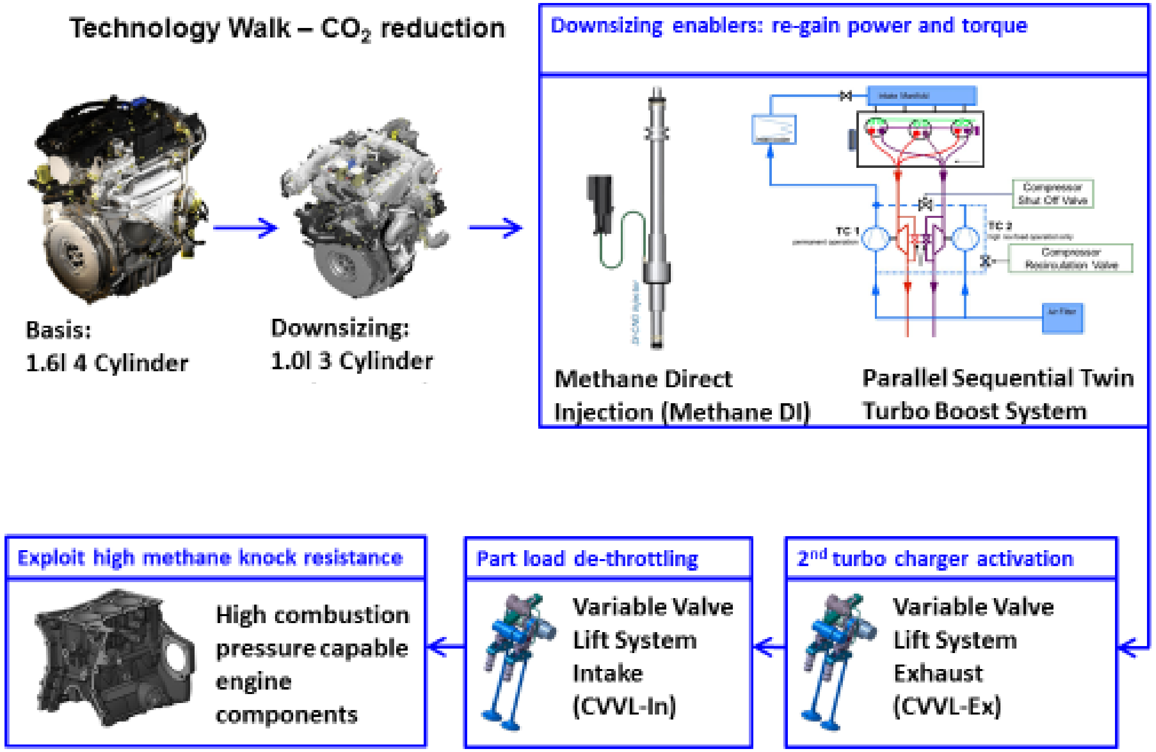
GasOn timing



GasOn final outcomes

- New generation of extremely efficient CNG engines
- New generation of CNG injection system
- New CNG combustion concepts
- Fuel quality sensor
- New storage layout complying with gasoline-like driving range

