HYSYS
Fuel Cell Vehicle System Components

HySYS: Fuel Cell Hybrid Vehicle System Component Development

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FC Hybrid Vehicle System Component Development

Project Facts

- **Coordinator**: Daimler AG
- **Total budget**: 22.7 M€
- **EC-Funding**: 11.2 M€
- **Partners:** 28 (17 Industry, 2 SMEs, 4 Institutes, 5 Universities)
- **Countries**: 8 EC Member States and Switzerland
- **Duration**: 01.12.2005 – 30.11.2010

Partners

DAIMLER, PSA PEUGEOT CITROËN, CRF CENTRO RICERCHE FIAT, RENAULT, VOLVO, ATB Technology in Motion, AVL, BOSCH, e2v, Continental, ELDOR CORPORATION, SELIN, fumatech Funktionelle Membranen und Anlagentechnologie, NUCELLSYS THE FUEL CELL SYSTEM COMPANY, saft, MAGNA STEYR, FISCHER, precise, RIVOIRA, cnm Centre Nacional de Microelectrònica IMB, ENEA, TNO, ika INSTITUT FÜR KRAFTFAHRZEUGE RWTH AACHEN UNIVERSITY, VKA ERBRENNUNGS RAFTMASCHINEN RWTH AACHEN UNIVERSITY, UNIVERZA V MARIBORU, EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, ume UNIVERSITÉ MONTPELLIER 2, Hochschule Esslingen University of Applied Sciences

Project Goals

- Improvement of **fuel cell** system components for **market readiness**
- Improvement of **electric drive train** components for market readiness
- Optimisation of **system architecture** for low energy consumption, high performance, high durability and reliability
- Optimisation of energy management, enhanced FC-drive train efficiency
- Development of low cost components for **mass production**
- **Validation** of component and system performance in **FC Vehicles**

Regarded Components

- Low cost automotive **electrical turbochargers** for air supply with high efficiency and high dynamics
- Low cost **humidifiers** with high packaging density
- Low cost **hydrogen sensors** for automotive use
- Effective low cost **hydrogen supply** line
- High efficient, high power density **electric drive train**
- Low cost high power **Li-Ion batteries**

Projectstructure HySYS

Project Management (Daimler: Wind) — SP 1000

Standardisation and Requirements (AVL: Prenninger) — SP 2000

- WP 2100 Definition of system and vehicle requirements(Daimler)
- WP 2200 Identification and analysis of synergies with ICE Hybrids (AVL)
- WP 2300 Codes, Standards and Safety (Renault)
- WP 2400 Training activities (AVL)

FC System Components (NCS: Eßling) — SP 3000

- WP 3100 Air Supply (NCS)
- WP 3200 Humidification (Daimler)
- WP 3300 H2 sensors (PSA)
- WP 3400 Educt control (CRF) (Injectors)

Drive Train Components (CRF: Ravello) — SP 4000

- WP 4100 Electric drive w. stepup: Bench Test (CRF)
- WP 4200 Electric drive w. DC/AC+DC/DC integration (Daimler)
- WP 4300 Battery Systems (Saft)

System Level (PSA: Corbet) — SP 5000

Vehicle validators:

- WP 5100 Full FC Delivery Van (Daimler: Feuerbacher)
- WP 5200 Small Power FC Vehicle (PSA)
- WP 5400 Full FC Compact Car (CRF)

System integration aspects:

- WP 5300 Modular system control and assessment of FC hybrid performance (AVL)

