Technology Issues in the CNG Bussiness

Strategic Panel 7

Friday 9.October 2009

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The Main Technical Challenges

- Vehicles
- CNG-Stations
- Renewables and Hydrogen

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Clean Engine CNG-Vehicles

Engine
- Higher Compression
- "Downsizing" + Turbocharging

Catalyzer concepts
- Precat after the exhaust turbine
- Chassis integrated principle cat

Results
- **-31 % CO_2- Emissions**
- Compliance with EURO 5 and EURO 6

Engine Control
Adjustment of the engine

Management

Model based approach

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Clean Engine CNG-Vehicle

EMPA
Materials Science & Technology

Institut für Mess- und Regeltechnik
Measurement and Control Laboratory

LAV

Development Companies

BOSCH

CORNING
Discovering Beyond Imagination

ENGELHARD

Industry

energieschweiz

SVGW SSIGE

DVGW

GAS WASSER

Institutions

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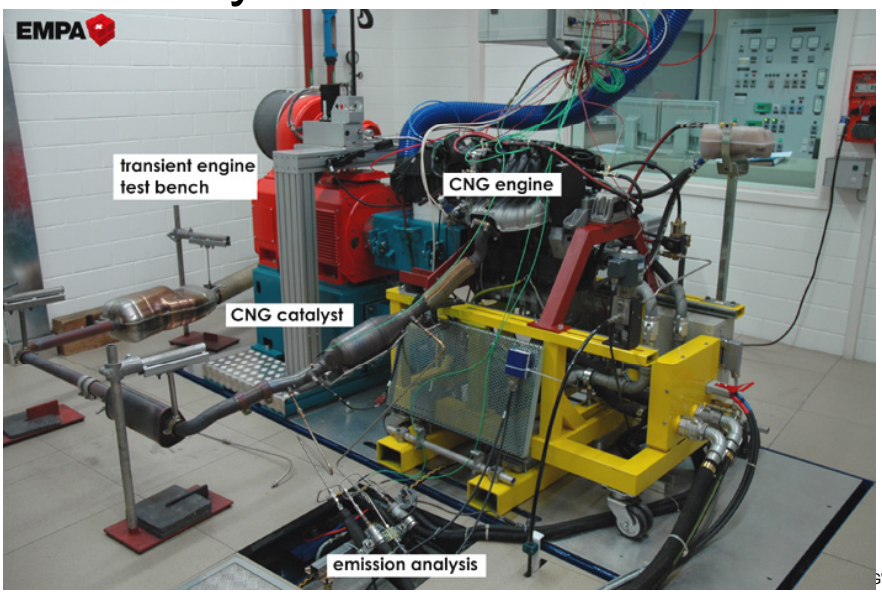
Dynamic test bench



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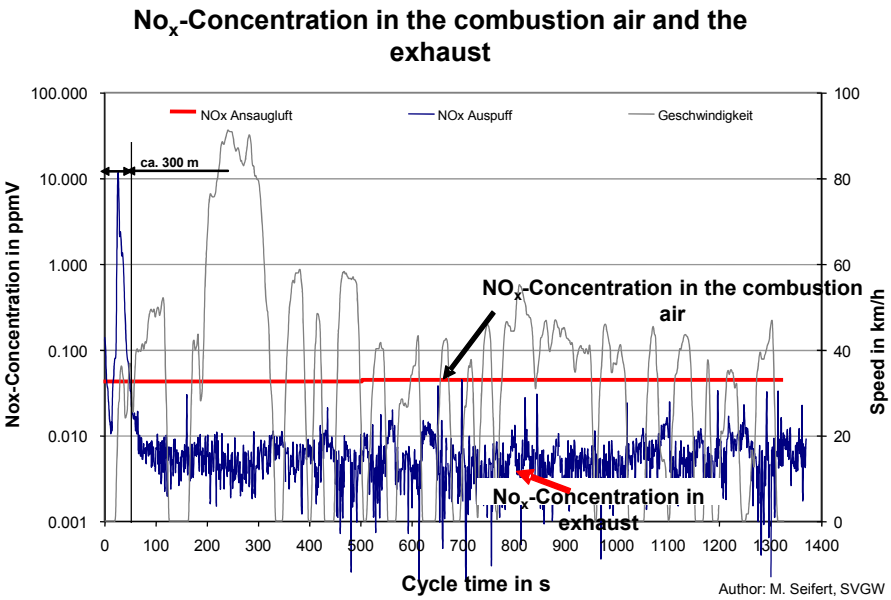

