HYNERGREEN

Renewable Hydrogen Production by means of Solar Energy as a Fuel for a Hybrid Vehicle based on a Fuel Cell System

Fuel Cells and Hydrogen Joint Undertaking (FCH JU) 2nd Stakeholders General Assembly

Verónica Mesa – Hynergreen Technologies, S.A.

Brussels, 26th October

Hercules Project:

- Introduction
- Objectives
- Results
- Problems encountered
- Possibilities for future collaboration
- Follow up activities

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Hercules Consortium: 8 Spanish partners (4 Companies, 2 Research Organisations, 1 Public Agency)

- Hynergreen Technologies
- Abengoa Solar New Technologies
- Carburos Metálicos (Air Products)
- Santana Motor
- GreenPower Technologies
- INTA (National Institute for Aerospace Technology)
- AICIA (Association of Research and Industrial Cooperation of Andalusia)
- AAE (Andalusian Energy Agency)

Hercules Project financing:

Budget: 9 Million €

Hercules Project has been partially funded by 3 Spanish Public Organisations:

- Ministry of Science and Innovation
- Innovation and Development Agency of Andalusia
- Technological Corporation of Andalusia

Timescale: January 2006 – December 2009

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Hercules Project is divided into three main activities:

- **"Las Columnas":** Design and development of a hydrogen filling station, including its production on site by means of solar energy
- **"El León":** Design and development of a hybrid vehicle based on a fuel cell system that supplies 85 % of the whole electric power
- **"El Olimpo":** Coordination and integration of the other activities ("Las Columnas" and "El León"), technology transfer and dissemination of the results obtained in Hercules Project

"Las Columnas": Specific Objectives

- Demonstrate the binomial renewable energy (solar energy) – hydrogen vector
- Generate a new technological market improving the Industrial knowdlege in this area
- Improve the feasibility of developing a filling hydrogen station network in Spain
- Test an alkaline electrolyser to compare with other kind of electrolysers (PEM)
- Compare different solar technologies integrated in the plant to supply electricty to the electrolyser
- Optimize the electrical integration between the solar energy and the electrolyser

"El León": Specific Objectives

- Integration of new technologies in the transport sector to reduce the CO_2 emissions (hydrogen and fuel cell systems)
- Participation in the automation area of companies that work in other sector that can have an application in the transport (cooling system, compressed systems, instrumentations, control and power systems)
- Acquisition of knowledge in hybrid vehicle based on fuel cell systems
- Design and development of the Balance of Plant in the hybrid vehicle (power and control systems, electric motor, cooling systems and instrumentation)

"El Olimpo": Specific Objectives

- Guarantee a well managed project
- Participation in the definition of the hydrogen filling station and the hybrid electric vehicle
- Definition of the test protocols for the vehicle and the hydrogen station
- Evaluation and dissemination of the results obtained in the project
- Technology transfer
- Creation of an Hercules Project web-site (www.proyectohercules.es)