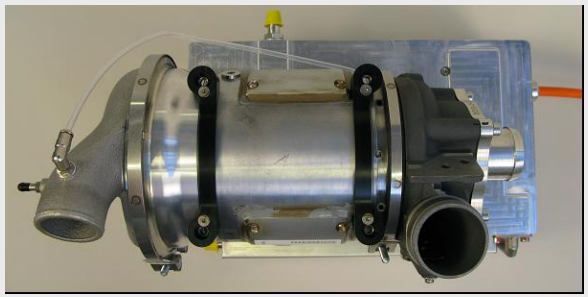
Definition of Vehicle Requirements

Parameter	DAIMLER Validator (MB-Sprinter)	CRF Validator (FIAT Panda)
Motor Power (cont/Peak)	70/100 kW	40/75 kW
Fuel Cell Power	80 kW	60 kW (nominal)–75 kW (peak)
Gearbox	One gear ratio	One gear ratio
Batterie LiIon	30 – 50 kW, 2 kWh	Not foreseen
Weight empty/fully loaded	<= 2.7 t / 3.5 t	1.4 t / 1.7 t
Range at ½ load	> 300 km	250 km
Vmax	130 km/h @ grade 0%	140 km/h @ grade 0%
Acceleration	0-80km/h < 21 s 0-100 km/h < 37 s	0-50km/h < 7 s 0-100 km/h < 15 s
Climbing ability fully loaded Vmax at ½ load on 4% slope	35% N/A	23 % > 80 km/h

Fuel Cell System Components #1

New air supply for FC system: Electrical turbo charger + Integrated air sensor (mass flow, pressure, temperature)

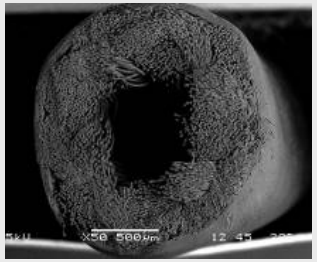
- ETC and IAS-sensors developed, delivered, successfully integrated and tested on component level, at the FC-system and in the demonstrator vehicle
- ETC as well as IAS performance meet the specified values and the FC-System requirements
- Achieved improvements:
  - Lower the weight ☑
  - Smaller sized packaging volume ☑
  - Decrease noise ☑
  - Improve efficiency ☑
  - Reduced electric energy consumption ☑



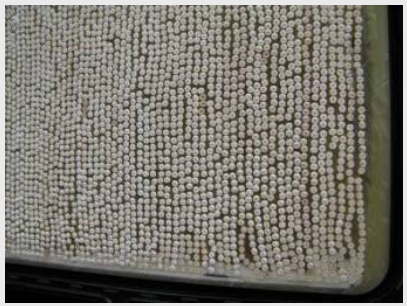
Fuel Cell System Components #2

Humidification Cathode side (gas-to-gas humidifier)

- Development of porous hollow fibre membrane
  - A completely new type of micro-yarn reinforced hollow fibre membrane was developed
  - The production of this fibre includes
    - the weaving of a polyester yarn,
    - the simultaneous coating of the micro-web with a solution of the recipe
    - followed by the phase inversion in a non-solvent
- Advantages
  - Ultimate high mechanical strength
  - Very high water vapour permeability
  - Different packing density



- Packaging
  - Fibres were arranged in parallel, with optimized custom package geometry
  - Optimisation of pressure drop and mass transfer by constant flow

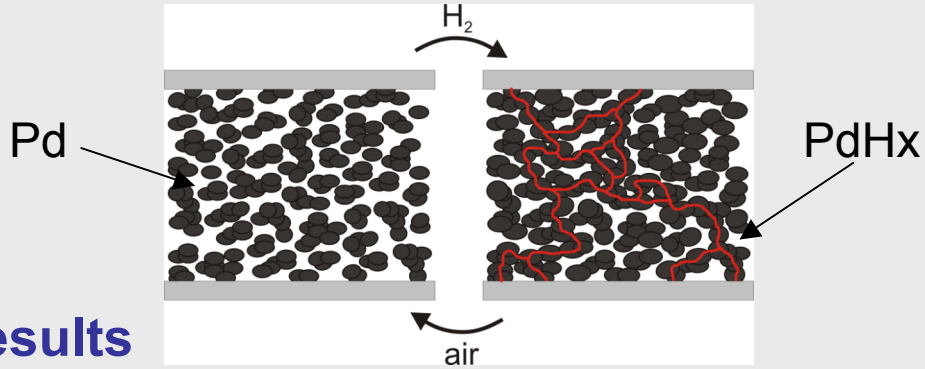


Fuel Cell System Components #3

Innovative hydrogen sensors

Principle of detection

- Resistive sensors based on discontinuous palladium (Pd) nanostructures: Creation of new conduction paths through the layer, in the presence of H_2



