MAGNUM Pirex AG

Fuel Cell Range Extenders for Electric Vehicles

Contact: Dr. Hubert Mäncher, CEO
MAGNUM Pirex AG
Schwanheimer Str. 28
64625 Bensheim
Germany

E-Mail: Hubert.Maencher@magnum.de
Phone: +49 6251 701890
www.magnum.de

April, 2018

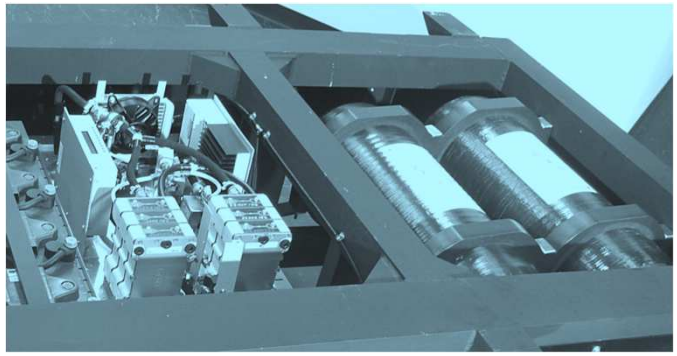
E-Mobility is the Future – the Future is now

The MIA from the French company mia Electric is the almost only real electric car, new and different design and construction, perfect for urban usage.

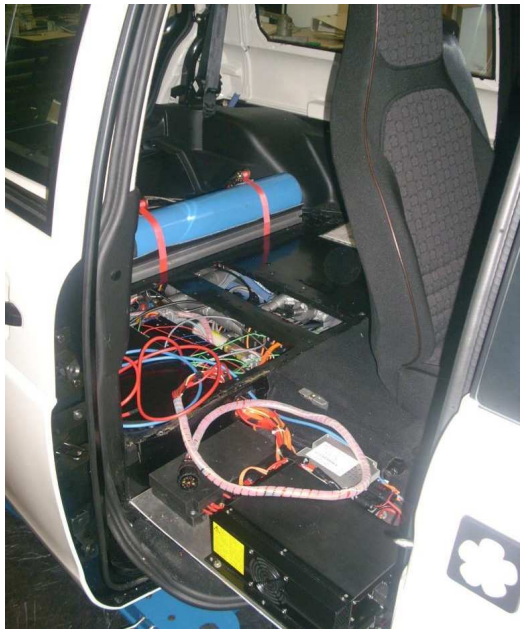
Let's have fun – outdoor activity in new dimensions: free of pollution thanks to mia, PIREX provides power for the outdoor discotheque.

magnum

E-Mobility – MAGNUM is its Driver



MAGNUM – Current Products



e-Mobility:

- Fuel cell range extender ***PIREX***
- System integration for electric vehicles
- Engineering services for automotive industry

Test Systems:

- Fuel cell and battery test stations ***FC-Midi***
- Customized, fully automated test systems for production and QC

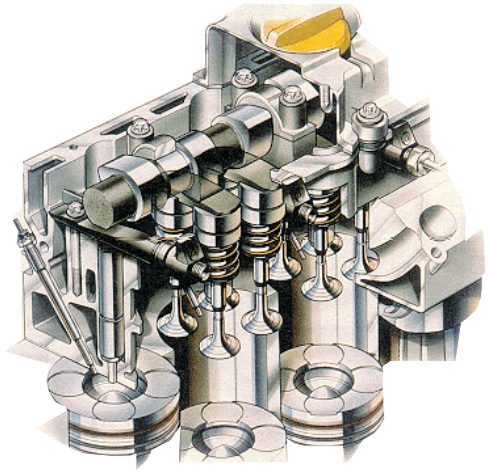
Company Overview

- MAGNUM Automatisierungstechnik GmbH was founded in 1987 by Dr. Hubert Mäncher. Since 2009 the company is integrated into MAGNUM Fuel Cell AG, changing to MAGNUM Pirex AG in 2012.
- Management: Dr. Hubert Mäncher, CEO, leads a team of top qualified scientists and engineers.
- MAGNUM is a strong partner for energy technologies, networked with leading companies in the area of electric mobility, fuel cells and renewable energy.
- Since more than 10 years MAGNUM is an established supplier of test and QC systems for fuel cells, batteries and other applications.
- More recently, MAGNUM developed its ground breaking plug-in range extender technology, ***PIREX***, enabling electric cars to achieve a substantially increased cruising range.