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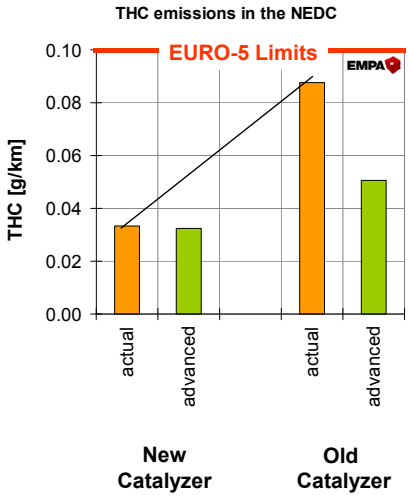
Catalyzers: Still a very critical element to reach the most anbitious emission limits

- Actual CNG exhaust gas treatment
- Advanced CNG exhaust gas reatment



Mastering the catalyzer aging

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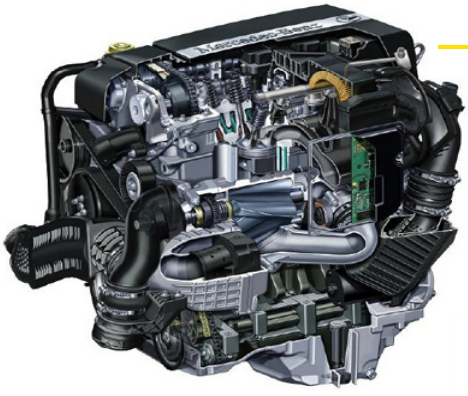
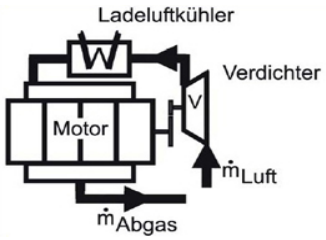
Charging the Engine



Mercedes-Benz 2,0 l 163 PS
Kompressor- CNG-Engine

Mechanical Charging

Serial OEM engine



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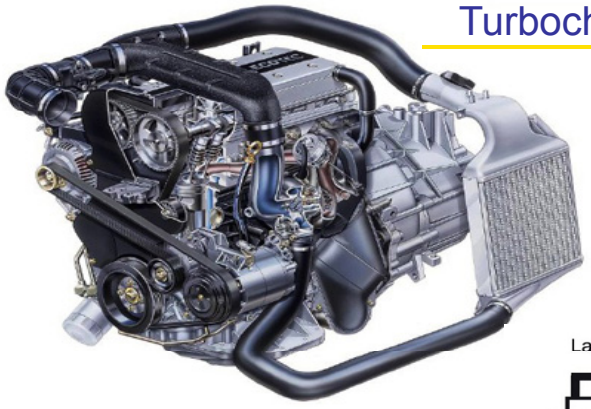
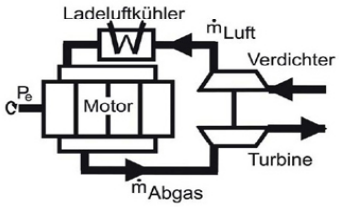
Charging the Engine