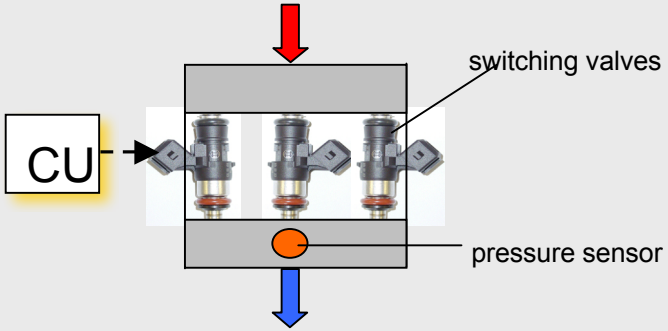
Results

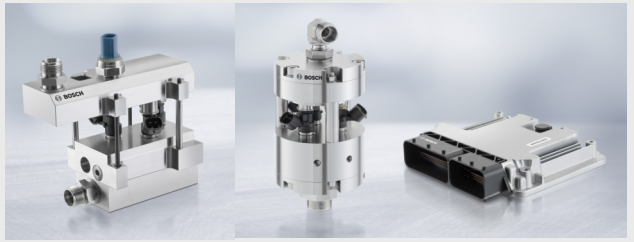
- Resistance level under clean air (base line) stable
- Large spread of the resistance levels: 800 kOhm to 2000 kOhm
- No cross-sensitivity to CO and NO_2 (automotive pollution gases)
- Influence of humidity on the base line and on the sensitivity Response times T90: at least 12 sec
- Recovery times: not relevant due to the fact that the sensors don't go back to their initial value

→ Further work necessary

Fuel Cell System Components #4

Hydrogen Metering Device





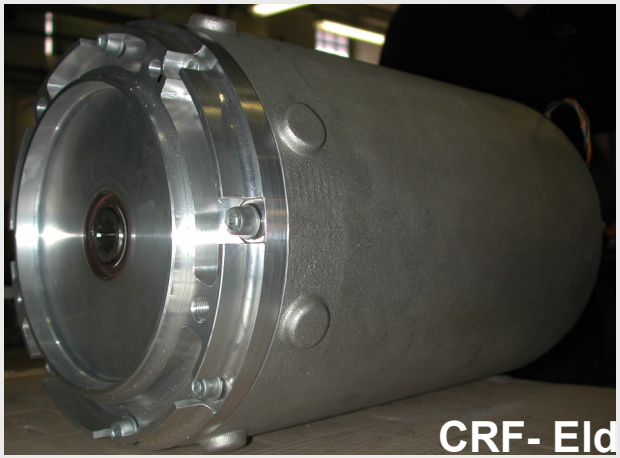
- Design based on NGI-valves
  -> reduced effort for development, testing and samples
- Robust technology and design