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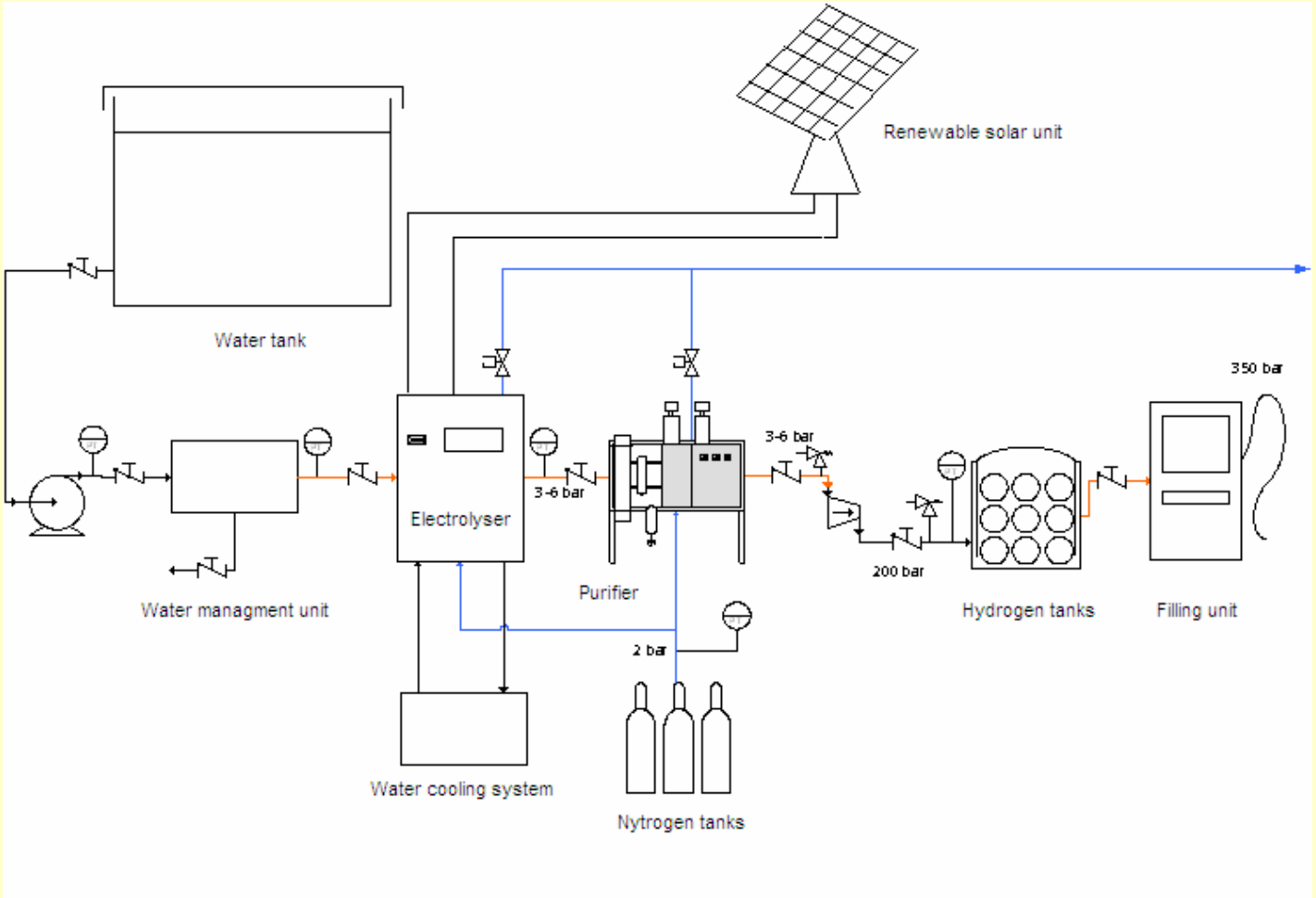
"Las Columnas": Location

"Las Columnas": Process Description



"Las Columnas": Solar plant

Whole electric power of the solar plant: 65.6 kW

- Two axis tracking: 18.6 kW
- Fixed Structures: 22 kW
- CPV: 15 kW
- Stirling Dish: 10 kW

"Las Columnas": Hydrogen station

"Las Columnas": Electrolyser

Maximun H_2 produced	12.5 Nm^3/h
Continuous H_2 produced	10 Nm^3/h
H_2 out pressure	4 – 6 barg
Electric Consumption	67 kWh
Maximum water consumed	10 l/h

"Las Columnas": Purifier

Maximun H_2 pressure	10 barg
Maximun N_2 consumed	2.5 Nm^3/h
Maximum H_2 purity	99.9995 %
Electric Consumption	1 kWh

"Las Columnas": Filling Unit

Maximun H_2 produced	12.5 Nm^3/h
Maximun air compressed	2 Nm^3/h
Maximun inlet H_2 pressure	150 – 200 barg
Maximum outlet H_2 pressure	350 barg
Electric Power Consumption	Only for electronic components