Turbocharging



Opel Zafira Engine



Opel 1,6 L Ecotec 150 PS CNG-engine

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Charging the Engine

Volkswagen Passat TSI ECOFUEL

Range: 1400 km
450 km NG

Engine: 1.4 l 4 Cylinder
150 PS
220 Nm max torque

CO_2-Emissions: 119 g/km

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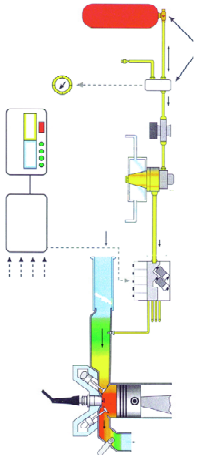
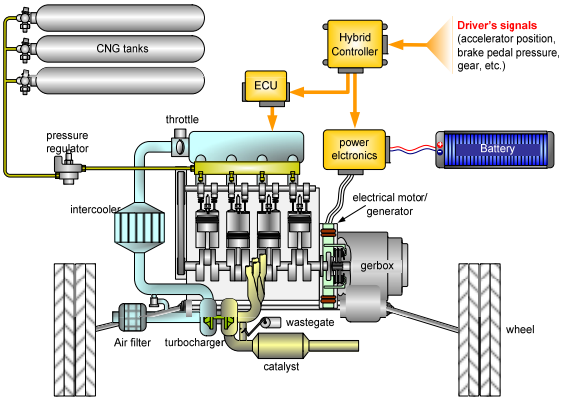
The future: CNG Hybrid





CNG-Turbocharged Engine

Milde Hybridization
Starter-Generator Concepts

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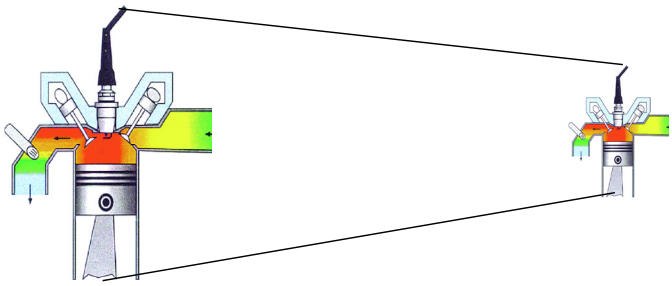

Requirements: New Combustion processes
- Downsizingcncepts (high turbocharging and EGR))
- Hybridization = less consumption, drivability + range

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Extreme downsizing

- 2 Cylinder engines
- Dynamic mass compensation
- Strong turbocharging/Downsizing factor 0.6: 0.8 l engine replaces 1.4 l engine
- Big cylinder units result in higher efficiency: 2 Cyl. Instead of 4 Cyl
- Reduction of thermal losses

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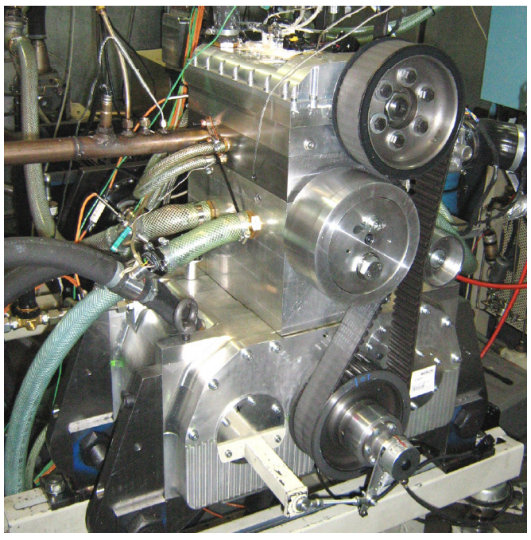
Prototype Engine