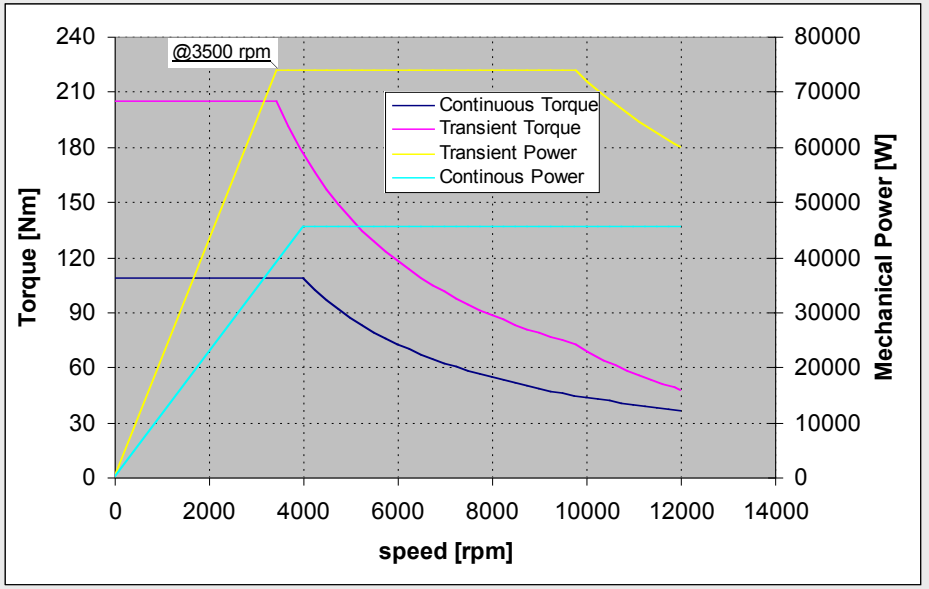
	State of the Art	Objectives	Achievements
Functionality			
Level of integration	seperate current driver	current driver in ECU	current driver in ECU
Maturity level	industrial valves	automotive prototype	automotive prototype
mass productivity design	small series production	mass production	mass production
Specification			
Mass	2000 g	500 g	500 g *
Volume	1000 ml	500 ml	530 ml
Temperature	-10 .. 60 °C	-25 .. 70 °C	-25 .. 70 °C
Mass flow	0 .. 2 g/s	0 .. 2 g/s	0 .. 3 g/s
Inlet pressure	8 .. 10 bar	8 .. 10 bar	8 .. 10 bar
Average Power Consumption	100 W	10 W	10 W
Dynamics	100 ms	2 ms	2 ms

E-Drive Components # 1

Electrical Motors (from WP4100)

- rated power: 45 kW_{mec}
- peak power: 75 kW_{mec}
- rated torque: 110 Nm
- max transient torque: 205 Nm
- base speed: 4000 rpm
- max operating speed: 12000 rpm
- mechanical overspeed: 14000 rpm



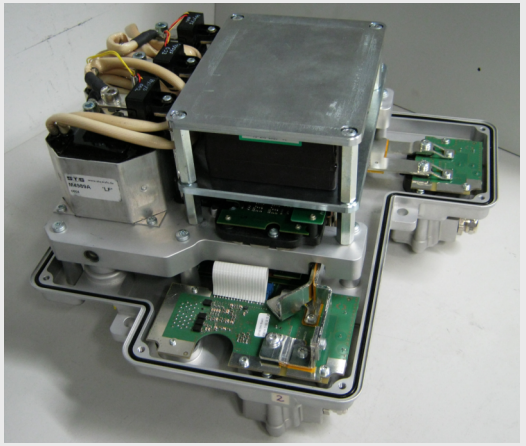


- 3 phase AC Permeance e-machine (synchronous reluctance with IPMs)
- liquid cooled
- integrated mechanical sensor
- Integrated interface to the proper coupling with the mechanical transmission

E-Drive Components # 2

Power Electronics (from WP4200)

- Modular Inverter / Converter System for different Fuel Cell Car Topologies has been successfully developed and tested
- Common cooling circuit for FC, electric traction drive and DC/DC converter up to 90°C can be used
- Integrated Low Voltage DC/DC Converter to supply 12V components
- Modular Design Concept
  Use of identical internal components means:
  - low development costs
  - low costs per piece (volume effect)
  - low qualification costs



High Voltage DC/DC Converter – technical data

- Input and output voltage range:120V to 430V
- DC-current: 180A continuous, 250A for 10s
- Maximum cooling water temperature: 90°C
- Maximum Power: 107.5kW

