

High Pressure Hydrogen All Electrochemical Decentralized Refueling Station PHAEDRUS

Project grant No: 303418



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Hydrogen Efficiency Technologies (HyET) B.V.

www.phaedrus-project.eu/

PROJECT OVERVIEW

- SP1-JTI-FCH.2011.1.8 (Collaborative Project)
- Transportation & Refuelling Infrastructure
- 01/11/2012 - 30/10/2015 (*finished*)
- Budget:
 - Total budget: € 6,309,832
 - FCH JU contribution: € 3,566,343 (56.5%)
- Design of a **scalable Hydrogen Refuelling Station** using new technology such as EHC, (A)PEM, at **200 kg/day** and validate their integration by testing at **5 kg/day**.



Shell Global Solutions



BAM



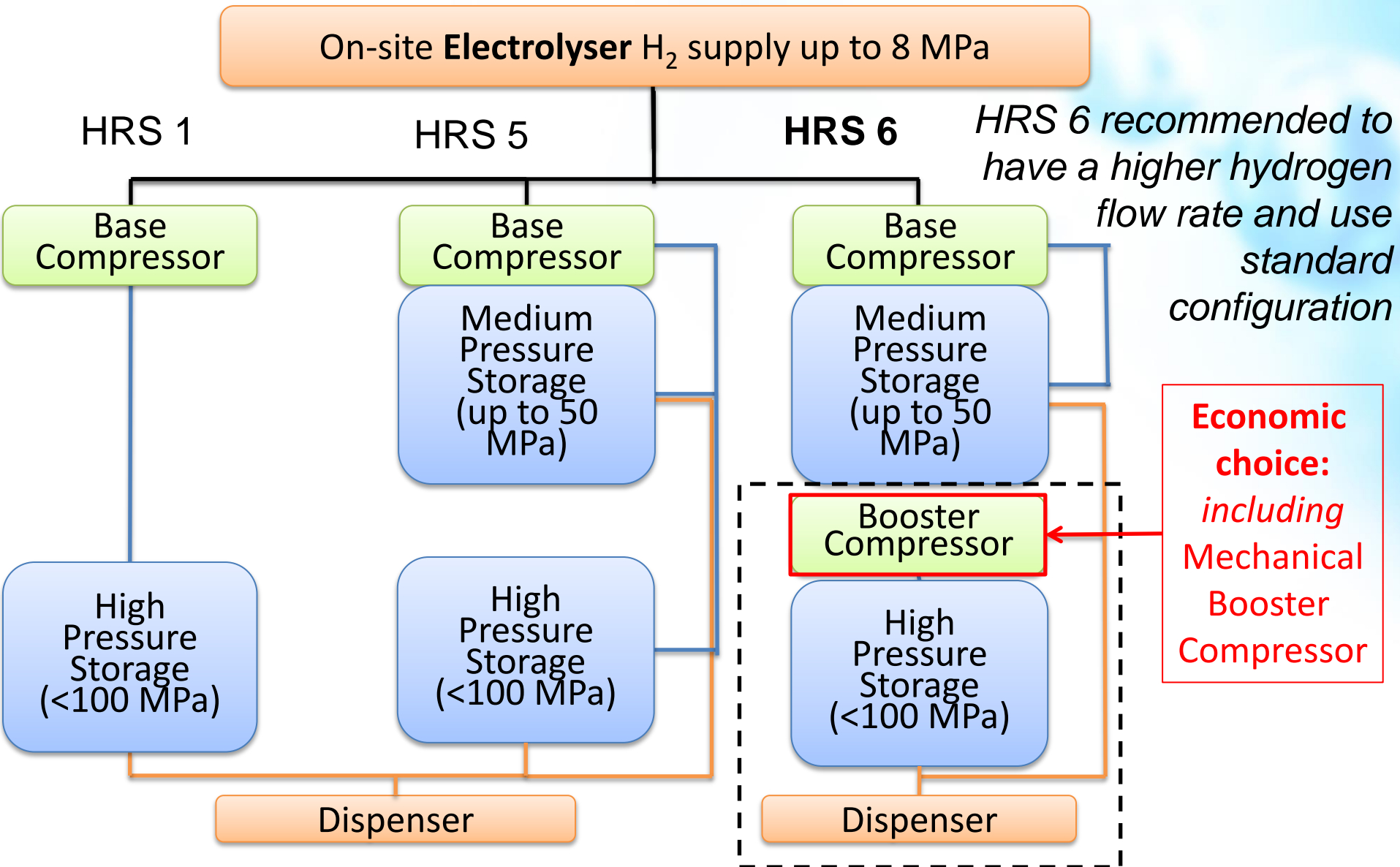
PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
MAIP			
HRS Capex 2015 target <1M€	Cascade system configuration simplified using new technology	HRS model is available as tool for optimal design before realisation	CAPEX Cost per daily dispensed H2 around 10,000 €/kg is feasible!
H2P CAPEX 2015 target: €3500 per Nm ³ /hr	Modular unit system, low membrane costs and low Pt catalyst loadings	Components were validated, membranes and low catalyst loading evaluation complete	Scalable unit validated at 5 kg/day, model shows large costs down potential with optimisation

