

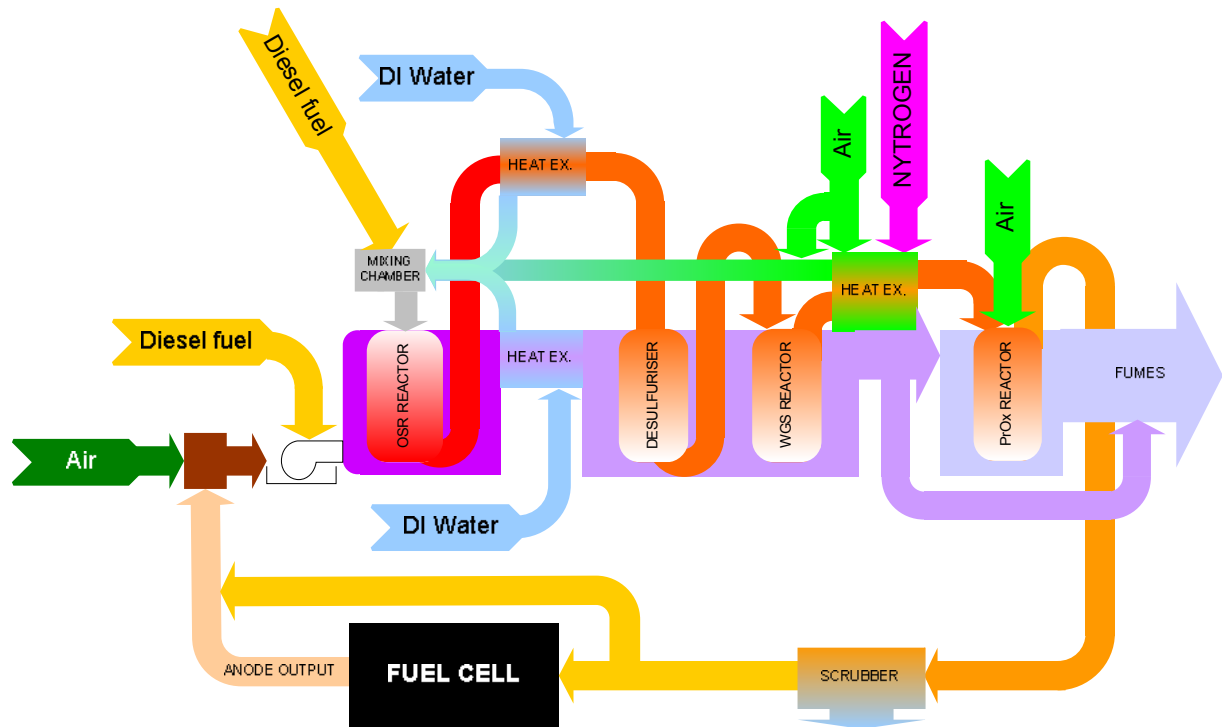
H₂

Fundación
cidaut 
Investigación y Desarrollo en Transporte y Energía

Hydrogen
Technologies

Hydrogen production

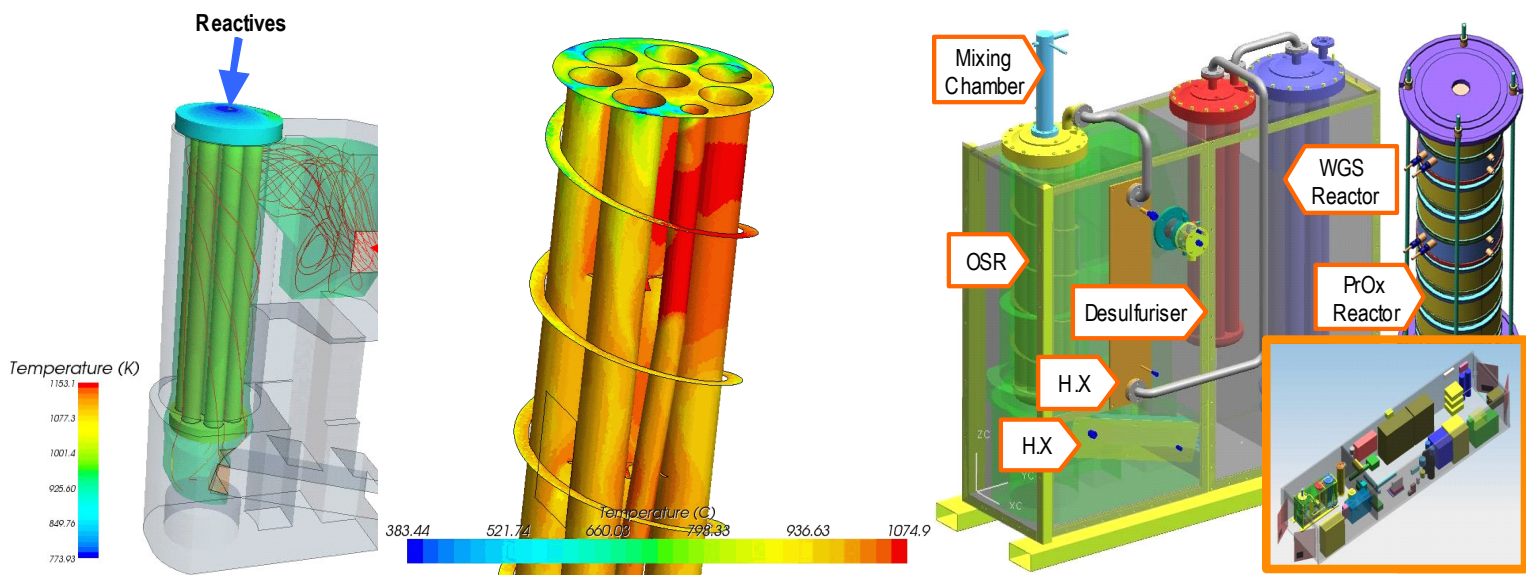
25kW Diesel fuel processor



Development of a 25 kWe diesel fuel processor that contains a Mixing Chamber, an OSR, a Desulfurizer, a WGS and PrOx reactors from 2008 to 2010 jointly with INTA and ICP-CSIC. Moreover, heat exchangers, auxiliary equipment and control systems are included in the facility, so it just need to be connected to a Fuel Cell for being autonomous.