Examples of the Automotive History

Online fault diagnosis
for diesel direct injection system:

- Real time application
- Implementation in ECU
- Analysis for complete speed range
- Integration in serial products



Diesel electric power train for city buses:

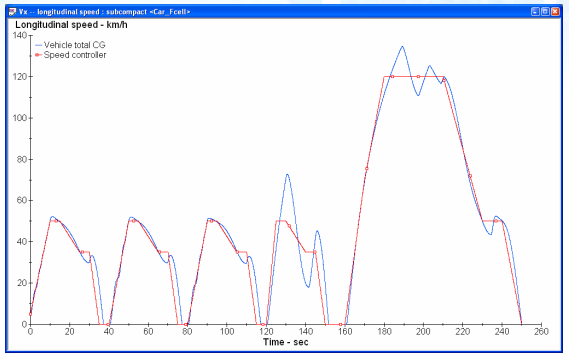
- Simultaneous engineering since 1990
- Electronic control by MAGNUM
- Conception * Simulation * Realisation
- Hardware and software development

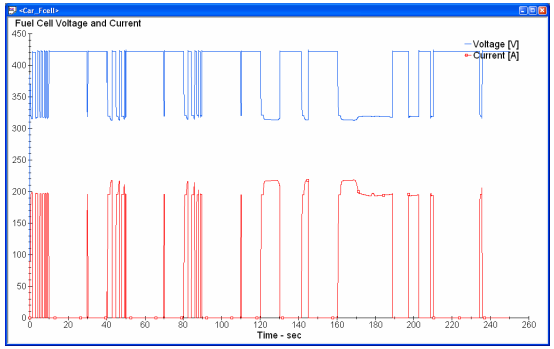
Methodology: Hardware-in-the-Loop-Simulation

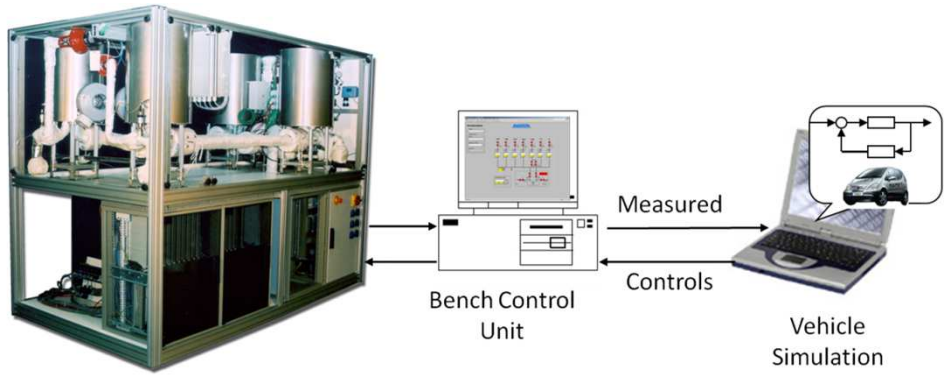
The scientific background of MAGNUM is cybernetics: analysis of process dynamics, modeling, and simulation.

It is the key to MAGNUM‘s ‚intelligent‘ control units, managing the drive trains of mechanical and electrical cars.

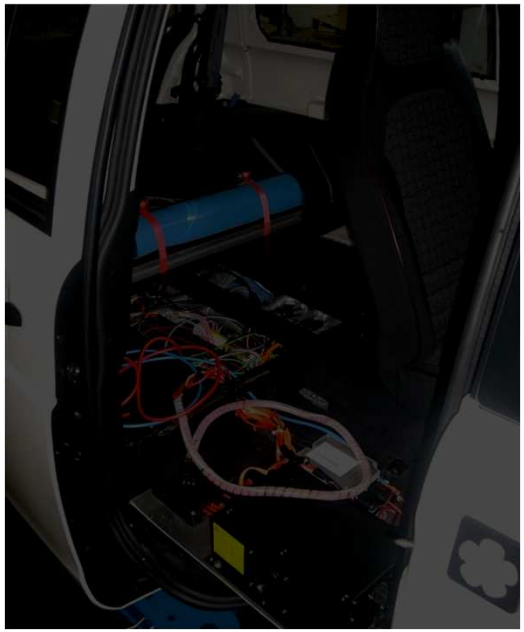
- Simulation of car parameters with hardware in the loop
- Model based caculation and control of parameters which can not be measured directly
- Test of single components







MAGNUM – Current Products



e-Mobility:

- Fuel cell range extender ***PIREX***
- System integration for electric vehicles
- Engineering services for automotive industry

Test Systems:

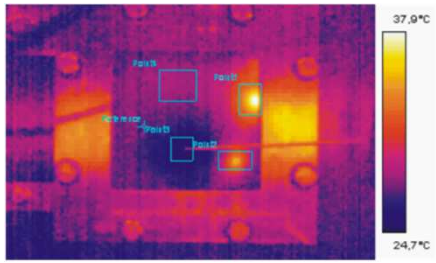
- Fuel cell and battery test stations ***FC-Midi***
- Customized, fully automated test systems for production and QC