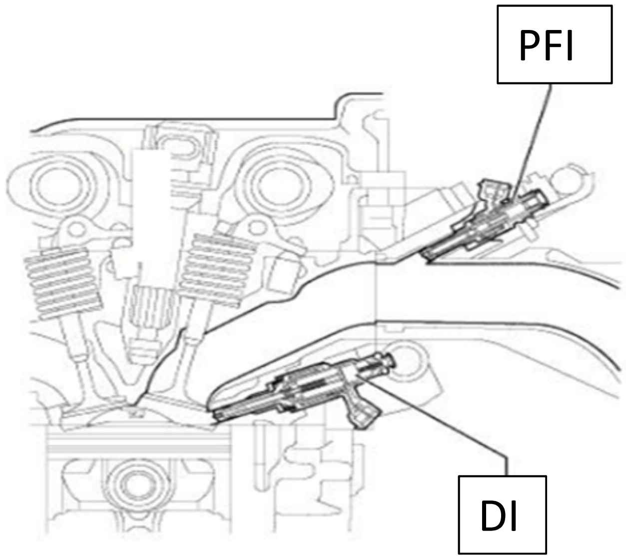
GasOn technologies & impacts

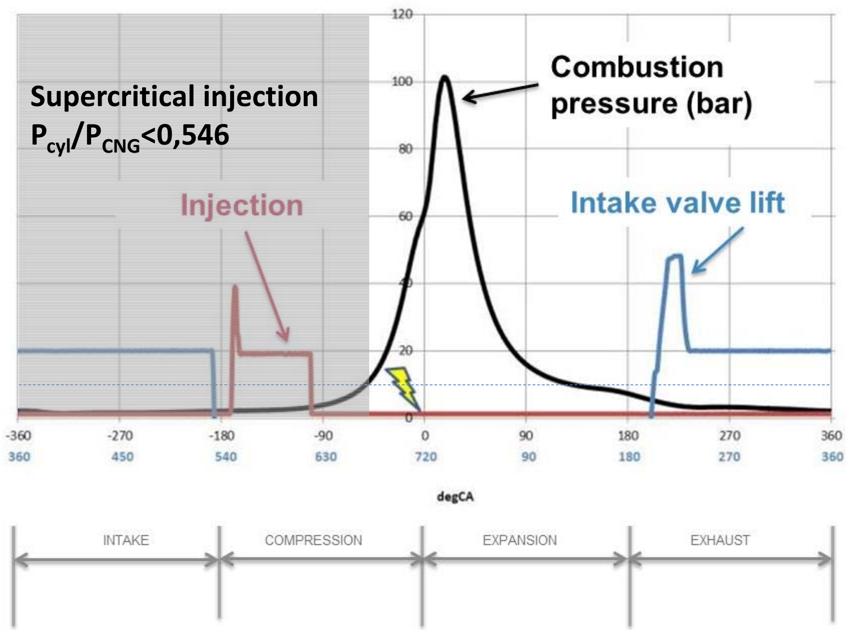


-20% CO2 tailpipe is feasible compared to current CNG solutions

Source Ford @ 39. Internationales Wiener Motorensymposium 2018:
Based on these steady state measurements vehicle cycle simulations have been conducted to verify conformance to NEDC and WLTC targets, based on a mid-class 7-seater van. The NEDC cycle prediction indicates a CO2 emission of 93 g/km, well below the initial target of 100 CO2 g/km. The prediction for the higher loaded WLTP cycle shows CO2 emissions of 120 g/km. The combination of these technologies leads to exceptionally low CO2 emissions which support the future emission glide path.

CNG DI (Direct Injection) concept

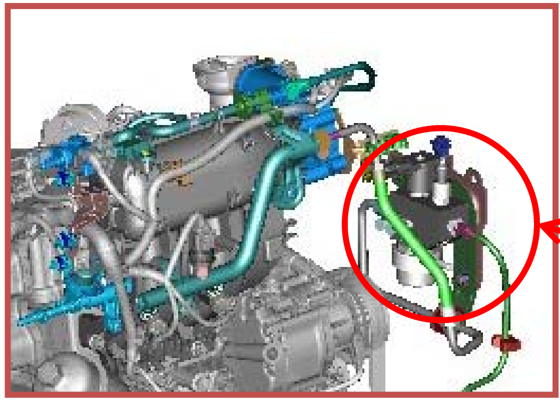




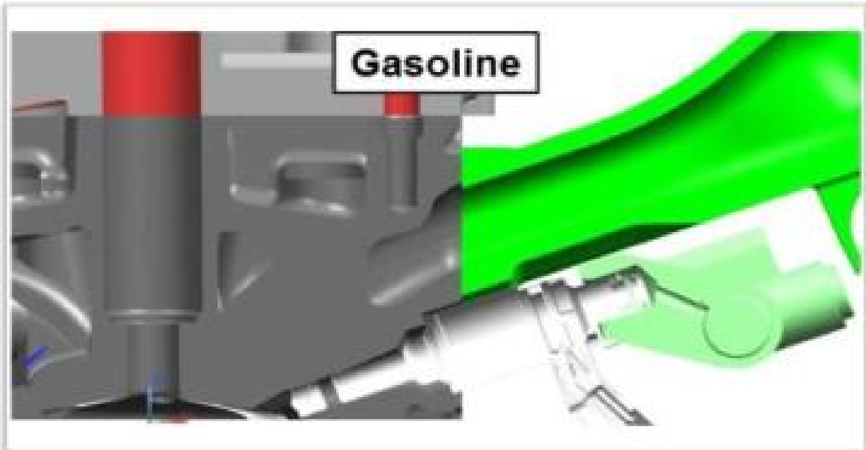
- Low pressure injection after intake valve closing (DI) to remove volumetric efficiency losses due to gaseous injection (PFI)
- Variable injection pressure system to comply with injection duration