All the necessary heat is supplied by a dual burner (diesel – reforming gas) developed by CIDAUT.

Each reactor was simulated for their optimum design taking into account CFD models with reactions kinetics.





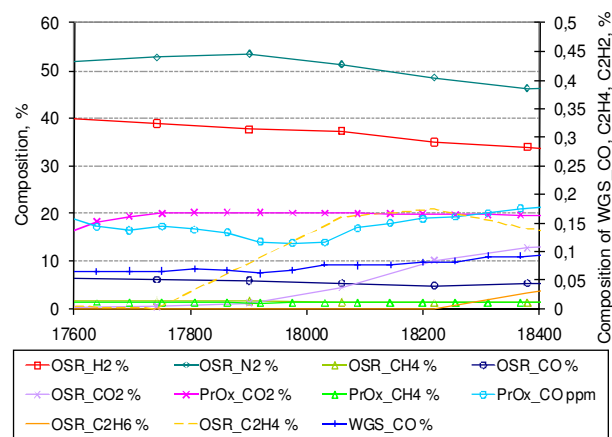
Reforming booth

The reformer is integrated inside a booth with two zones: ATEX and safe zone. This booth is transportable.

The facility has the CE Certificate because it meets all the current regulations.

The facility works automatically, with the option of remote operation. It has been designed for steady state working conditions, but can operate from 30 to 100% of nominal conditions with transient time of 7 minutes from one to another.

The design of the fuel processor took into account maintenance operations for aiding this labor, focusing on the replacement of catalytic systems.



Gas composition at the OSR, WGS and PrOx Reactors output

Features

Diesel fuel flow-rate: 4 – 12 l/h
(7 – 25 kWe in a PEMFC)

Less than 40 ppm of CO

Hydrogen concentration up to 34%

O₂ / C ratio: 0.4 – 0.6

H₂O / C ratio: 2 – 4

Pressure: 0.5 – 3 bar

Efficiency 58% without gas recirculation, 75% with reforming gas recirculation

Burner: Diesel flow-rate: 1 – 4 l/h

Reforming gas flow-rate: 0 – 75 Nm³/h

Start-up time: 1.5 h

Transient time from 30 to 100%: 7 min



Auxiliary systems zone



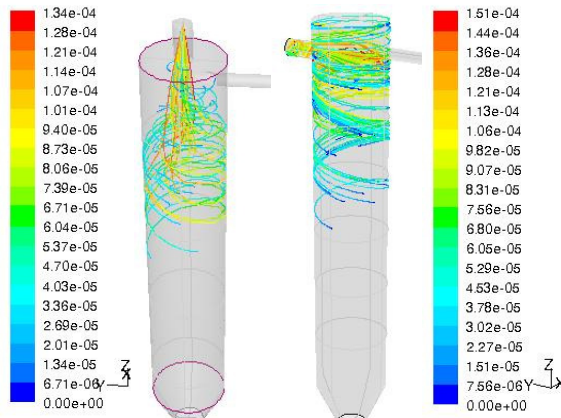
Reactors (ATEX) zone



Control system

Hydrogen production

5kW Diesel fuel processor



Features

Diesel fuel flow-rate: 0.8 – 2.5 l/h

Hydrogen concentration up to 35%

O_2 / C ratio: 0.35 – 0.6

H_2O / C ratio: 2 – 4

Pressure: 0.5 – 3 bar

6 thermocouples per reactor

Burner:

Diesel flow: 0.4 – 2 l/h

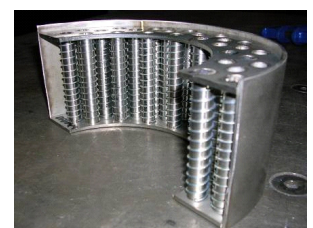
Reforming gas flow: 0 – 12 Nm³/h

Development of a 5 kW facility composed by a Mixing Chamber, an OSR, a tail reactor (with the working conditions of a Desulfurizer), heat exchangers and a burner, in 2007 jointly with INTA and ICP-CSIC.

Design of a burner that was able to supply the heat for the process, with the function of admitting dual fuel: diesel and/or reforming gas from the anode of a PEM Fuel Cell.

Simulation, by means of CFD codes, of the fuel evaporation inside the Mixing Chamber and study of the cool flame process were carried out to optimize the Mixing Chamber design. An experimental facility was used for data validation.

Successful integration of water vaporization using fumes and gas reforming flows were accomplished.



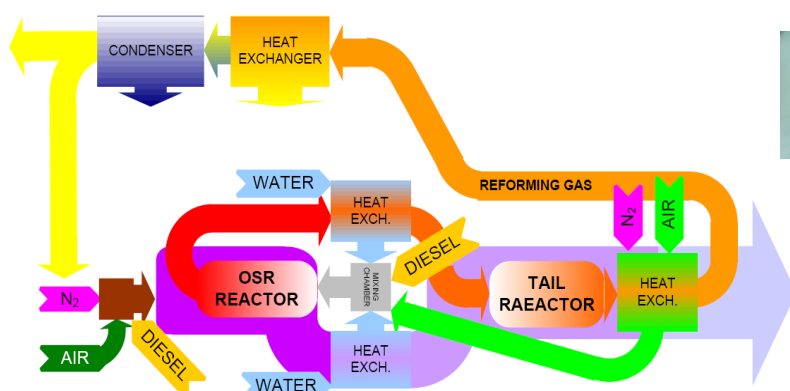
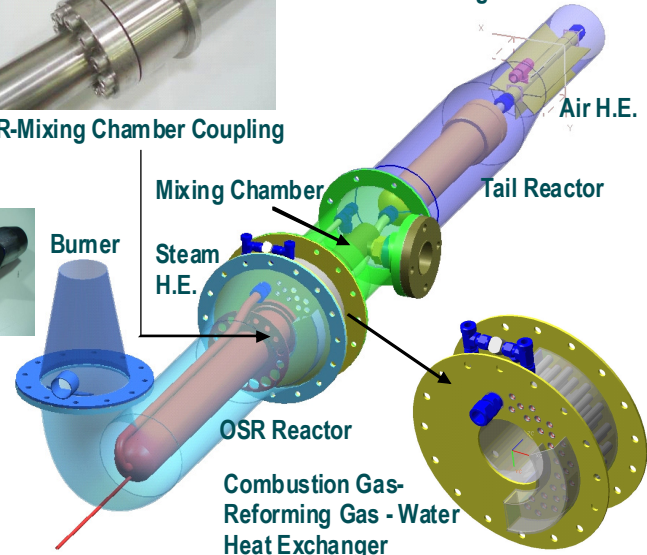
Heat Exchanger Detail



