PHAEDRUS Newsletter

May 2014

Facts & Figures
- Full name: High Pressure Hydrogen All Electrochemical Decentralized RefUeling Station
- Acronym: PHAEDRUS
- Start date: 1/11/2012
- End date: 31/10/2015
- Funding EU: 3.5 M€
- Total budget: 6.3 M€

Impact
Developing and validating a new concept for 70 MPa hydrogen refuelling retail stations enabling self sustained infrastructure roll-out for early vehicle deployment volumes.

In this issue
- General over the project:
  - Objectives
  - Project Structure
  - Concept
- Preliminary results

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PHAEDRUS Project

Introduction

The PHAEDRUS Consortium proudly presents the first issue of the project's Newsletter. This first issue introduces the structure of the project, its goals and objectives, as well as the main results. You can read about the results achieved until now.
We wish you informative reading!

Goals & Objectives

Goals

- New concept and new technologies for a hydrogen retail refuelling system
- High performance electrolyser (prototype with 5 kg/day capacity)
- High performance hydrogen electrochemical compressor (prototype with 5 kg/day capacity)
- Hydrogen Refuelling System including electrolyser, electrochemical compressor, hydrogen storage and dispensing unit
- Design for a Hydrogen Refuelling System design is made for 200 kg/day capacity

The project is scheduled for 3 years and can be regarded as phase one of a two-step development. In the first phase technology will be developed, a, and validated on a 5 kg/day scale. Subsequently in phase two the technology will be demonstrated in a scalable 200 kg/day Hydrogen Refuelling System.

Objectives

The objective of the project is to develop and validate a new concept for 70 MPa hydrogen refueling retail stations enabling self sustained infrastructure roll-out for early vehicle deployment volumes, showing the applicability of the electrochemical hydrogen compression technology in combination with a PEM electrolyser, storage units and dispensing system.

- The use of electrochemical hydrogen compression technology is expected to provide a step change in both the efficiency and cost of ownership of an integrated hydrogen refueling system.
- The applicability will be demonstrated in a fuelling system producing 5 kg hydrogen per day, while a design is made for a fuelling system capable of producing 200 kg hydrogen per day. This is typical for the need of fleet owners and early markets.
- Another objective is to analyze and validate the safety aspects, efficiency and economic viability of the system. Important factors influencing cost and efficiency are the absolute and relative sizes of the individual building blocks.
- The business case for the final refueling system will be done by a reliable assessment of the cost and energy efficiency of the H2 compression and refueling cost as a function of the production size (in size and in (production) number of stations) in comparison to systems based on mechanical compression.

Project Structure

Work Packages & Main results

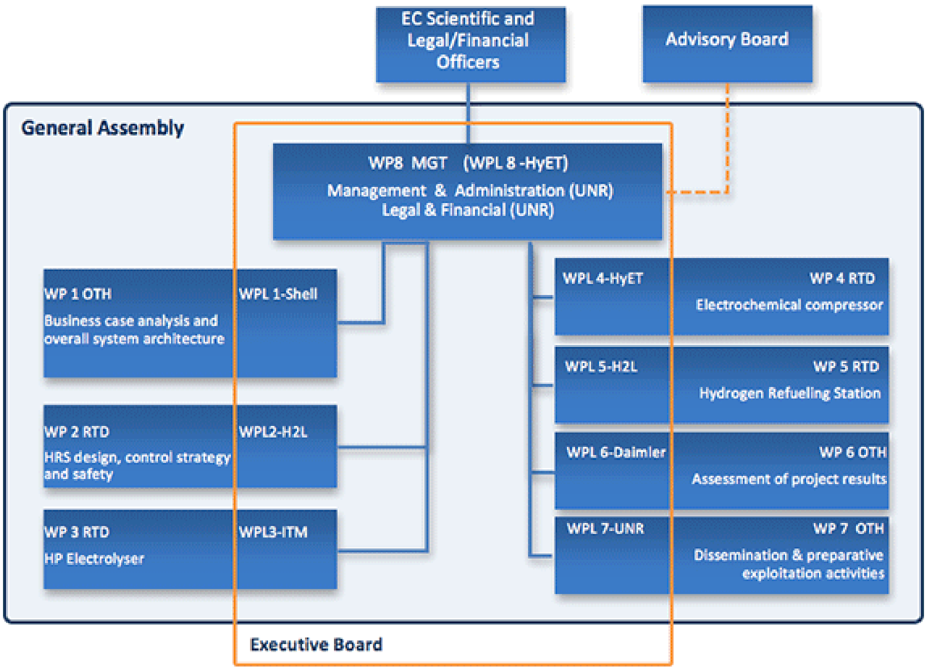
To realise the PHAEDRUS objectives, a structure of 8 Work Packages has been defined. In WP1 a market analysis is carried out using the input from roll-out scenarios and the work on standardisation, in addition the preferred system architecture is selected and the optimum sizes of the different building blocks are determined relating to cost and efficiency. The requirements for fuelling stations will be determined, and the different size classes. Also the allowable costs for the investment and operational expenses are determined as a function of station size and deployment volumes.