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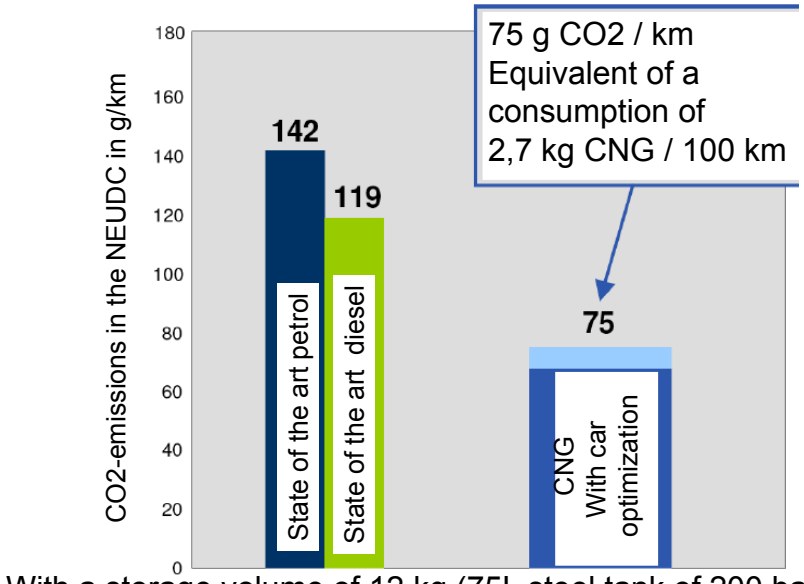

With a storage volume of 12 kg (75L steel tank of 200 bar)
There are ranges of 400 km possible

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On board gas quality measurement

- Emission optimization
- Catalyzer protection
- Constant power control
- Combustion control

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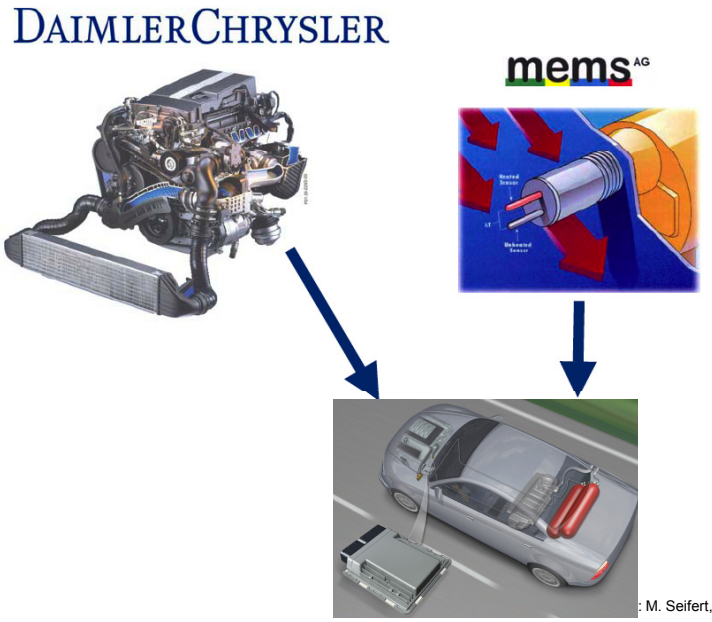

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Refuelling Station Technology

- Improvements in Modularity
- Less power consumption
- Durability
- Low maintenance costs

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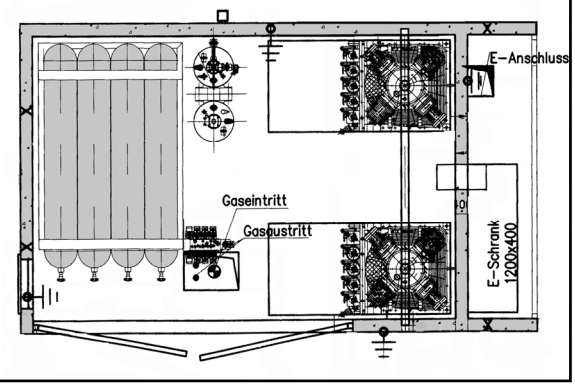
Duo Concepts

- 1. Stage: 1 Kompressor 250 m^3/h
- 2. Stage: 1 Kompressor 250 m^3/h
- Storage expendable 2 m^3 geom.Vol to 4 m^3 geom. Vol



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Ionic fluid compression technology

- Ionic organic fluids (ionic organic salts) in use in hydraulic compressors
- Handling like hydaulic oils
- High thermal conductivity
- Almost no vapour pressure