OSR-Mixing Chamber Coupling



Burner



Hydrogen production

5 kW Alkaline Electrolyser

Development of technologies related to pre and post treatment of fluids in alkaline electrolyzers for being integrated into an experimental facility. Project carried out from 2008 to 2010 for ACCIONA under the National Project SPHERA.

CIDAUT developed the whole BOP (except the stack) including mainly the gas-liquid separators and the purifying systems of hydrogen: a de-oxo reactor for Oxygen removal and an automatic regenerable system of adsorbent filters for water elimination. Control system and strategies were also designed by CIDAUT.

The facility has a flexible design allowing the test of different stacks configuration and gas-liquid separators (horizontal and vertical)

The working pressure is adjustable from 1 to 20 bar.

The facility was designed accomplishing current regulations and guaranteeing a safety handling of each fluid.

Features

Hydrogen flow-rate: 1 Nm³/h

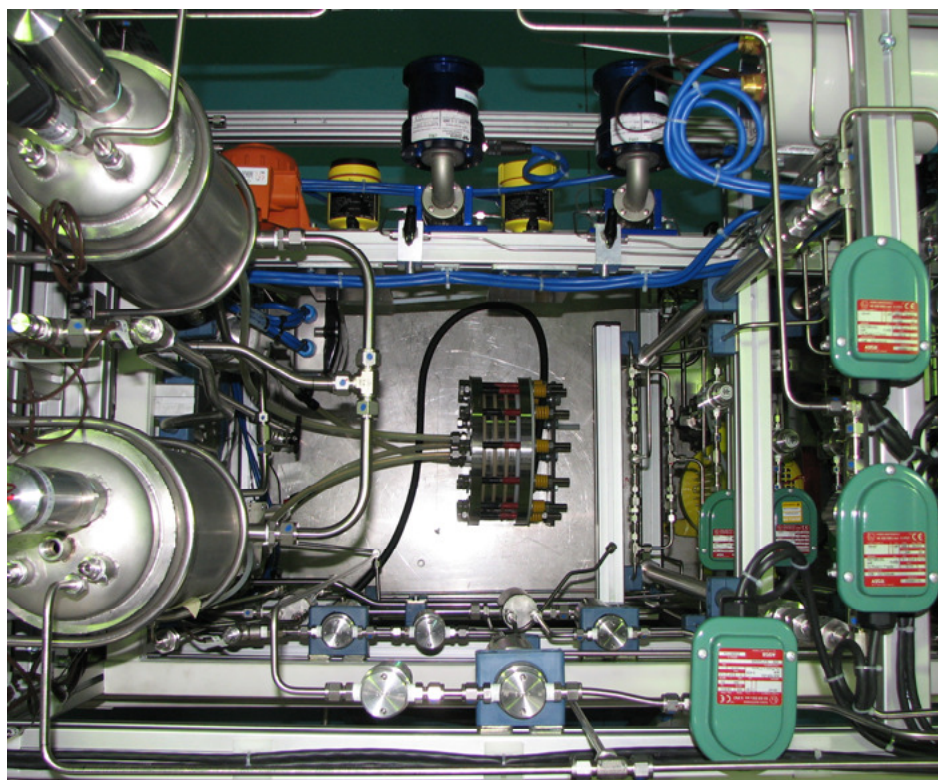
Hydrogen purity: 10 ppm of O₂

Pressure: adjustable up to 20 bar

Electrolyte temperature: 80°C

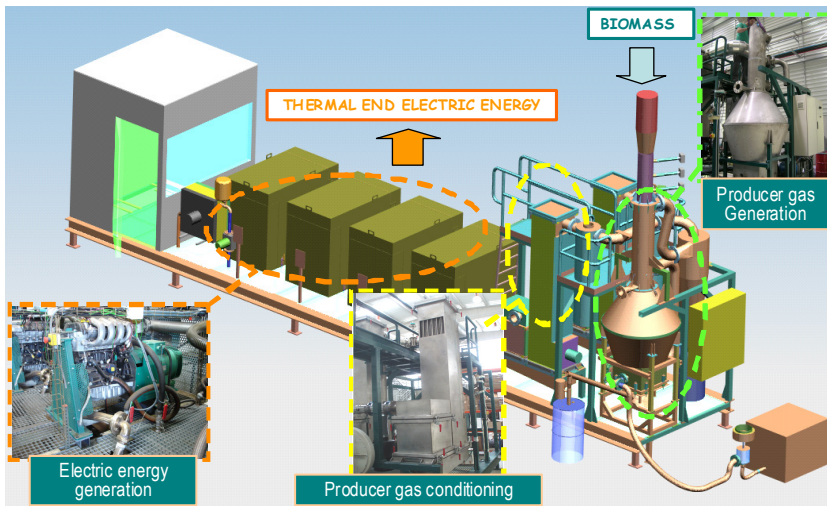
Start-up time: up to 5 min

Transitory time from 30 to 100%: 1 - 2 s



Hydrogen production

100kW Gasification system



Features

Electric Power: 100 kWe

Thermal Power: 200 kWt

Biomass: Lignocellulosic wood

Maximum granulometry: 8 cm

Biomass consumption: 100 – 125 kg/h

Dimensions: 12 x 2.5 m

Weight: 10 Tm

Transportable

Fast installation and start-up

CIDAUT has developed a gasification plant with a compact design integrating all the necessary subsystems for small scale electric and thermal generation from lignocellulosic biomass. It is based on co-current fixed bed with cleaning and cooling stages of the producer gas, which is used in internal combustion engines to produce electricity and thermal energy with the following main characteristics:

- High thermal energy recovery ratios
- Short term logistics: Long routes to transport biomass to the plant are avoided. Adaptable to different biomass types
- Distributed generation: low investment costs on electric infrastructure
- CE Certificate

It can be coupled to a Fuel Cell by means of a reforming process, because the obtained producer gas has 20% CO, 18% H₂, 2% CH₄ and <0.5% HC, in order to increase hydrogen concentration and/or decrease CO or HCs to tolerable values.