Fuel Cell Test Stations *FC Midi*

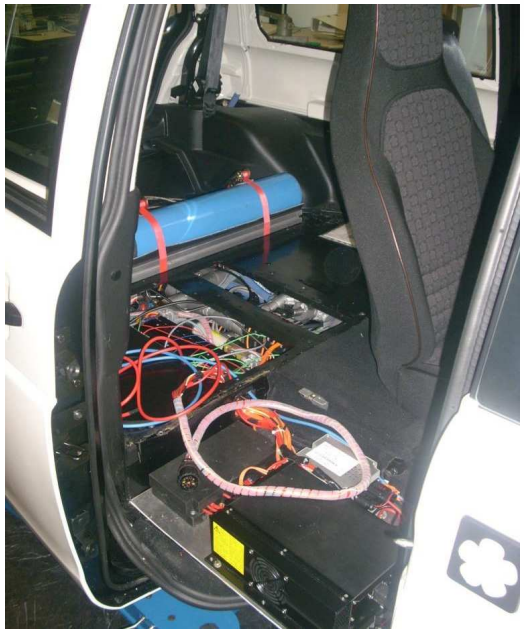
- Spanning the course of many years, MAGNUM has established itself as a leading supplier of test systems for fuel cells, commercialized under the trade name *FC-Midi*.
- Modular state-of-the-art test stations covering a broad range of power densities, from 100 W to 50 kW and more.
- Test systems in customized configurations both for laboratory use and quality control available.

Example for Customized Quality Control System

- MAGNUM developed a highly customized leak detection system for membrane manufacturing at BASF.
- A sample of Membrane-Electrode-Assemblies (MEA), the key component of every fuel cell, was taken out of the production process.
- In a test cell an infrared camera detects and localizes areas of hydrogen cross-over (hot spots). Hot spots in the MEA are a critical parameter for lifetime of every fuel cell.
- The MAGNUM test system precisely determines number, size and preferred location of hot spot material defects. The customer can correlate them with production parameters and develop mitigation strategies.



MAGNUM – Current Products



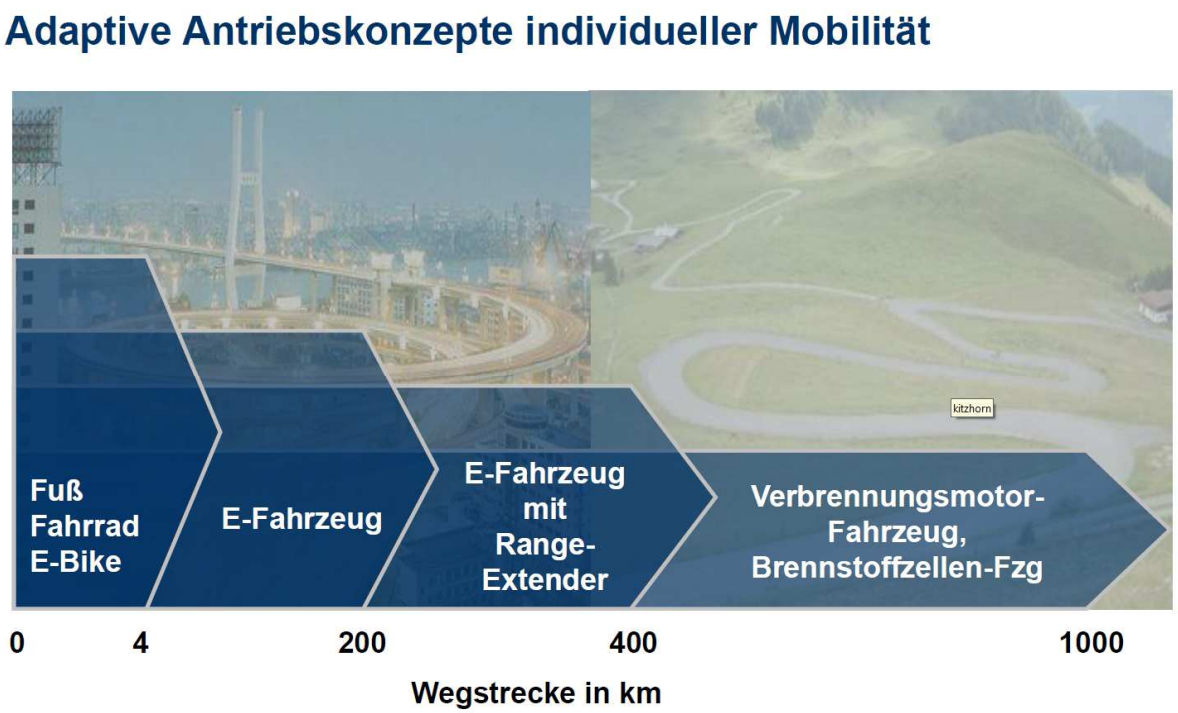
e-Mobility:

- Fuel cell range extender ***PIREX***
- System integration for electric vehicles
- Engineering services for automotive industry

Test Systems:

- Fuel cell and battery test stations ***FC-Midi***
- Customized, fully automated test systems for production and QC

Why Range Extender?