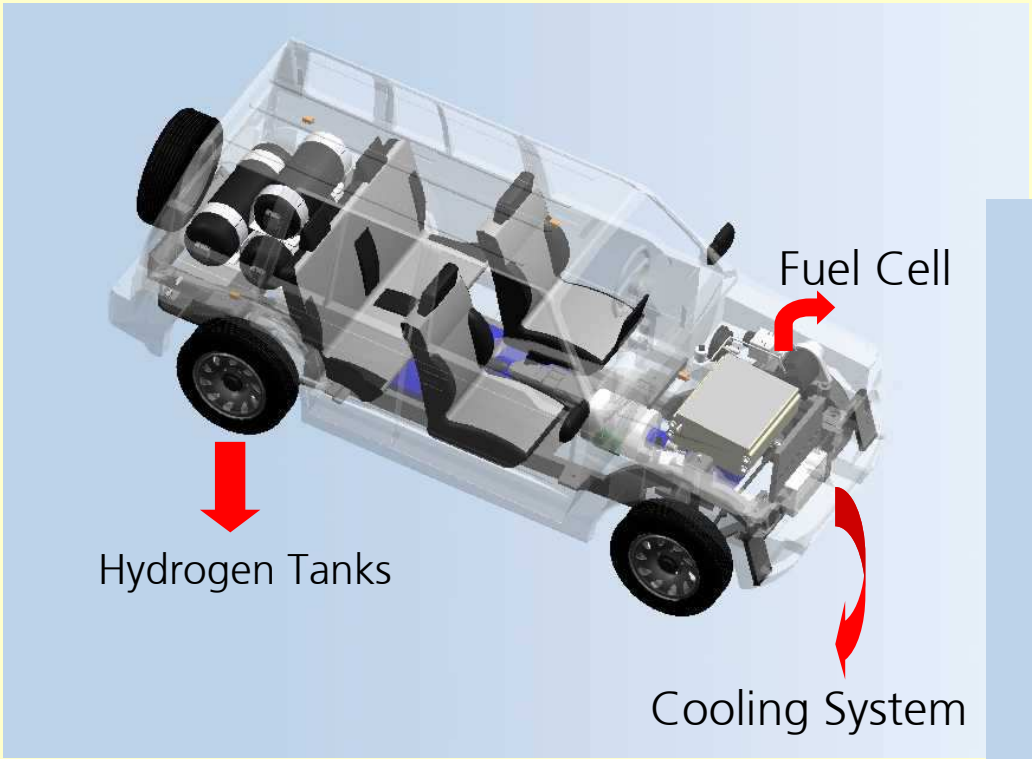
"Las Columnas": Hydrogen tanks

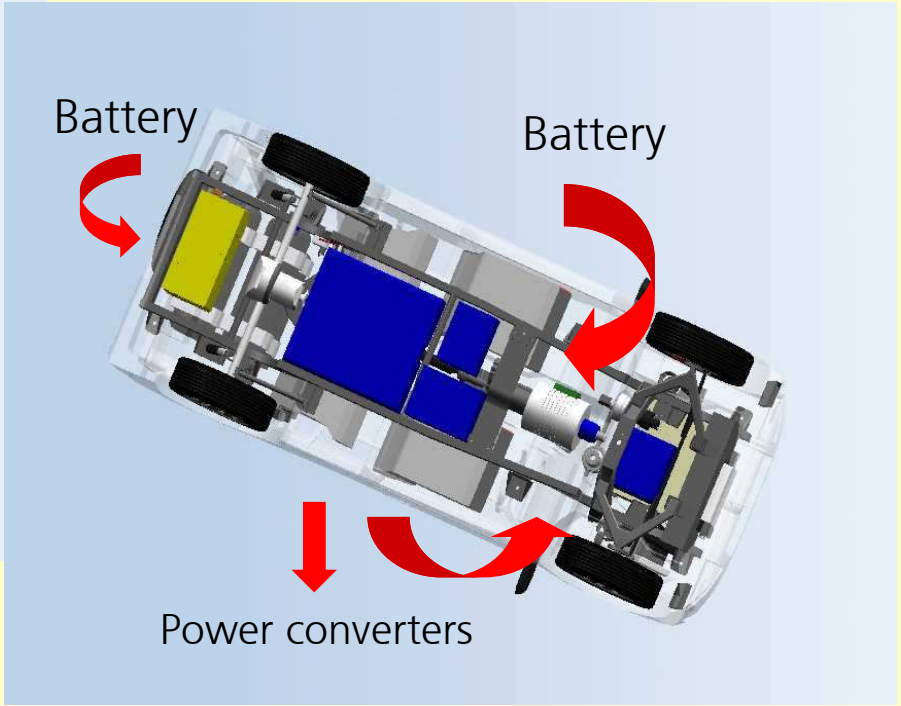
Maximun inlet H_2 pressure	8 barg
Maximun air compressed consumed	4 - 6 Nm^3/h
Maximun H_2 pressure	150 – 200 barg