Demonstration Projects

Tram applications. ECOTRANS



From: gerenshill.com

CIDAUT, jointly with HYNERGREEN, is involved in the National Project ECOTRANS, with the aim of studying the viability of hydrogen technologies for light railway vehicles.

The sizing of the different components of the powertrain was accomplished throughout an energy model, which is fed by the power curve of the vehicle or by the profile of the route and the desired specifications of the vehicle. Specifically, two studies were carried out for checking the viability of replacing the current electric power systems of Sevilla and Zaragoza trams by hybrid systems of PEM Fuel Cells, batteries and/or supercaps. The analysis not only involved physical issues but also technical and economic ones.

It has also been carried out a report about the current technology for hydrogen storage and the prospects for improving their features.

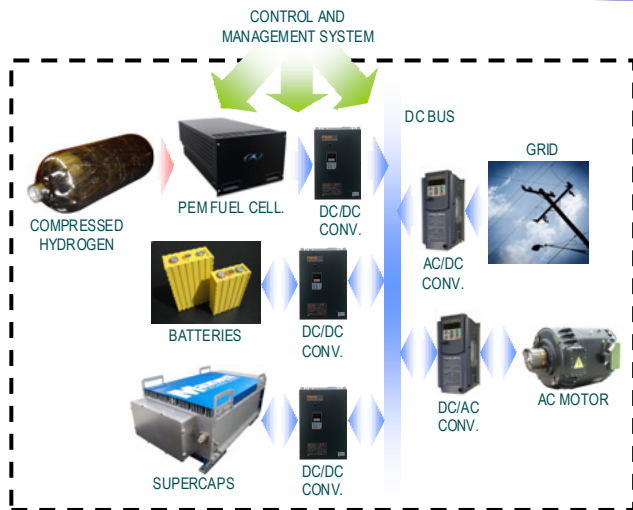
Finally, a study about current regulations for using hydrogen in vehicles has been carried out, without finding specific rules for the railroad sector, although they exist in the automotive one. Normative about hydrogen storage and usage of hydrogen has also been analyzed.



From: www.hotelbellavistasevilla.com

Demonstration Projects

Tram applications. TRANVÍA-H2



Features

Vehicle mass: 26 Tm

Max. Speed: 30 km/h

Max. Acceleration: 1 m/s²

Fuel cell power: 2 x 12 kW

Battery peak power: aprox. 120 kW

Supercaps peak power: 89 kW

Nominal Motor Power: 4 x 30 kW

Maximum peak power: 120 – 140 kW

Hydrogen Storage: 10 kg

Passengers: 22

Expected start-up time: 2-3 min

Expected max. transient time: < 1 s

Development of a hybrid tram propelled by Fuel Cells, batteries and supercaps jointly with FEVE from 2009. This vehicle is going to be the first tram in Europe integrating these technologies.

Firstly, an energy model of the system was developed in order to size the different subsystems and test several control strategies for managing the power distribution, the system behavior and the DC bus control.

The developed vehicle is a rolling test bench that allows to evaluate the behavior of the different hybrid systems configurations: Fuel Cells with batteries or supercaps, or both systems at the same time.

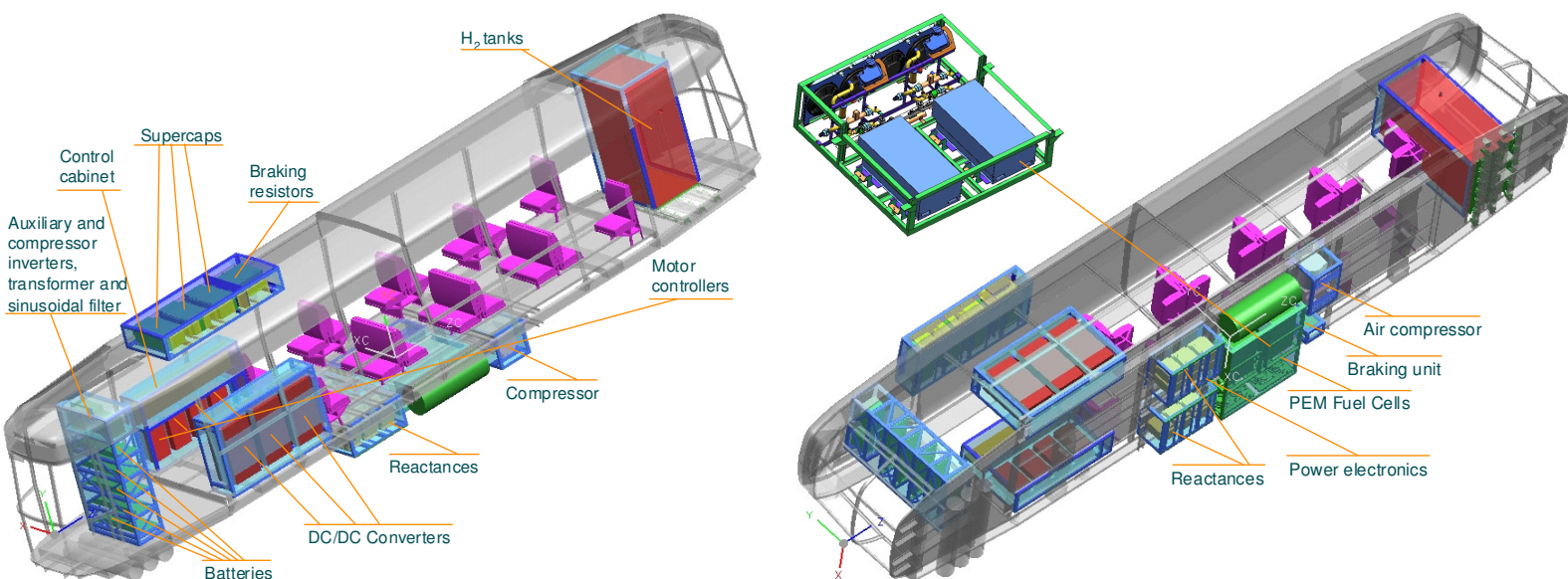
The powertrain and the hydrogen storage has been sized for carrying out 15 trips of 2.6 km from LLuvia to Ribadesella.