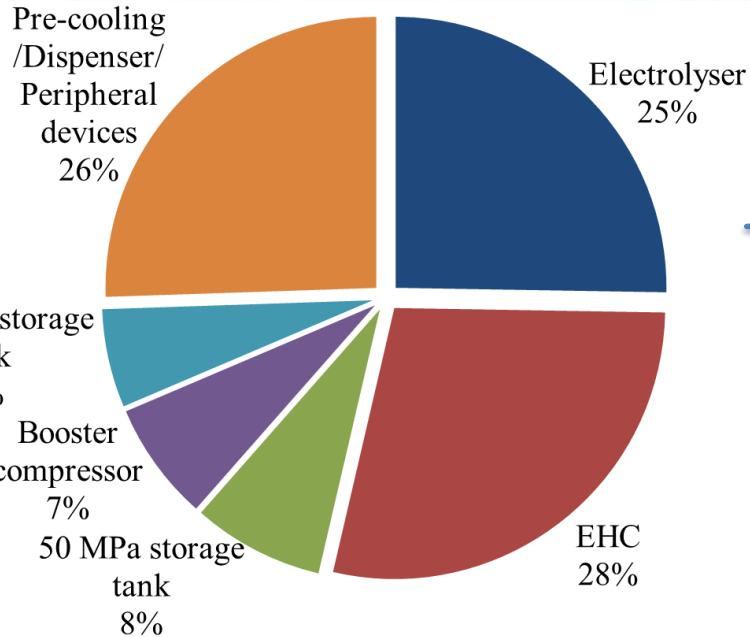
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AIP 2012			
Optimisation of compression & storage systems with respect to cost, efficiency and capacity	Balance component specifications in final system configuration	Component sized using model based on component test results and realistic costs	Configuration relates impact of costly high pressure storage tanks and component limits
Compliance	standardised compliance verification and BAM evaluation		H2 Logic applies refueling control system adapted to new SAEJ2601
Hydrogen Price	2015: 10-15 €/kg	<2015: 13.7 €/kg	>2015: 10.6 €/kg

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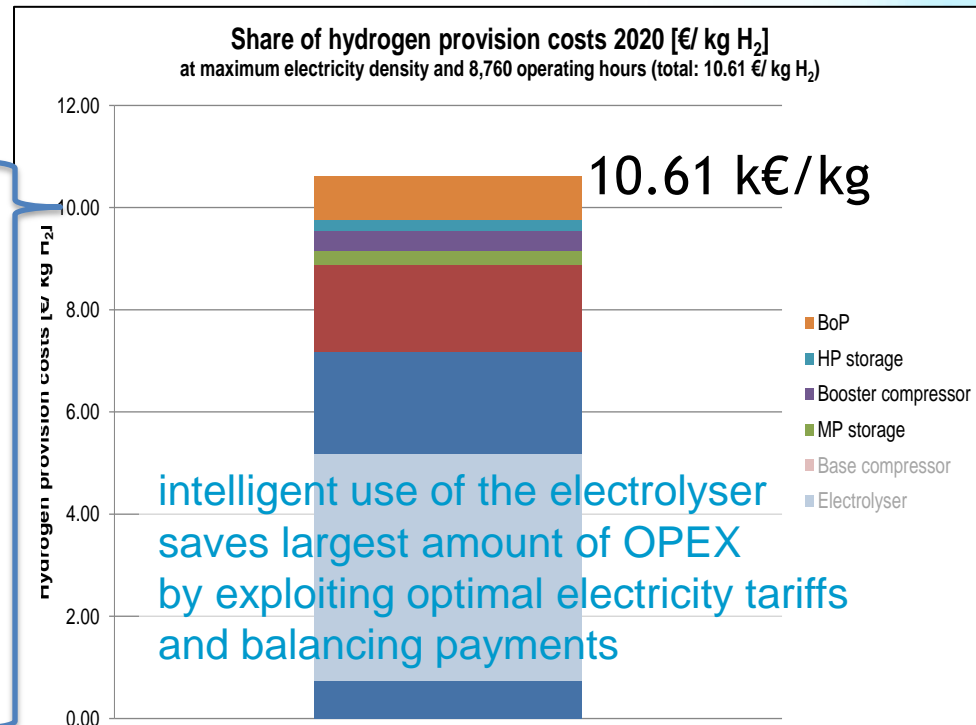
CAPEX Cost per daily dispensed H₂ around 10,000 €/kg is feasible!