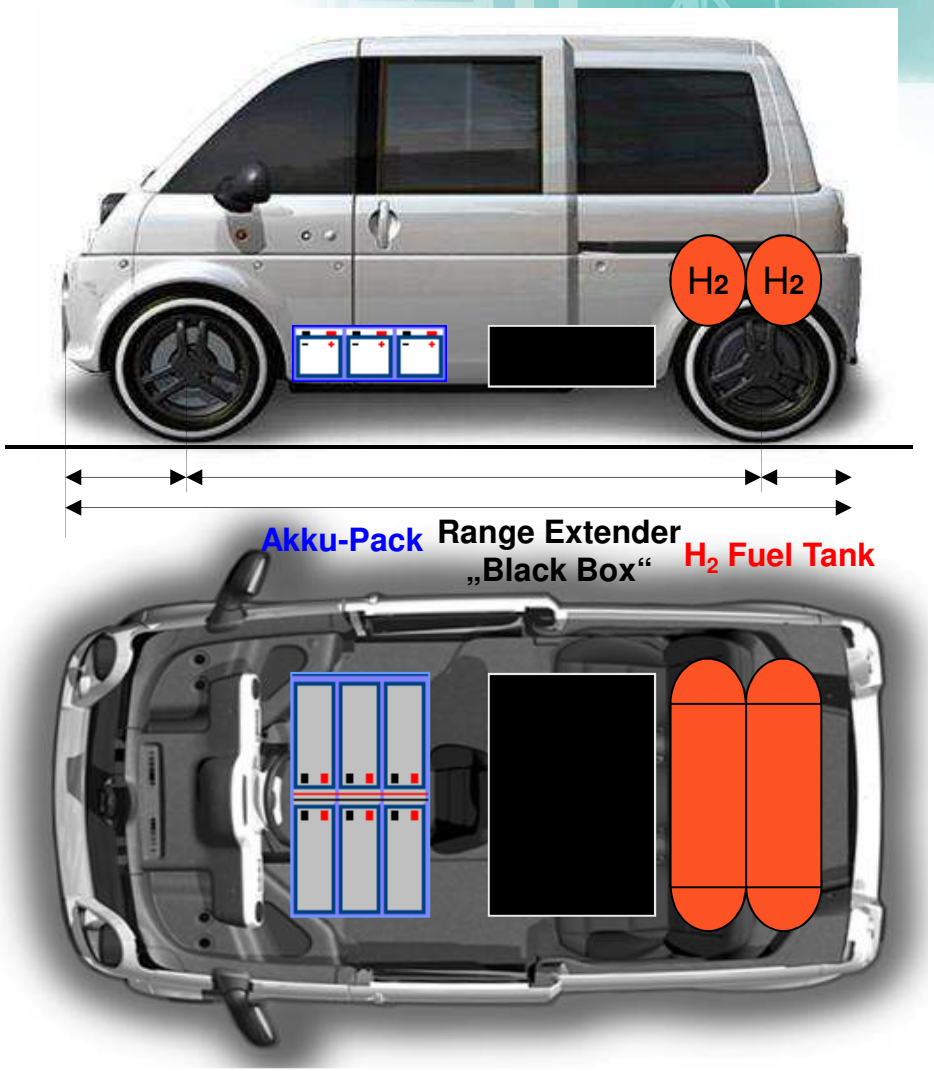


Source: S. Schmitz, N. Brandau, Volkswagen AG,. Workshop ‚Marktplatz der Zulieferer' der NOW GmbH, 5.5.2011, Berlin

New Product: Plug-in Range Extender *PIREX*

- Quiet with **zero emission**: electric mobility is one of today's most emerging markets. However, battery technology remains the main challenge and hindrance of e-mobility.
- **Limited cruising range** and with several hours **time consuming re-charging** are identified as the major hurdles of e-mobility on the way to a broad mass market.
- MAGNUM's groundbreaking PIREX technology perfectly addresses those issues: The fuel cell range extender allows for a **cruising range of factor 5** and hydrogen can be **re-filled within minutes**.
- The only by-product of the fuel cell is water, respectively steam. The vehicle operates still at **zero emission**.