FEVE acquired a vehicle series 3400 made by SNCV in the 50's. It was refurbished in the 70's and operated in Valencia until the 80's.



Original vehicle

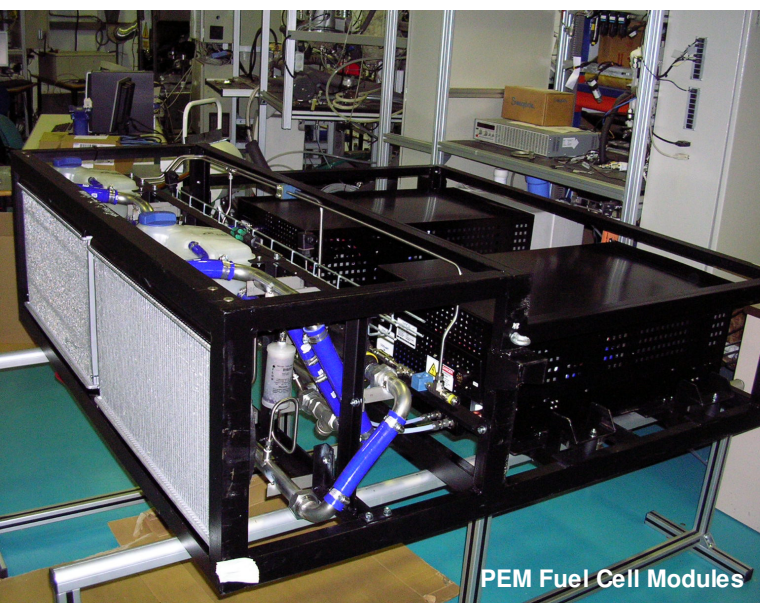
Tram Route



CIDAUT selected the powertrain elements and supervised their integration in the tram. Each system has been individually tested, being nowadays in the starting-up of the vehicle. It is planned its normal running during the next months.

All the systems have been designed to accomplish current normative related to hydrogen and railway sector.

CIDAUT develops the tram's control strategies and control systems, paying special attention to the behavior during transitory states. The system has been designed so the supercaps control the bus voltage, the batteries help the supercaps during power peaks (accelerating and braking), and the Fuel Cells, working in quasi steady state conditions, maintain the state of charge of the batteries and supply all the energy needed by the tram.



From: FENITRAIL

Demonstration Projects

APU applications. APU-SOFC

CIDAUT, inside the National Project PROSAVE², in collaboration with HYNERGREEN is going to develop a model validated by means of a scaled testing facility for sizing APUs for the aeronautic sector based on SOFC technology.

From data of the different systems consumption that must feed the APU, not only on ground but also in flight, of the different energy recovery inputs of the system, and following the specific requirements of the APU system and the normative, a model is going to be developed that sizes the hybrid APU based on Fuel Cells, batteries and/or supercaps for two different types of aircrafts.

Finally a testing facility is going to be developed to validate results from the model. This facility is going to consist on a SOFC, batteries, supercaps, power converters, necessary auxiliaries and a fuel processor. This facility is going to be used for testing the load from the models scaled to the facility size.



Demonstration Projects

Residential applications. COPICOGAS, AEROPILA

Integration of PEM Fuel Cell technologies with hydrogen production for their applicability in the residential sector, jointly with COLLOSA from 2003 to 2006.

The first stage was the development of the BOP of the Fuel Cell facility. Then, it was integrated with a natural gas reformer of 5 kW that directly fed the stack.

The second stage was the integration of the system with a 10 kW alkaline electrolyzer, able to work in transitory conditions (typical of renewable energies) and a pressurized storage system. The whole system was coupled to a wind turbine simulator to test the behavior of the electrolyzer and its power converter. The power converter track the maximum power point of the wind turbine

The aim of the facility was using hydrogen as an intermediate storage system that allowed to uncouple wind energy generation from energy demand.

The system was able to give 5 kW to the grid through an inverter.