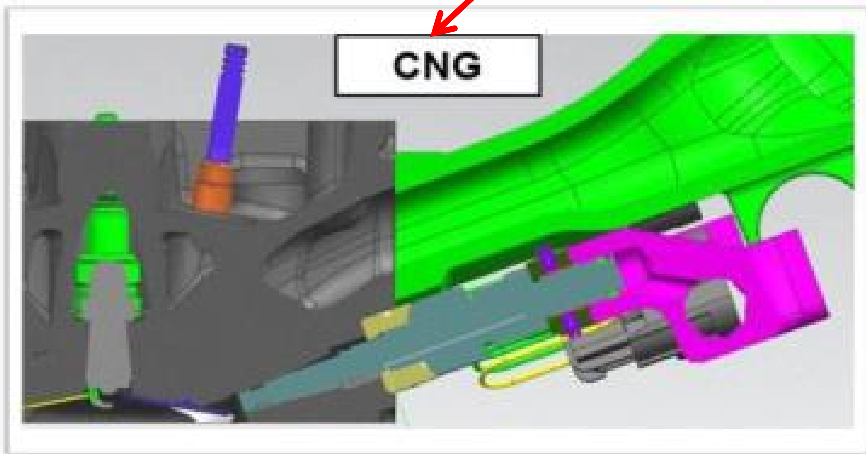
Easy adaptation of CNG DI system into GDI engine