Plug-in Concept



Excursion: Hydrogen Infrastructure

Source: H2 Logic, Denmark

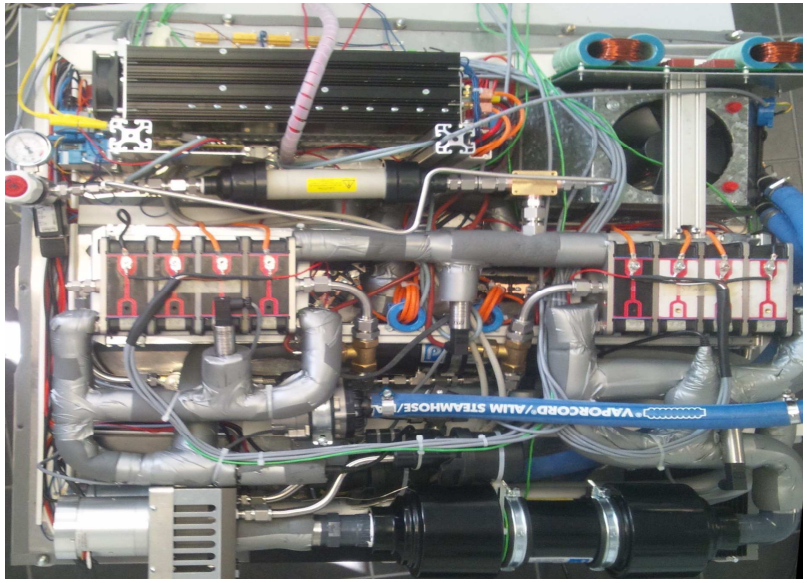
PIREX – First Prototype

First PIREX prototype in laboratory:

- Low temperature PEM fuel cell stacks
- Industrial periphery components
- SPS control unit

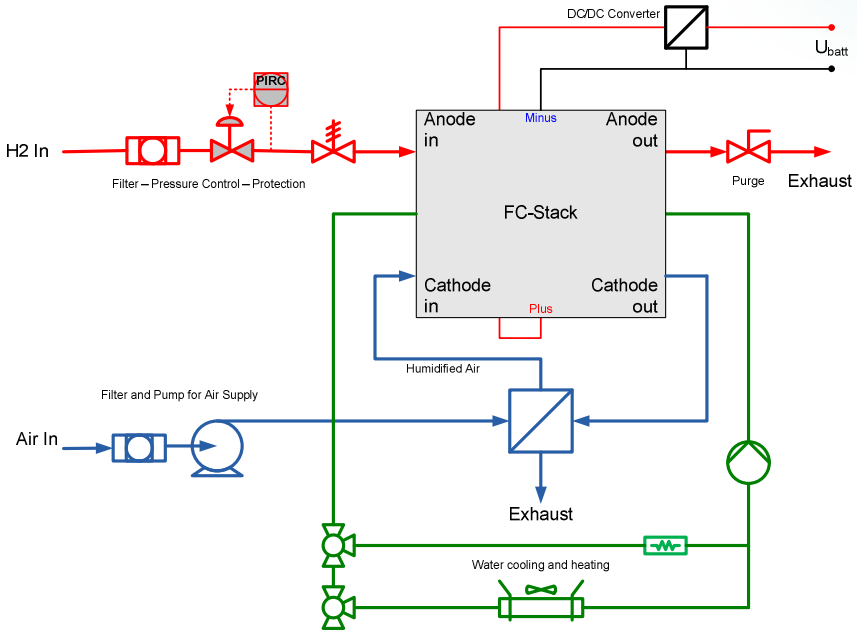
Pirex – a Set of Modules

- The Black Box is the Energy Converter including the Complete Fuel Cell System
- Tank System and Hydrogen Supply Technology
- ECU – the Electronic Control Unit incorporates all Controls Know-how

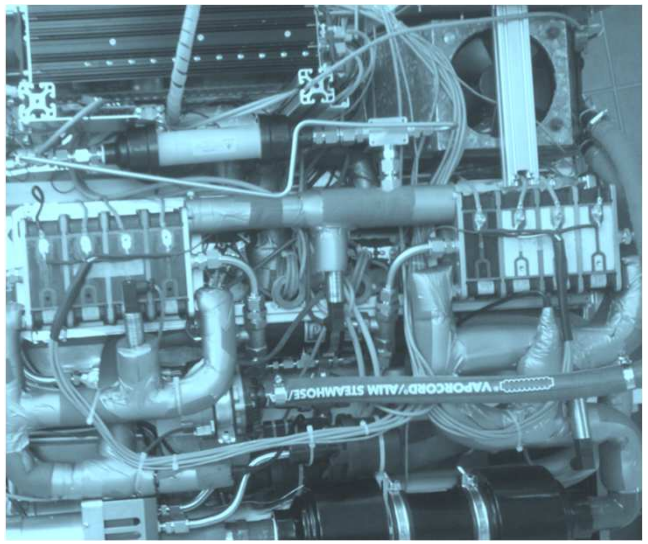


Power Source for Electric Mobility: The *PIREX* Fuel Cell System

PI Scheme of *PIREX*:

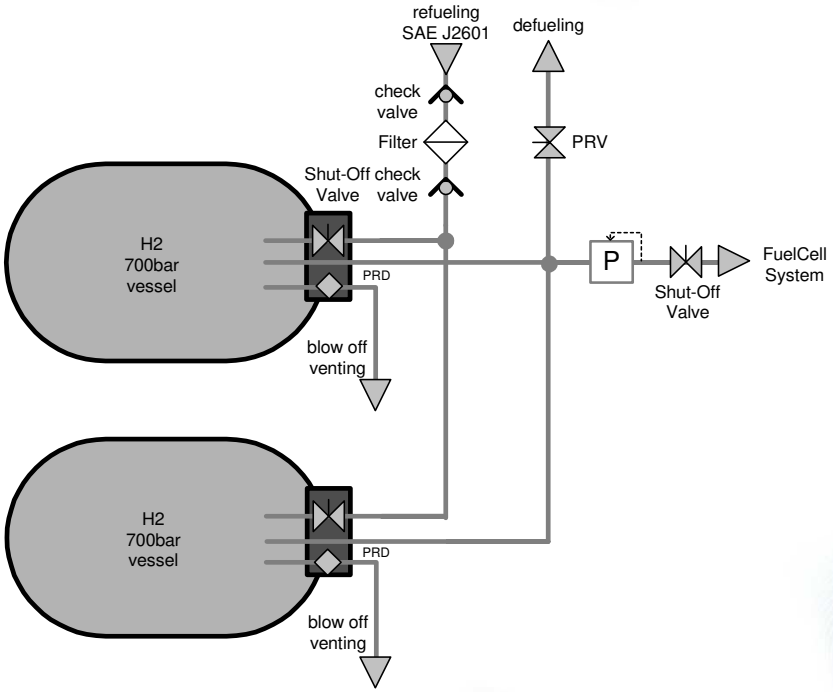


***PIREX* Fuel Cell System:**

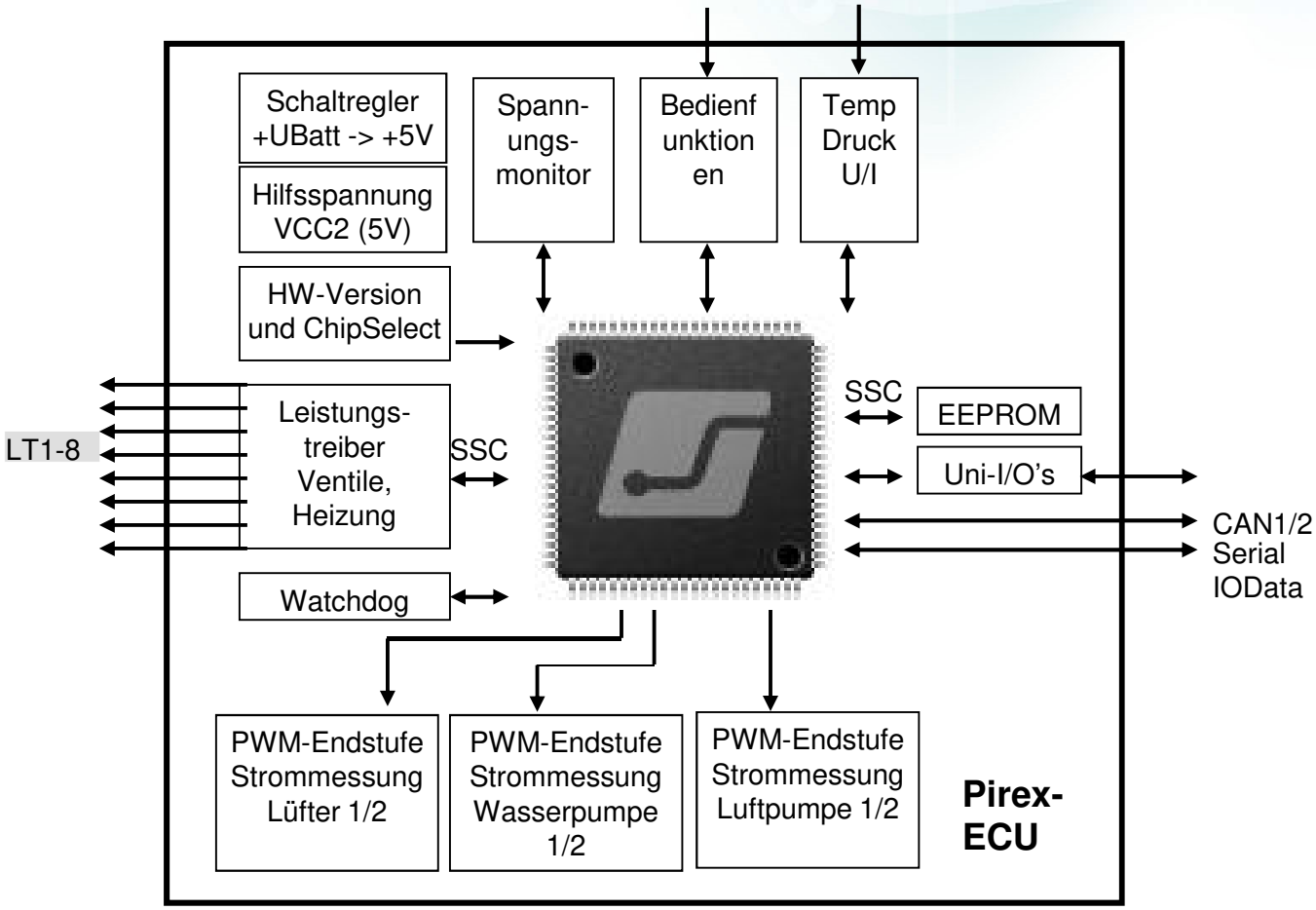


E-Mobility at Zero Emission: Hydrogen Supply for the Fuel Cell

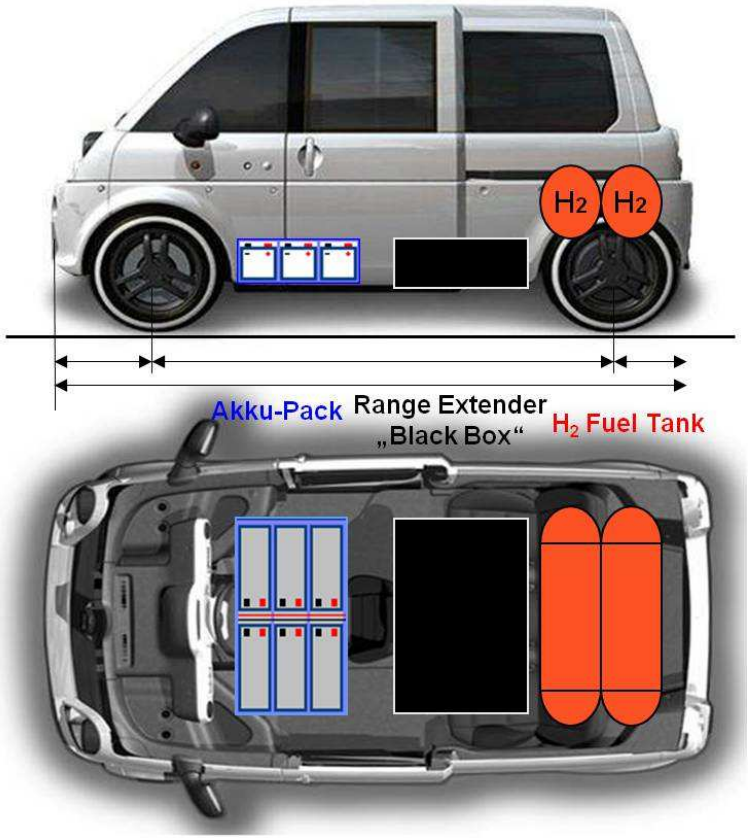
PIREX is powered by pure hydrogen, producing water / steam as the only by-product. The range extender employs two hydrogen tanks, refilling adapters, pressure reducer and safety package.