Features

Fuel cell power: 5 kW

Thermal power: 5.5 kW

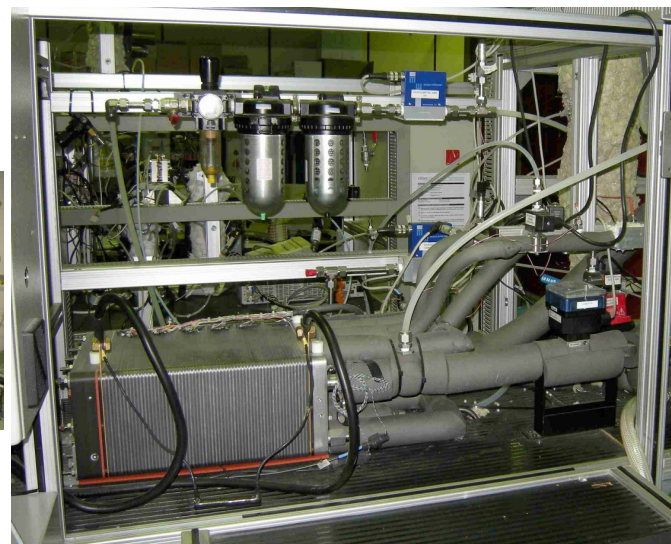
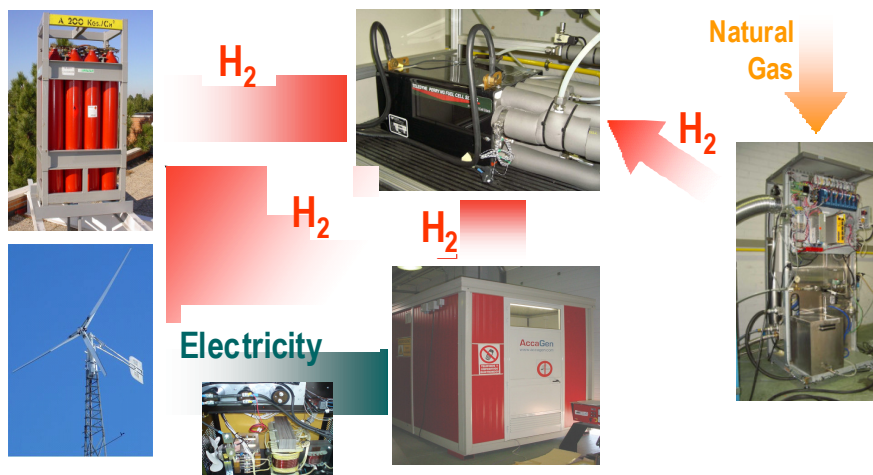
Electrolyser hydrogen flow: 2.2 Nm³/h

Electrolyser hydrogen purity: 99.999%

Reformer hydrogen flow: 3.5 Nm³/h

Reformer hydrogen purity: 99.99%

Hydrogen storage pressure: 30 bar



Demonstration Projects

Residential applications. PILEREN



Features

Nominal electrical power: 1 kW

Peak electrical power: 4.4 kW

Fuel cell power: 1.5 kW

Battery power: 3.3 kW

Thermal power: 1.6 kW

300 h testing under simulated demand of a typical house

Development, in 2003, of the first application of a PEM Fuel Cell for the residential sector, granted by the EREN and with the support of INTA.

CIDAUT developed a hybrid system with a set of lead acid batteries, accomplishing also the thermal integration of the system for obtaining hot water. The batteries gave the peak power and the PEM Fuel Cell supplied the energy

CIDAUT designed control strategies for the stack and the typical electric loads at home (appliances, tv set, lights,...), simulating typical daily consumption cycles. This system worked for more than 300 hours.



Test Bench

5kW Diesel fuel processor

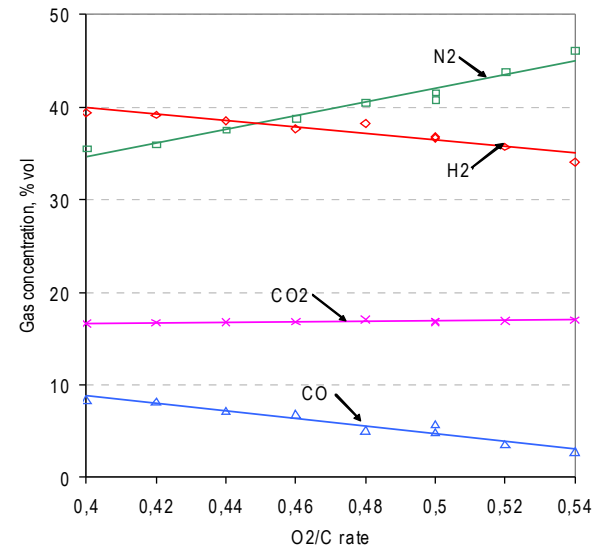
In 2005, CIDAUT, jointly with INTA and ICP-CSIC, developed a testing facility for characterizing catalytic beds for reforming process. The tests were carried out with diesel.

The facility has a Mixing Chamber, an Oxidative Steam Reformer (OSR), a Desulphurizer, a Water Gas Shift Reactor (WGS) and a Preferential Oxidation Reactor (PrOx).

The facility has the ability to:

- Heat or cool each reactor independently to control its temperature.
- Carry out tests in controlled conditions for a wide range of O_2/C and H_2O/C ratios, pressure and temperature.
- Fine control of the reactors working conditions without taking into account thermal integration.

A CFD model for output gas composition and (heat transfer) thermal management determination of the OSR was carried out considering the kinetic expressions obtained at laboratory scale by ICP-CSIC.



Variation of the gas concentration at the OSR output at H_2O/C ratio of 3, and different O_2/C ratios.

Features

Diesel fuel flow-rate: 0.7 - 2.5 l/h

Hydrogen concentration up to 40%

Less than 50 ppm of CO

O_2/C ratio: 0.3 – 0.8

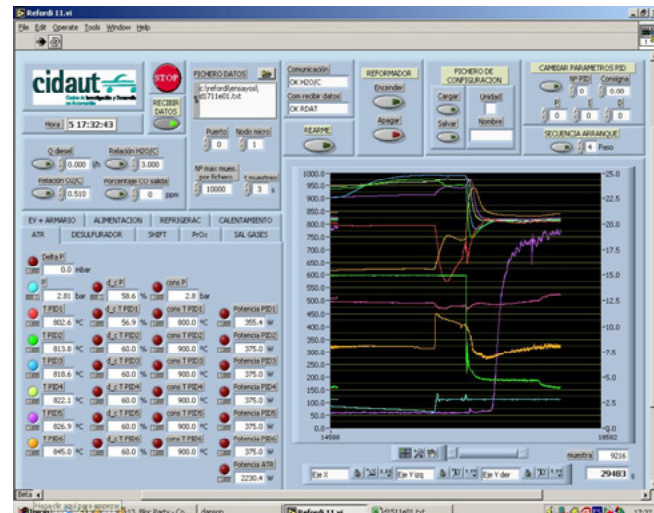
H_2O/C ratio: 2 – 5

Pressure: 0.5 – 3 bar

Maximum OSR Temperature: 900°C

6 thermocouples per reactor

Temperature control by means of electrical heating



Test Bench

Hydrogen Safety. Hydrogen Sensors

Participation in the 6th Framework Program “STORHY”, with the aim of promoting attractive economy and environmental solutions for hydrogen storage and exploring the potential risks in the storing techniques with new compounds.