"Las Columnas": Nytrogen tanks

“El León”: Picture

"El León": Vehicle Diagram

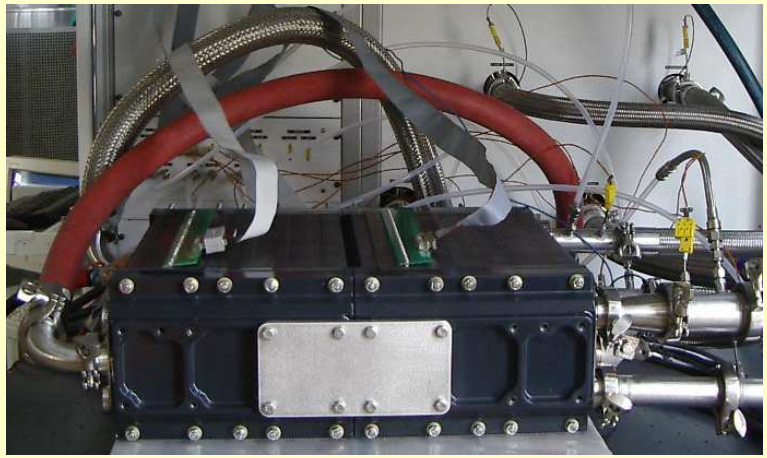




Characteristics of the main components in the vehicle:

Fuel cell (Nuvera):

- Nominal Power: 56 kW
- Maximum Current: 360 A
- Hydrogen recirculation for humidification
- Water cooling system (flow 97 lpm)
- Voltage Rate:150 – 247 V



Characteristics of the main components in the vehicle:

<u>Three Tanks (2´46 kg of hydrogen):</u>

- Hydrogen Capacity: 96 l
  - ❖ 2 x 34 l
  - ❖ 1 x 28 l
- Nominal Pressure: 350 bar

Characteristics of the main components in the vehicle:

Three Power Converters:

- Fuel cell converter:

Increase the out voltage from the fuel cell (150 – 250 V) to 350 VDC

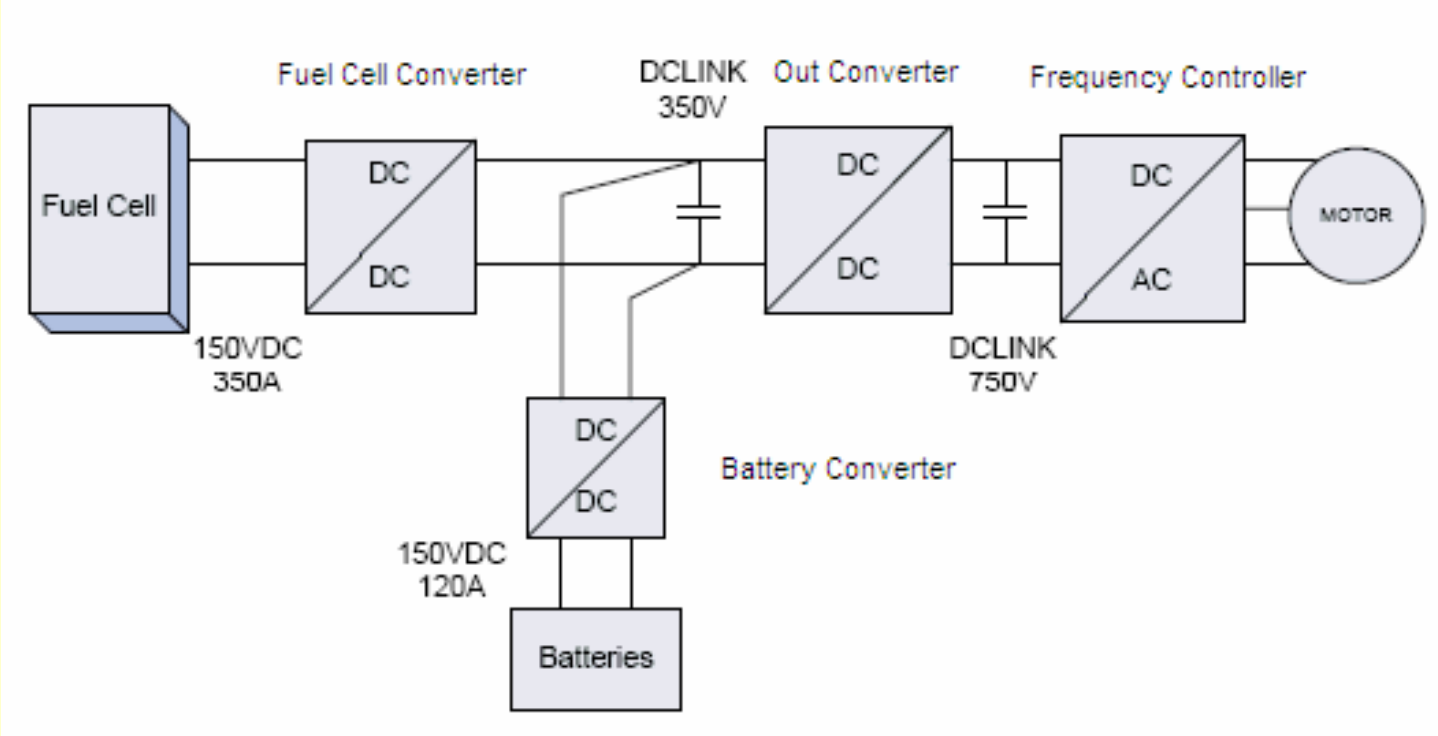
- Battery converter:

Increase the out voltage from the battery 150 VDC to 350 VDC

- Out converter

Increase the voltage from 350 VDC (battery and fuel cell) to 750 VDC (Three-phase electric motor; 1 frecuency controller)