Cylinder Head & Block:
- No modifications

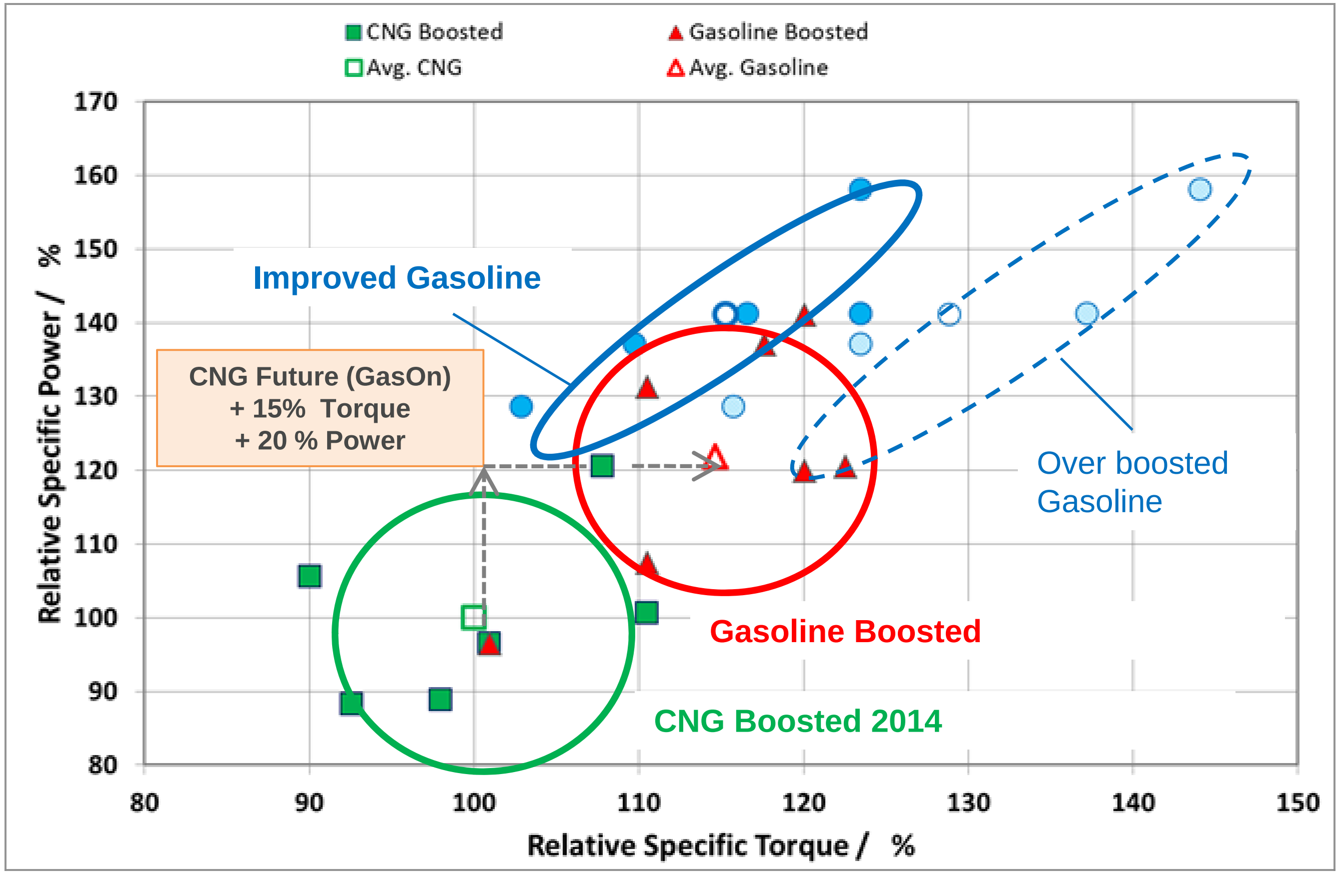


Injection system CNG:
- DI CNG injectors, fuel rail and electronic pressure regulator





GasOn engine performance



2014 CNG vehicle market: CNG port fuel injection (CNG PFI) only

Low specific torque:	~15% below comparable average gasoline DI
Low specific power:	~20% below comparable average gasoline DI

GasOn - New CNG combustion concepts

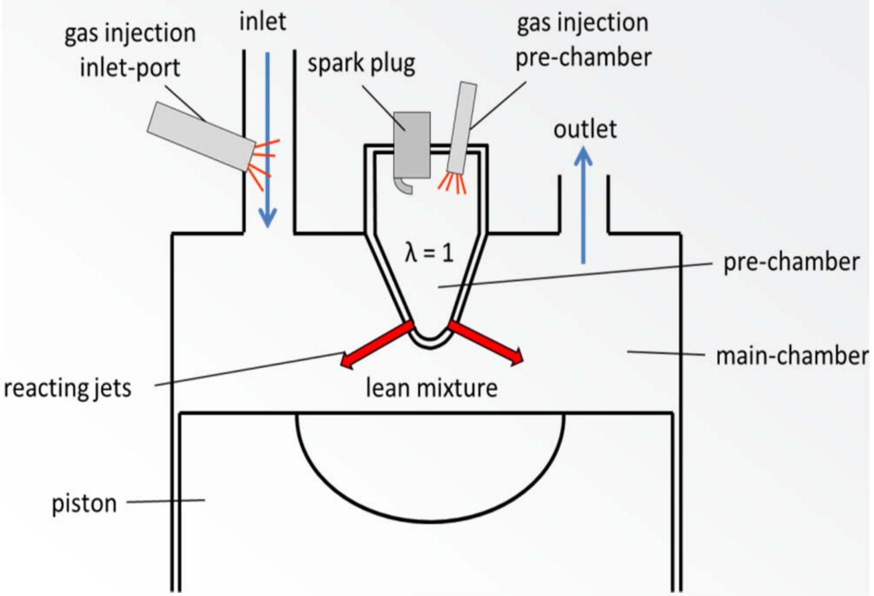
MOTIVATION

Monovalent CNG-Combustion to exploit fuel advantages and reach maximum efficiency

- **Efficiency can be improved by using lean combustion for CNG with λ>>1**

  Target: λ=2
- **Increased requirements for ignition system (mixture, pressure)**
- **Creating a suitable distribution of NG in the air locally and globally**

Combustion Process

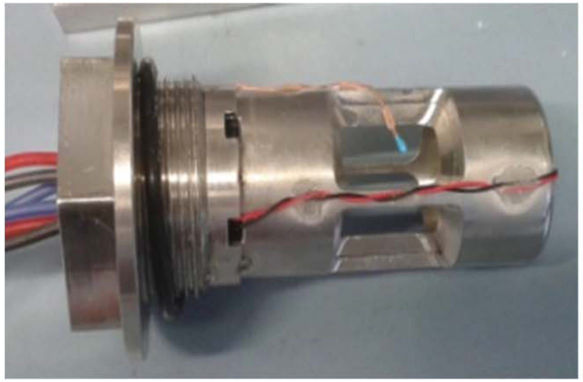


- Ignition chamber combustion increases lean limit
- Downscaling from big bore engines feasible
- Engine efficiency of 44% already shown
- Challenging aftertreatment system