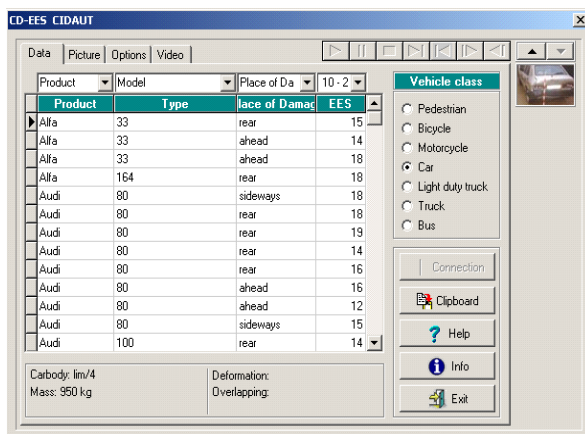
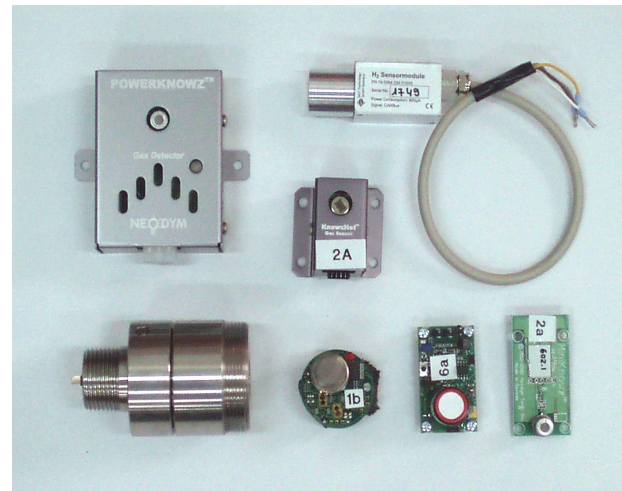
CIDAUT led two Work Packages inside the subproject “Safety characteristics and specifications”:

- WP 2: “Safety equipment and sensors”, where a testing facility was developed for hydrogen sensors characterization in working conditions at fuel stations and vehicles, with the final goal of establishing the testing protocol for characterizing the behavior of the sensors.
- WP 4: “Crash behaviour” where the traffic and accident statistics were evaluated; and a definition of the survival space related to the type of vehicle and the storage system, classified function of accidents probability, was accomplished.