Vehicle characteristics: Power diagram

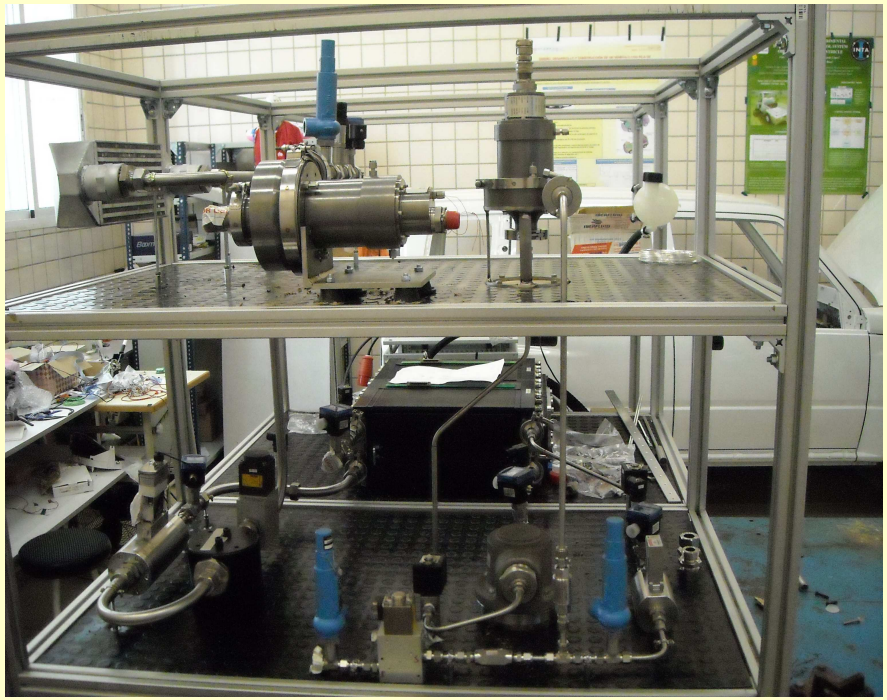


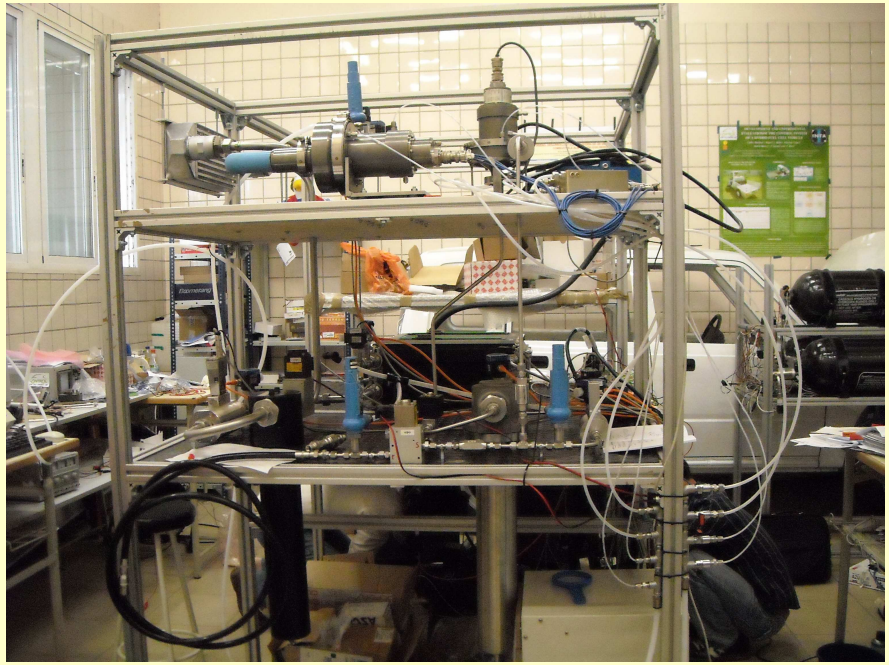
Characteristics of the main components in the vehicle:

Compression Units:

- Nominal air flow:
  - ❖ (flow, pressure) = (2,600 lpm, 650 mbarg)
- Nominal hydrogen flow:
  - ❖ (flow, pressure) = (1,000 lpm, 650 mbarg)

"El León": Test bench Integration and Evaluation





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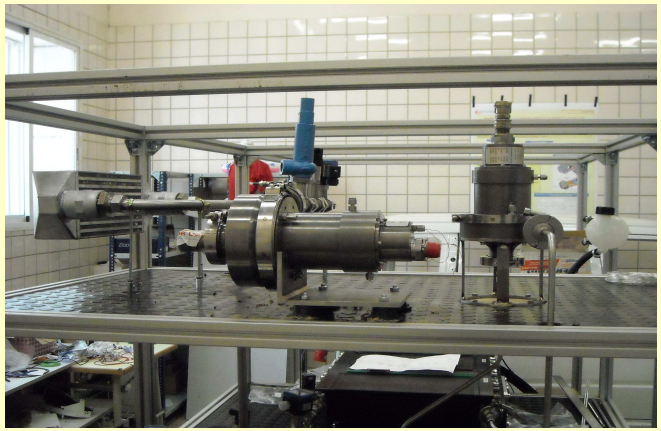