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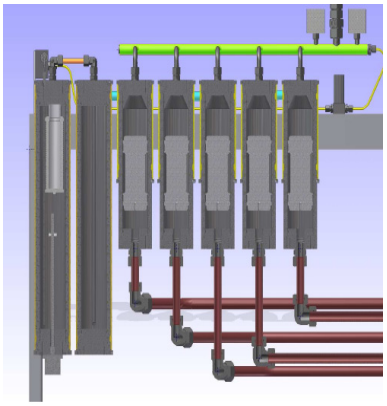
Ionic Compresor Technlogy



Near isothermal operation
Displacement type work principle
Slow piston movements
Very low death volume

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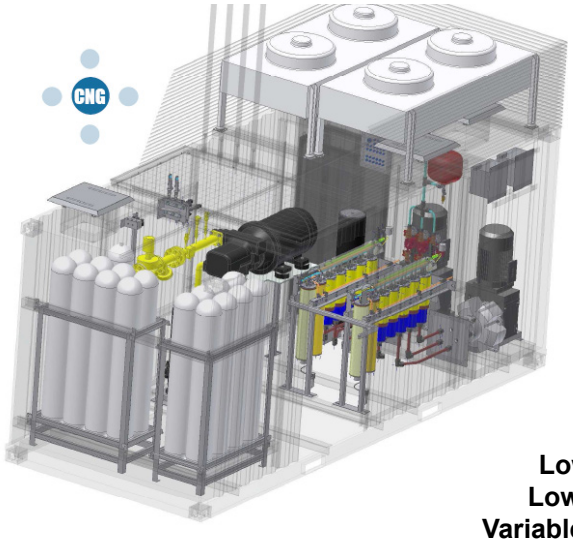
Ionic Compressor Station



Low maintenance costs
Low energy consumption
Variable inlet pressures possible

Example of an iCompressorstation

Airport Refuelling Station Vienna

Capacity: 2 x 280 m³/h

Refuelling Coupling

- In most European Countries CNG self service
- The refuelling receptacle is the direct link to the client
- High safety requirements in operation needed

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The common refuelling pistols

Two hand use

Single hand use

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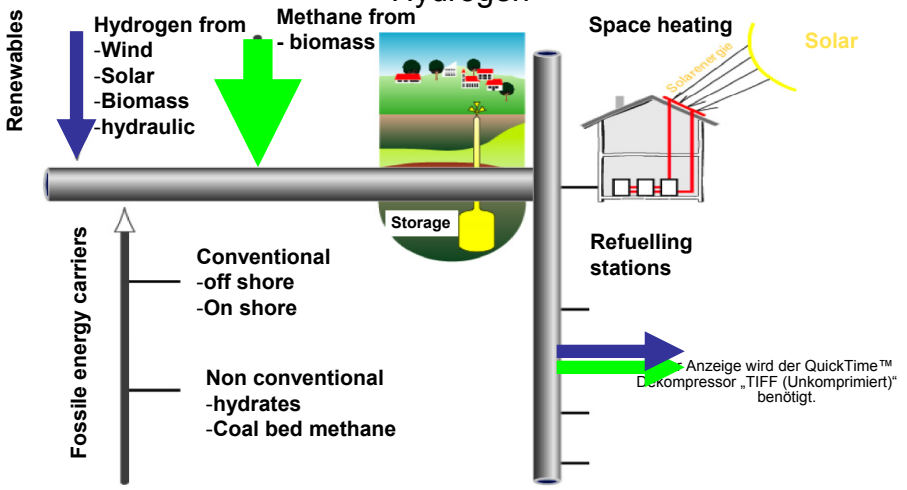
CNG of the future: NG enriched withBiomethane and Hydrogen