E-Drive Components # 3

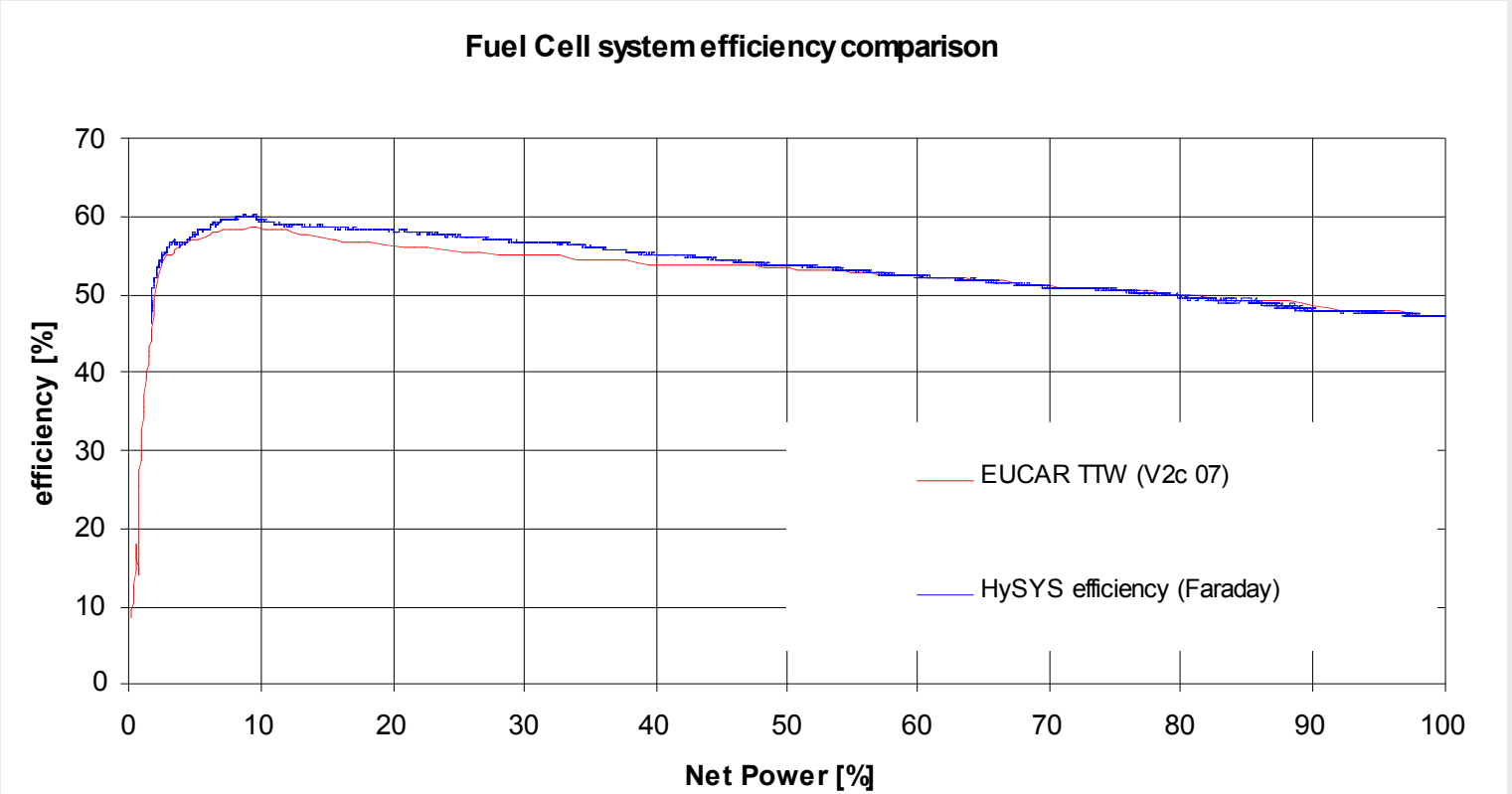
Li ion battery system

- Li ion cells included in a module structure
- Active liquid cooling of the cells
- Cell supervising circuit with voltage and temperature measurement, cell balancing
- Battery Management System with SOC & SOH calculation
- Power box