GasOn – Fuel Quality Sensor

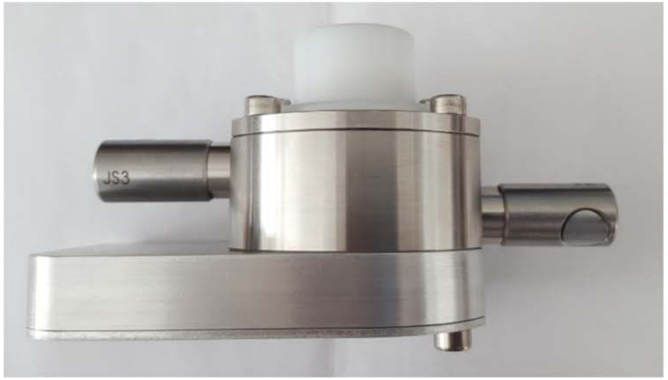
On-board sensor concept and module to detect the relevant gas quality parameters (eg. caloric value and composition)

- Integrated sensor module with multiple measurement principles
- 2 modules for optical and non optical measurements with the advantage of higher flexibility during development



Ultrasonic Sensor

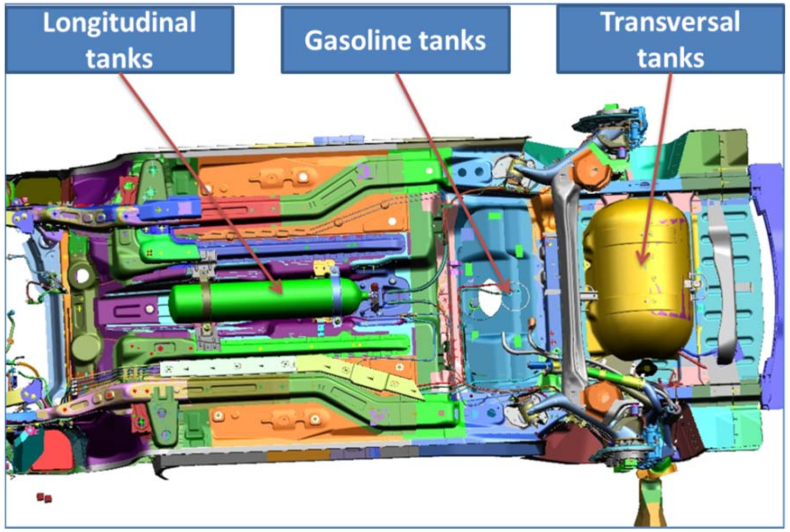
Thermal Sensor



Optical sensor

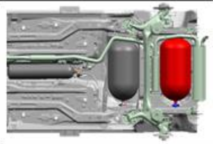
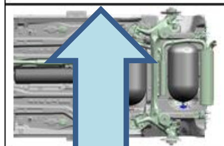
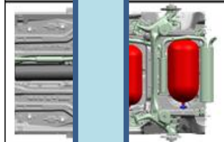
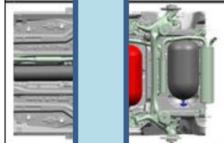
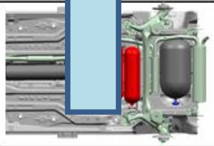
GasOn - Storage

Existing underfloor lay-out



2 tanks = 86 liters = 300 km

GasOn project

Option	Capacity liters	Range (Km)	Tank lay out	Lay out modification
	163	580	N°1 tunnel (18L) + N°1 rear (68L) + N°1 rear Ø410x769 (77L)	• Rear seat • New 2 tanks
	154	545	N°1 tunnel (18L) + N°1 rear (68L) + N°1 rear (68L)	• Rear seat • New 1 tank
	150	530	N°1 tunnel (18L) + N°1 rear Ø356x740 (55L) + N°1 rear Ø410x769 (77L)	• Rear seat • New 2 tanks
	141	500	N°1 tunnel (18L) + N°1 Ø210x690 (55L) + N°1 Ø410x769 (68L)	• Rear seat • New 1 tank
	124	440	N°1 tunnel (18L) + N°2 Ø210x690 (19L x2) + N°1 Ø410x769 (68L)	• New 2 tanks

2 times driving range vs current solutions

GasOn further support on Natural Gas arena

- Support development of CNG Infrastructures
- Validate new technologies as direct injection
- Further research in ultralean CNG engines
- Synergies with H2020 HDV project

You are invited to attend
Final GasOn Workshop in Aachen on 24 October 2018

Thank you for your attention