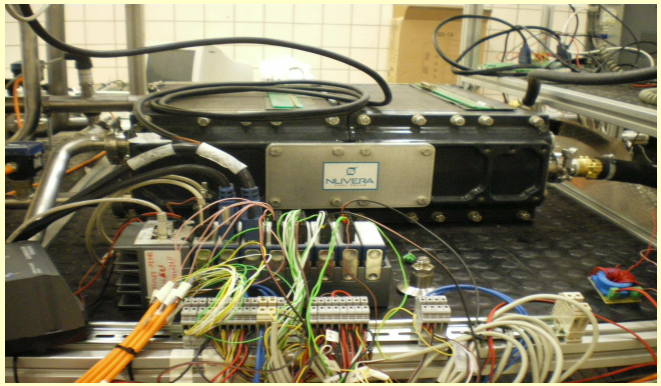

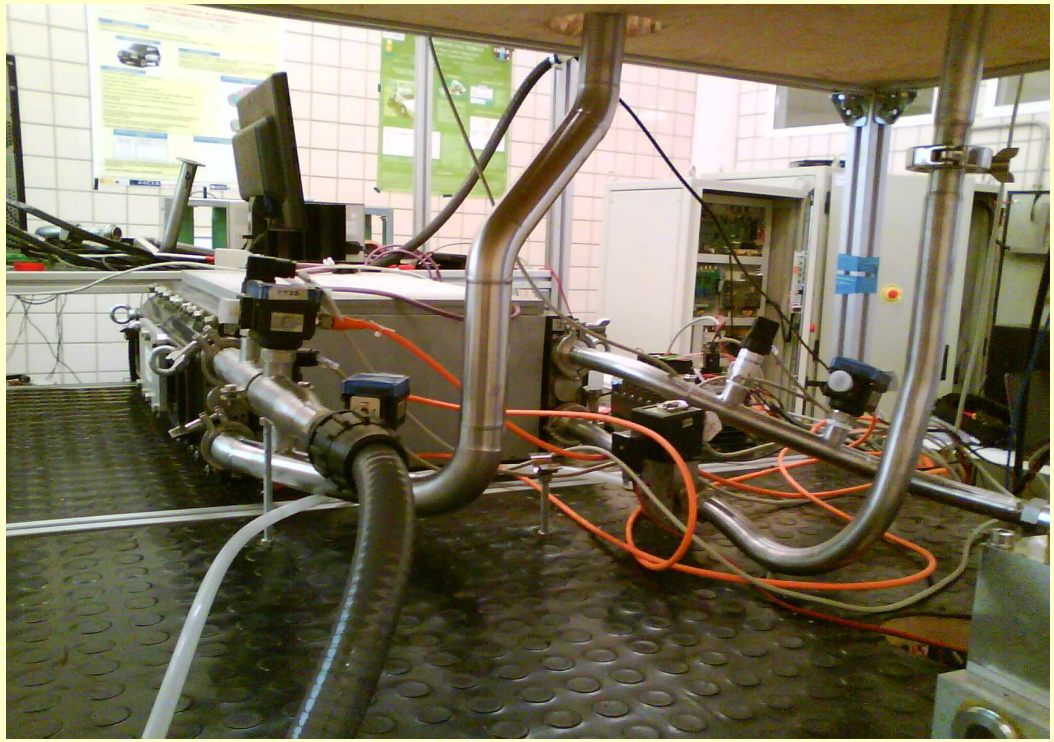

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Problems found in Hercules Project:

- Regarding the hydrogen station, the license managment that has been needed to build and start up the hydrogen filling station has delayed the Project
- Electrical and control integration between the solar plant and the electrolyser
- For the vehicle it has been difficult to find some commercial devices that can be used in this application (for weight and volumen reasons)
- The choice of the most appropiate fuel cell (a few amount of fuel cell manufactures are able to comply with all the requirements: cost, power and experience)

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- Currently the vehicle is being assembled in Santana Motor (Vehicle manufacture partner). The evaluation in the test bench has finished but we have to evaluate the integration in the vehicle (final tests)
- Regarding the hydrogen filling station, the construction has just finished and in November we hope to start up the station (solar plant integrated with hydrogen devices)

❖ Hercules Project Consortium would like to implement the experiences learnt during the project in any activities related to hydrogen filling station and hybrid vehicle based on fuel cell systems

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- Hercules Project should be finished by the end of 2009 but due to the delay the time for the final test has not been enough. For this reason, the Consortium has decided to continue with the evaluation of the hydrogen station and the vehicle for a year (beyond the timetable)

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