The results from work package 1 are used as input for WP2. Based on the selected system architecture a design is made for a 200 kg/day class fuelling station in WP2. The design includes also a control strategy and communication protocols between the different sub systems of the fuelling station. The design is thoroughly analysed for safety aspects.
In WP3 an efficient electrolyser concept delivering hydrogen at a pressure level of 10 to 20 MPa at an efficiency of 85 % is developed. A full-scale design is made aiming at targets of €1700 per kg/day for capital costs. It is validated on a 5 kg/day scale, including endurance testing.

In WP4 an electrochemical hydrogen compressor capable of compressing 200 kg/day at full scale at an energy consumption of 4 kWh/kg and capable of handling peak demands is developed. The technology is validated on a 5 kg/day scale, including endurance testing.

WP5 is to conduct R&D of a complete turn-key HRS that integrates the compressor and storage with a refuelling control and pre-cooling system connected to a dispenser and integrated into a modular packaging skid.

The results of work packages 2 to 5 are assessed and evaluated in WP6 and compared to the requirements and targets set in WP1. The project results are disseminated in WP7 to the general public, relevant bodies and industry. Preparations for a full scale demonstration of the developed technology are made. Finally the overall progress of the project is monitored in WP8.



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Shell Global Solutions · BAM · ARMINES · Hochschule Esslingen University of Applied Sciences · UNIRESEARCH

PROJECT CONCEPT

Concept & Building Blocks

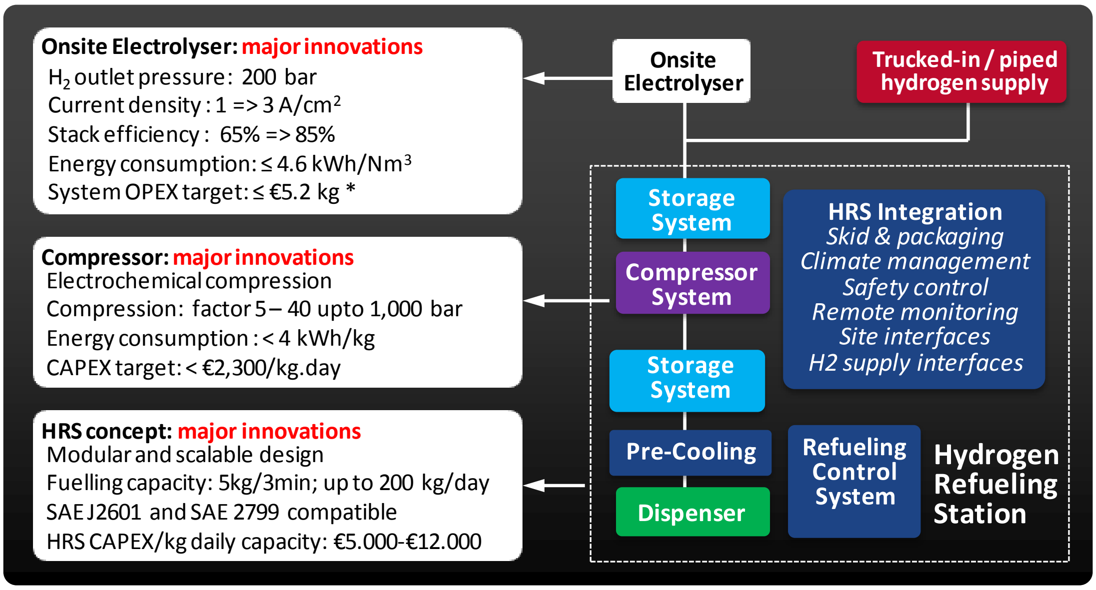
The PHAEDRUS CONCEPT proposed (figure below) is based upon the following key features:

1. Electrochemical compression
   Electrochemical H_2 compression will provide a step-change in terms of energy efficiency, and cost reduction. Using gastight proton conducting membranes and dedicated electrode configurations in a cell, hydrogen can be brought to a higher pressure by simply applying a DC-current over the membrane-electrode-assembly (MEA). Another major benefit is that it is an easily scalable technology by either increasing the active area of the cell, or the number of cells in a stack or the number of stacks.

2. Step-improved electrolysis
   An onsite electrolyser that is highly efficient, compact and scalable, and which yields a high outlet pressure, is one of the building blocks of the Hydrogen Fuelling Station.

3. Modular Hydrogen Refuelling Station Architecture (HRS)
   An HRS architecture that is modular by nature as it consists of standardized building blocks for compression, storage and dispensing, enables flexibility in individual design, footprint and size while at the same time it allows for low CAPEX.

The proposed hydrogen refuelling station concept consists of the hydrogen production by electrolyser, storage, compression and dispensing system with pre-cooling device, whereby the storage, compression, pre-cooling and dispensing are integrated in the Hydrogen Refuelling Station (HRS). The concept of the HRS allows combination with other hydrogen on-site production methods and with trucked-in or piped hydrogen as well.



PRELIMINARY RESULTS

The following deliverables have been submitted:

- D1.1 Report on fuelling system requirements and targets for CAPEX and OPEX (Public Document)
- D1.2 Report on initial system architecture & sizing (Confidential Document)
  Overall designs suggestions have been formulated showing various concepts for HRS configurations with regards to storage and compression. This has been conducted by development of an advance dimensioning simulation model tool.
- D2.1 & D2.2 Report on System design and the control strategy (Confidential Document)
  An overall system/module design has been developed that details the technical interfaces between the Hydrogen Production (H2P), Hydrogen Compressor (H2C) and Hydrogen Refueling Station (HRS). Initial and overall design consists of PFD and P&ID for the complete system on module level. Each company is to handle detailed module design internally. A control strategy has also been formulated addressing between H2P, H2C & HRS. This involves selection of communication standards & communication/control parameters.
- D2.3 Safety Analysis under legal aspects (Restricted to other Programme Participants)
- D7.2 Project identity, public and restricted website, e-newsletters and templates for dissemination materials (Public Document)

The following Milestones have been achieved:

1. Agreement within coalition on fuelling station requirements and financial targets
2. Initial system architecture & sizing of components
3. Design and control strategy ready for WP3, WP4 and WP5

By the Work Package Leaders

Status WP6:
Daimler AG is the project leader of the work package 6 and contributes with its expertise in the development of fuel cell electric vehicles (FCEV) and is responsible for economic and technical analysis. The project partners HyEt, ITM, H2Logic, Hexagon and UASE are responsible for different tasks within the work package and support Daimler AG in his function as a project leader. Both, the single components and the overall system architecture have to be analyzed. In work package 6 the results of previous WPs were assessed and complemented with a well-to-wheel analysis. The cost of CAPEX and OPEX for the whole HRS was presented in detail for developed technologies including production, compression and refueling for different years and volumes were evaluated. A comparison of the improved technologies and the potential of upcoming market implementations conclude the work Daimler AG and his project partners have done so far.

For more information, visit the project website: **www.phaedrus-project.eu**

Consortium
The PHAEDRUS Consortium consists of 10 partners from 6 EU countries:

1. Coordinator: HyET B.V.
   www.hyet.nl
2. ITM Power (Trading) Limited
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3. H2 Logic A/S
   www.h2logic.com
4. Raufoss Fuel Systems AS
   www.hexagon.no
5. Daimler AG
   www.daimler.com
6. Shell Global Solutions International B.V.
   www.shell.com
7. Bundesanstalt fuer Materialforschung und –pruefung
   www.bam.de
8. Armines
   www.mines-paristech.eu
9. Hochschule Esslingen
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