Features

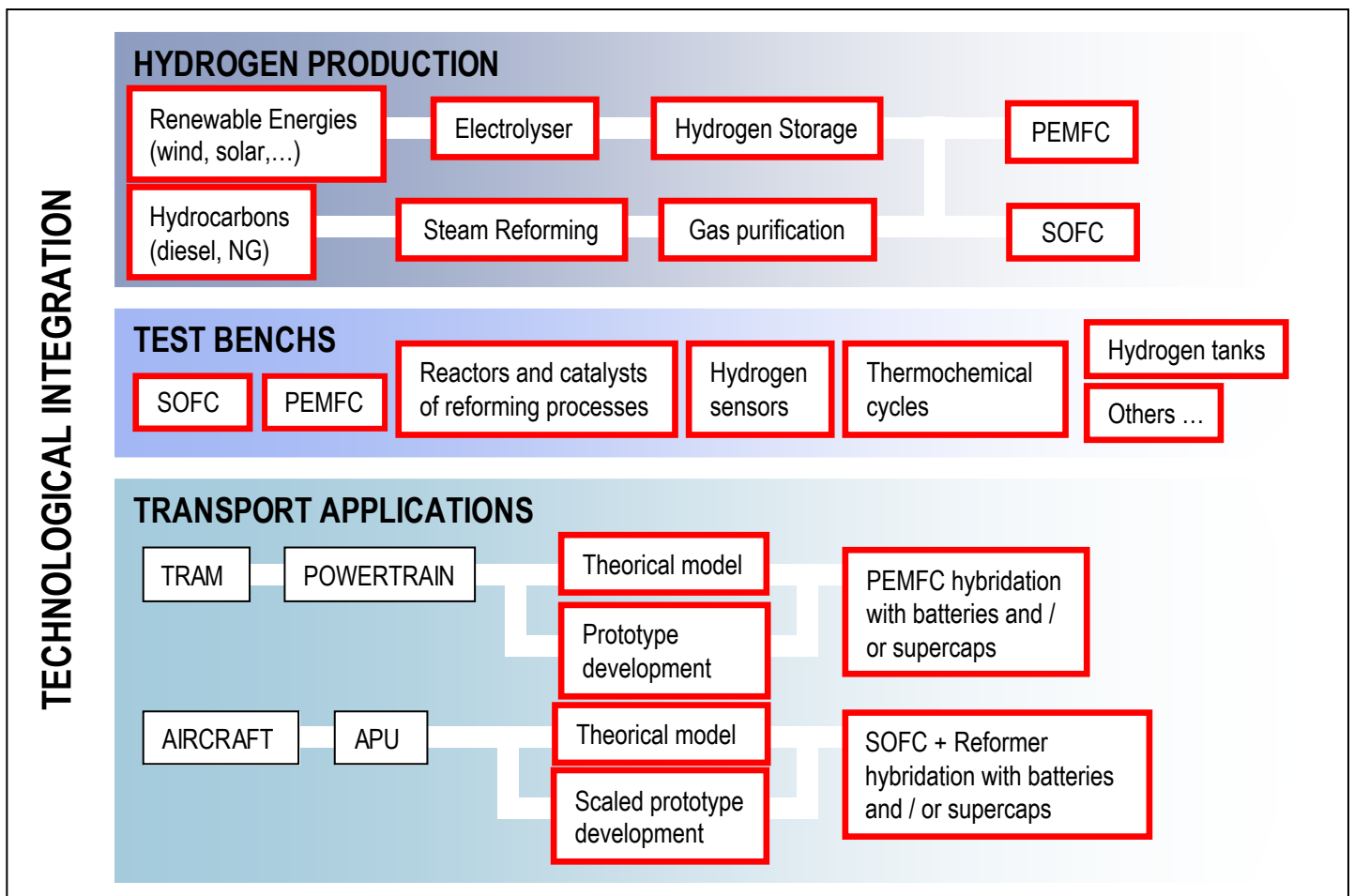
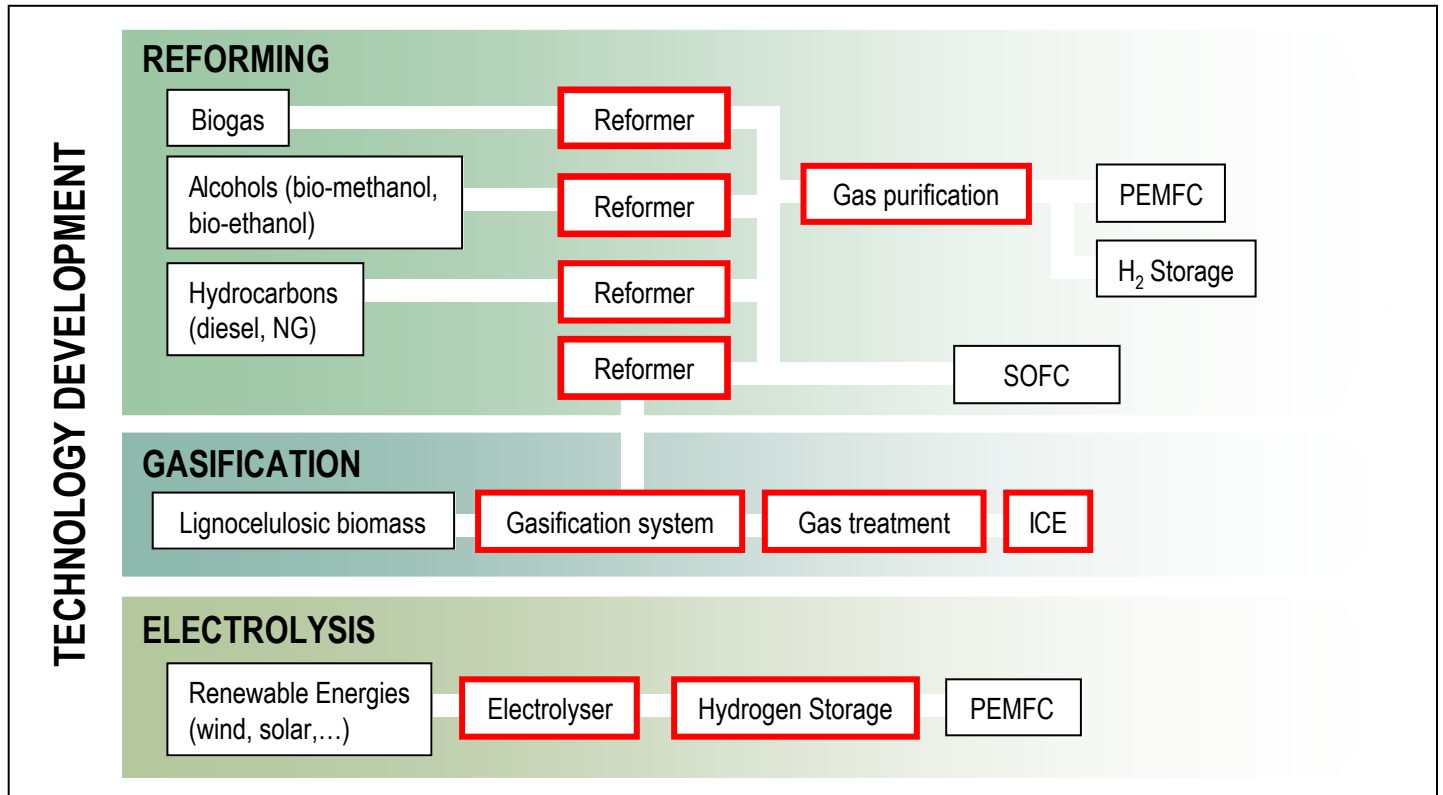
The facility is able to do the following tests of hydrogen sensors:

- Ambient conditions: Temperature (up to 85°C), pressure (0.6 – 1.3 bara), humidity (up to 95% RH)
- Response time and recovery time
- Gas Velocity: up to 50 m/s
- Measurement range: 0 – 100% LEL
- Cross Sensibility with other gases
- Long term stability. Fatigue test



Hydrogen Technologies

Capabilities



CIDAUT CAPABILITY

Foundation CIDAUT, is a non-profit Research and Development Centre, which was created in 1993. The Foundation promotes scientific investigation, technological development and innovation applicable to industry in general and to the transport and energy sectors in particular.

The technical force of CIDAUT is formed by more than 300 engineers and researches that have developed more than 200 research projects during the last years. Regarding our experience at EU level, CIDAUT has participated in more than 30 EU research projects, being 10 of them in FP7. CIDAUT facilities stretch over an area up to 23,304 m² and the total investment in equipment is above 62 million Euros.

The R&D section is divided into the following areas: Transport Safety, Product-Process-Materials; and Energy and Environment.

The development of new technological concepts which permits the use of energy sources less polluting but economically feasible, the definition of processes which permits the minimal output of residuals, the promotion of the design of systems which transform energy and the efficient use of energy at different levels, make up the basic objectives of the research carried out in CIDAUT in Energy and Environment.

Foundation CIDAUT's energy and environment department focuses its technological innovation efforts in developing technologies and processes related to renewable energies, being its basic work lines liquid biofuels, solid biomass, hydrogen technologies, energetic design methodologies in building (sustainable building), equipment development for predictive maintenance of fluid energetic systems and development of products linked to generation, transformation, exchange and use of energy.

Foundation cidaut

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