Parameter	Value
Specific power (module level)	1,83 kW/kg (2s)
Specific energy (module level)	52 Wh/kg
Efficiency	95%
Life time	15 years

HYSYS WP 5100, Full power Fuel Cell Van

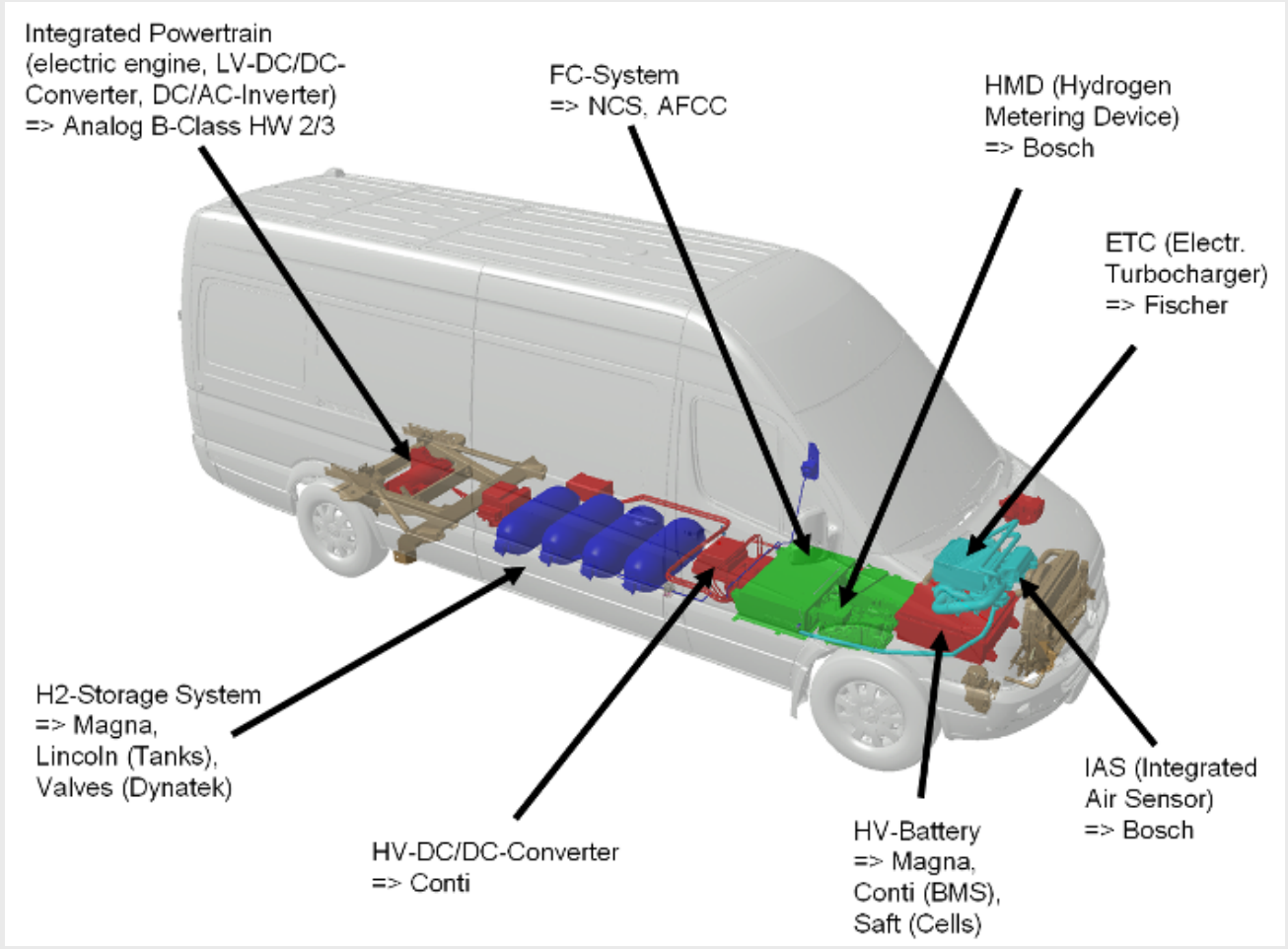
Fuel Cell System Efficiency Comparison



Fuel Cell System Comparison:
HySYS fuel cell system efficiency compared with fuel cell system efficiency curve from EUCAR WTW Study