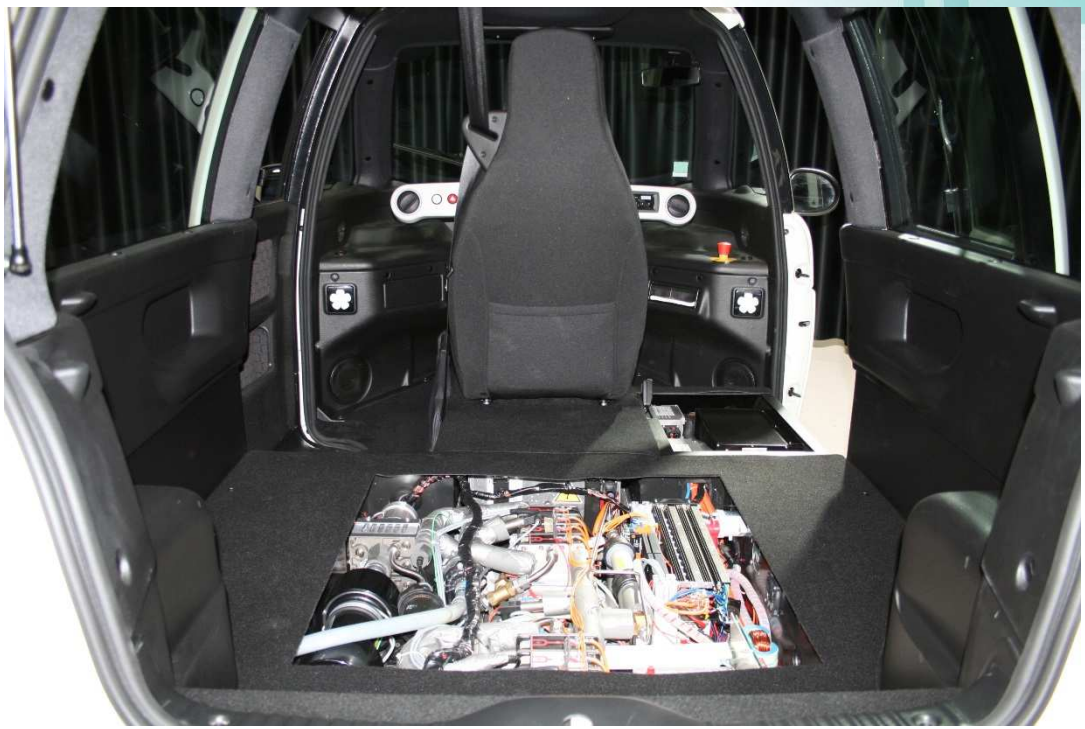
Electronic Control Unit – ECU

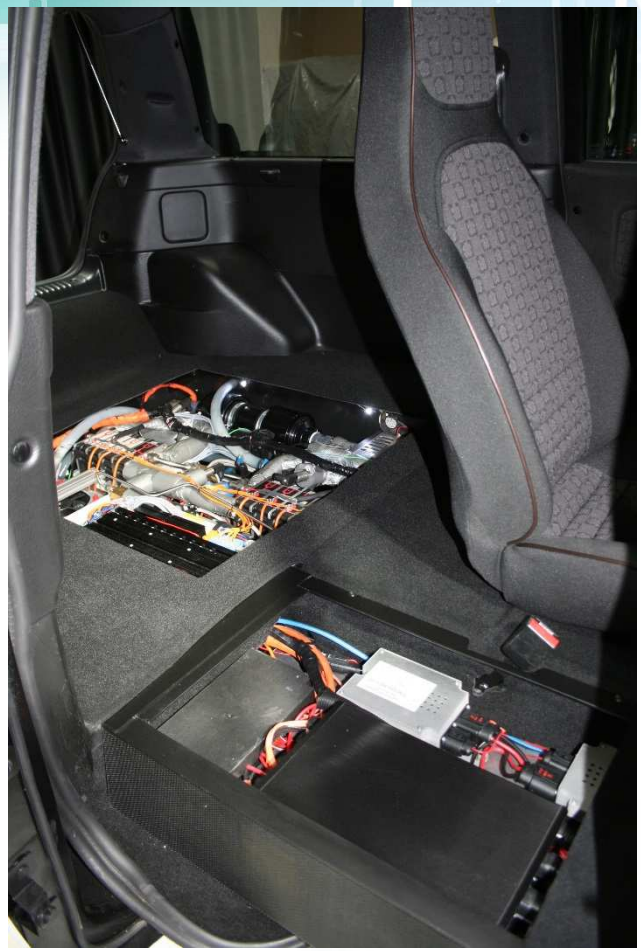


Example: *PIREX* Installed in Passenger Vehicle *mia*

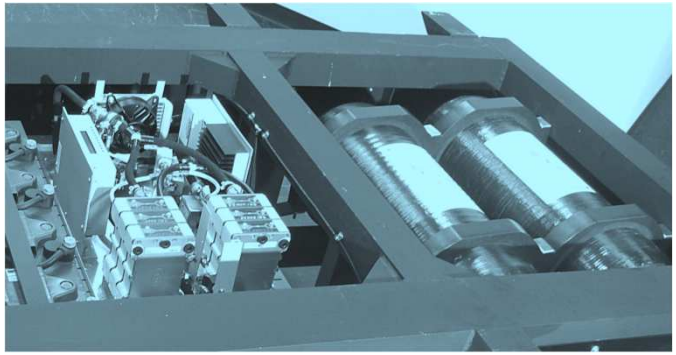


Example: *PIREX* Installed in Passenger Vehicle *mia*





Example: *PIREX* Installed in Utility Vehicle *Ecocarrier®*



Thank you for your attention