meeting target range PHAEDRUS set 5-12 k€/kg,

- OPEX Costs depends on electricity
- No easy comparison with high variations in components /size

Future recommendation:

- make a better analysis before constructing the HRS, to know HOW to design effectively



PROJECT TARGETS AND ACHIEVEMENTS

Successful integration of components demonstrated at ITM linking Electrolyser and EHC on the 29th + 30th Sept 2015:



ITM
Electrolyser
(5 kg/day)

HyET
Electrochemical
Compressor
(here 2 kg/day)

PROJECT TARGETS AND ACHIEVEMENTS

- Development of a model for the most energy efficient method of generating, compressing and dispensing hydrogen at 70MPa
- Development of high pressure, high current density **electrolyser stack & BoP**
- Optimisation of an **electrochemical compressor** and mobile EHC MoHyTO system
- Development and test in MEA's of new electrocatalyst supports, based on carbon aerogels, for the electrochemical compressor
- Extensive **durability** data for developed components and systems
- **Technology cost comparison** and projection undertaken by Daimler
- Validation of a **new approach** and required technology for decentralised H₂ generation & refuelling
- Successful integration and operation of a high pressure, high current density electrolyser module with an electrochemical compressor
- Hydrogen cost target of €10/kg for 2020 assuming EHC achieves projected cost savings, but feasible **now** in specific situations.

RISKS AND MITIGATION

- Output pressure PEM Electrolyser reduced to 8 MPa
 - Design specification, no impact of feed-in pressure for EHC
- Development low-cost APEM electrolyser, PEM validation
 - Resorting to PEM enabled timely validation (agreed at review)
- Alternative HC membrane developed for EHC
 - Improved performance, delay roll-out stack (2 kg/day)
- Improved EHC cell hardware developed based on data
 - Enhanced thermal control, delay roll-out stack (2kg/day)
- Integration of new HRS components, validation on-site
 - Validation testing executed at ITM site, instead of H2 Logic
- Insufficient capacity of EHC operating with one stack
 - Target capacity of 5 kg/day feasible with two parallel stacks
 - Pressure target 100 MPa reached in single cell, 45 MPa stack in HyET and 15 MPa demonstrated during validation testing at ITM

EXPLOITATION PLAN/EXPECTED IMPACT

- Worldwide **premiere** validating integration of Electrolysis + EHC where data analysis and model showed commercial feasibility.
- Both Electrolysis and EHC are silent technologies and capable of following **dynamic energy peak profiles**, reducing OPEX costs.
- PHAEDRUS provides a **modelling tool** to evaluate the optimum HRS configuration considering bespoke situations and demand cycles.
- Hydrogen cost below $<10\text{€}/\text{kg}$ can already be achieved in 2020 if HRS concept, approach and operation are chosen in a smart way!
- **Next: Continued Component Development**
 - Electrochemical compressor needs to increase TRL level but potential benefit and cost-down potential justifies its pursuit
 - Electrolyser development projects further cost reduction
- **Cross-cutting Impact:**
 - Validation on-site highlighted the potential of new technology, Influencing the formulation and implementation of safety codes and standards.

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- Collaboration with HyAc (H2Logic)
- Demonstration EHC on-site in DonQuichote (HyET)
- Link to projects h2trust.eu
- Knowledge relevant to TEN-T infrastructure



HORIZONTAL ACTIVITIES

- Lessons learned and Model publically available through website
- Full public presentation and show & tell at WES (Stuttgart, 2015)
- Project awareness raised using multimedia, presentations, publications, *including* preparation animation video of key event
- Continued collaboration between partners after project finish



DISSEMINATION ACTIVITIES

Virtual Media

- Website www.phaedrus-project.eu
- E-newsletters (3x) provided by UniResearch
- Movie + animation summarising project achievements

Presentations

- UASE (Toledo, Spain - European conference)
- H2L (Status presentation at Danish FCH - national by-annual event)
- HyET (Cancun, ECS 2014)
- HyET booth and presentation (World of Energy Solutions 2015)

Publications

- Proceedings at WHEC 2014 (BAM)
- Proceedings at ECS 2014 (HyET)
- Proceedings at SAE 2016 (UASE)
- *Publications pending in peer referenced journals and book chapter*