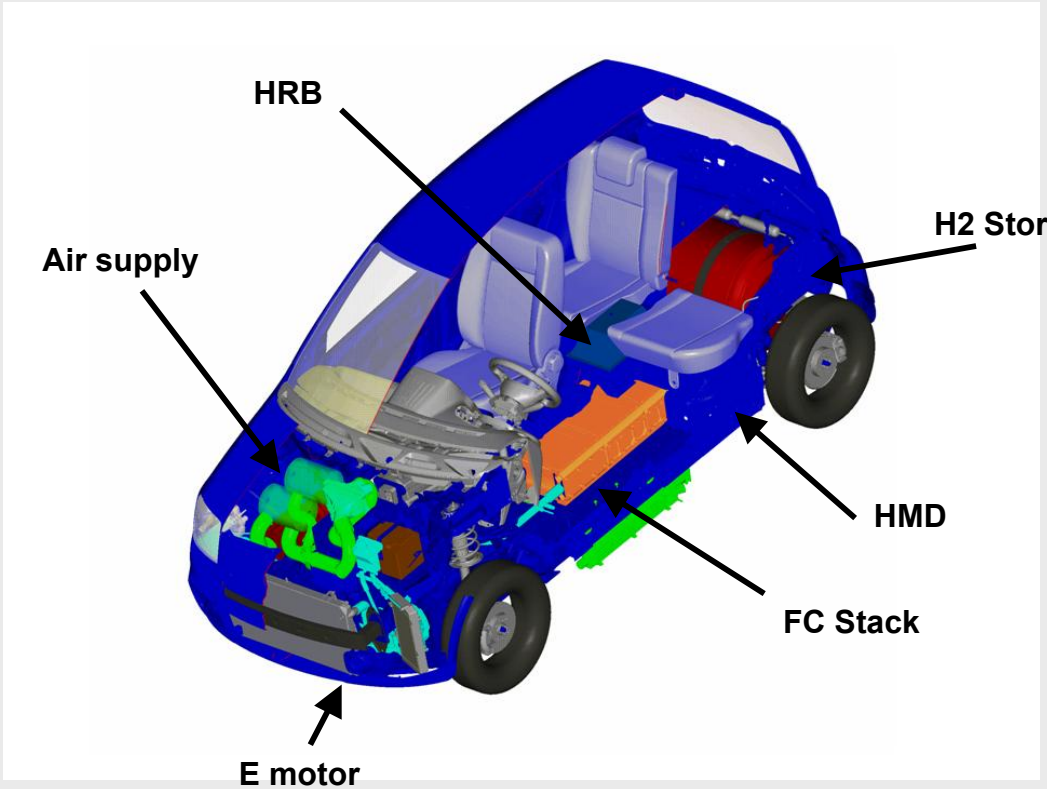
Validator Vehicle: Mercedes Benz FC-Sprinter

Vehicle Integration –Daimler Validator: Packaging Concept



Validator Vehicle: FIAT Panda

Vehicle Integration – CRF Validator: Packaging Concept



Thank you very much for your attention

More information on:

http://www.hysys.eu