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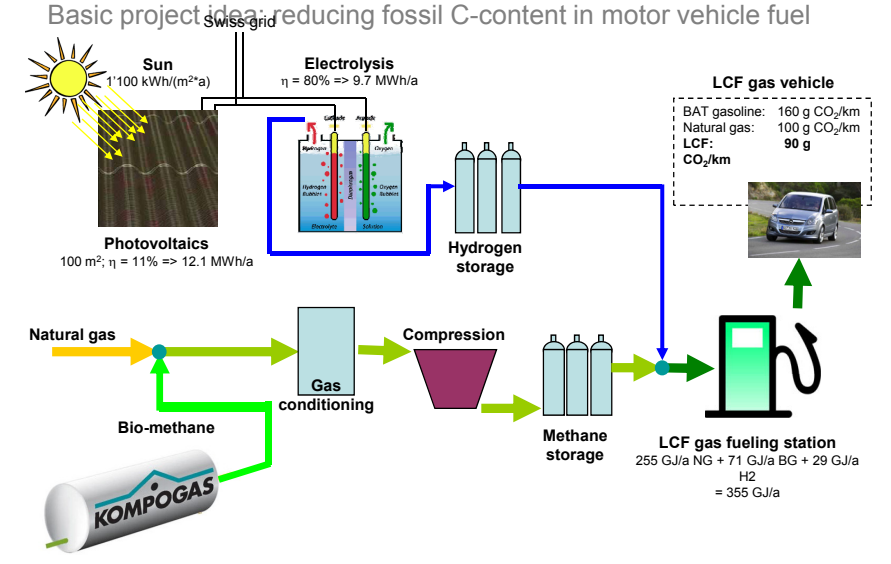
Low carbon fuel project (LCF)

Basic project idea: reducing fossil C-content in motor vehicle fuel



Gasoline -22% CO_2 Natural Gas -20% CO_2 20% Biogas -10% CO_2 10% Hydrogen = -45% CO_2

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Low carbon fuel project (LCF)

Estimation of CO_2 reduction potential of car fleet

Sun
1'100 kWh/m2*a

↓

PV
100 m2
11.0%
12'100 kWh/a

↓

Electrolysis
80.0%

↓

Hydrogen
9'680 kWh/a
34'848 MJ/a
1'081 l Gasoline-Aeq./a

Natural Gas
"unlimited"

Biogas
20.0%

Actual gasoline consumption PC-fleet Empa:
11'000 l Gasoline/a
353'214 MJ/a

Potential 100 m2 PV:
9.9%

$H_{Gasoline}$	42.7 MJ/kg	CO2 Gasoline	74 g CO2/MJ
$H_{Natural\ Gas}$	47.0 MJ/kg	CO_2 Natural Gas	59 g CO2/MJ
H_{Biogas}	47.0 MJ/kg		
$H_{Hydrogen}$	120.0 MJ/kg		
Density NG	0.790 kg/m3		
Density H2	0.089 kg/m3		
Density Gasoline	0.752 kg/l		

Actual Gasoline	Version 1 Natural gas	Version 2 Natural gas/biogas	Version 3 NG/BG/H2
100% Gasoline	**100% Natural gas**	**80% Natural gas**	**70% Natural gas**
353'214 MJ/a	353'214 MJ/a	282'572 MJ/a	247'724 MJ/a
11'000 l/a	9'513 m3/a	7'610 m3/a	6'672 m3/a
26'266 kg CO2/a	20'667 kg CO2/a	16'533 kg CO2/a	14'494 kg CO2/a
		20% Biogas	**20% Biogas**
		70'643 MJ/a	70'643 MJ/a
		1'903 m3/d	1'903 m3/a
			10% Hydrogen
			34'848 MJ/a
			3'263 m3/a
CO2	**CO2**	**CO2**	**CO2**
26'266 kg CO2/a	20'667 kg CO2/a	16'533 kg CO2/a	14'494 kg CO2/a
	-21.3%	**-37.1%**	**-44.8%**

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Low carbon fuel project (LCF)

From demonstration to market

The Issues

- **Fueling station concept development**
- **System integration of solar H_2 production**
- **Vehicle operation (combustion analysis, cold/hot start, emissions)**
- **Safety issues (permeation losses)**
- **Eco balancing**
- **…**

P&D
F&E

Market

- **Fuel specification**
- **Parts specification**
- **Durability**
- **Costs**
- **…**

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Thank you for your attention.

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