



Introduction to portfolio of Hydrogen Production, Distribution and Storage projects

Nikolaos Lymperopoulos, Project Manager



AGENDA Day 2 Afternoon

13:50 – 14:10 Introduction to portfolio of Hydrogen Production, Distribution and Storage projects

Hydrogen production, distribution and storage

Nikos Lymberopoulos

Question and Answer Session

14:10 – 16:00 Session on Hydrogen Production, Distribution and Storage

PANEL 5

Energy: Hydrogen Production, Distribution and Storage

Moderators: Nikos Lymberopoulos, Eden Mamut

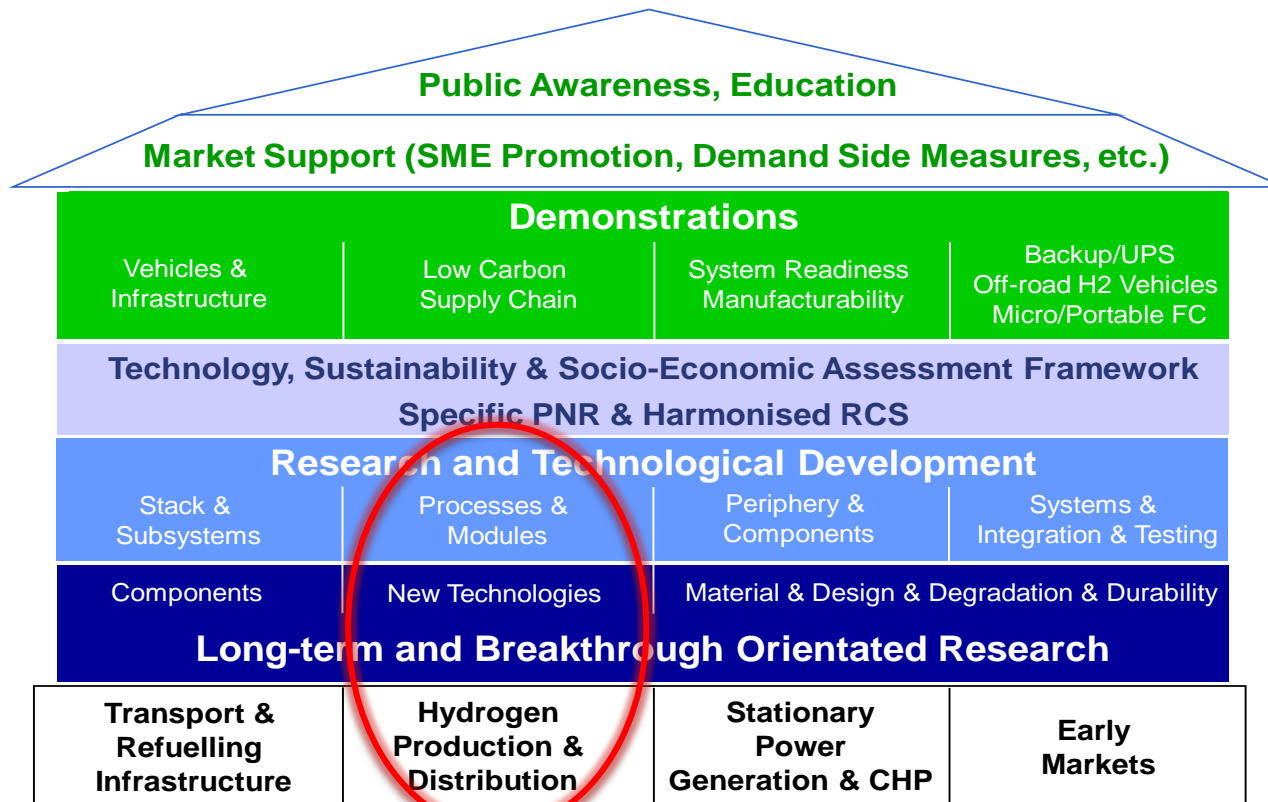
14:10-14:40 **BOR4STORE**

14:40-15:10 **ELECTROHYPEM**

15:10-15:40 **UNIFY**

15:40-16:00 **Storage Study** – Nikos Lymberopoulos

- Energy - RTD - H₂ Production & Distribution

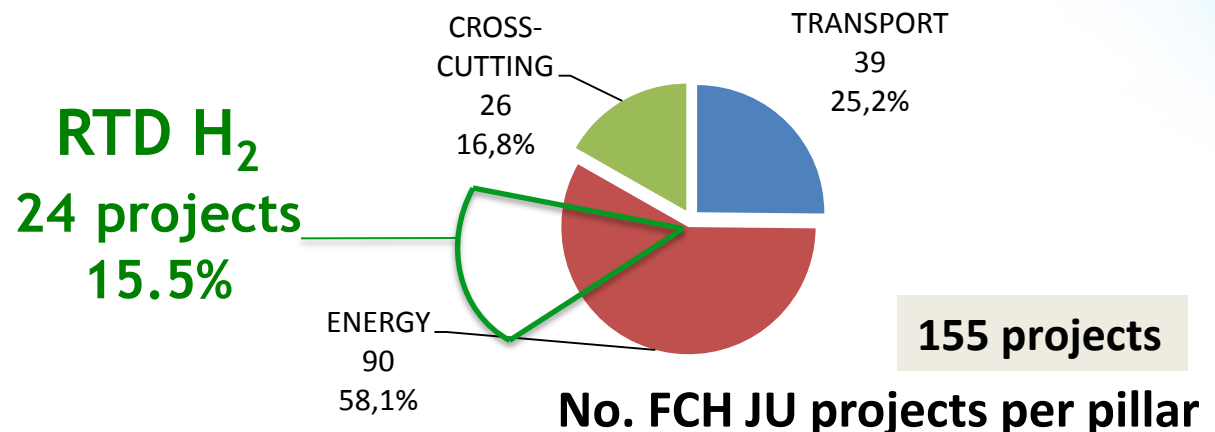
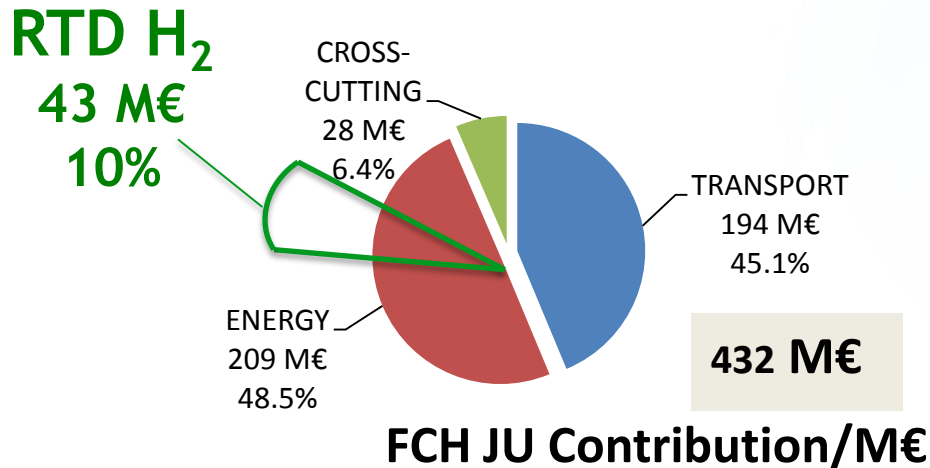


- Energy - H₂ Production & Distribution

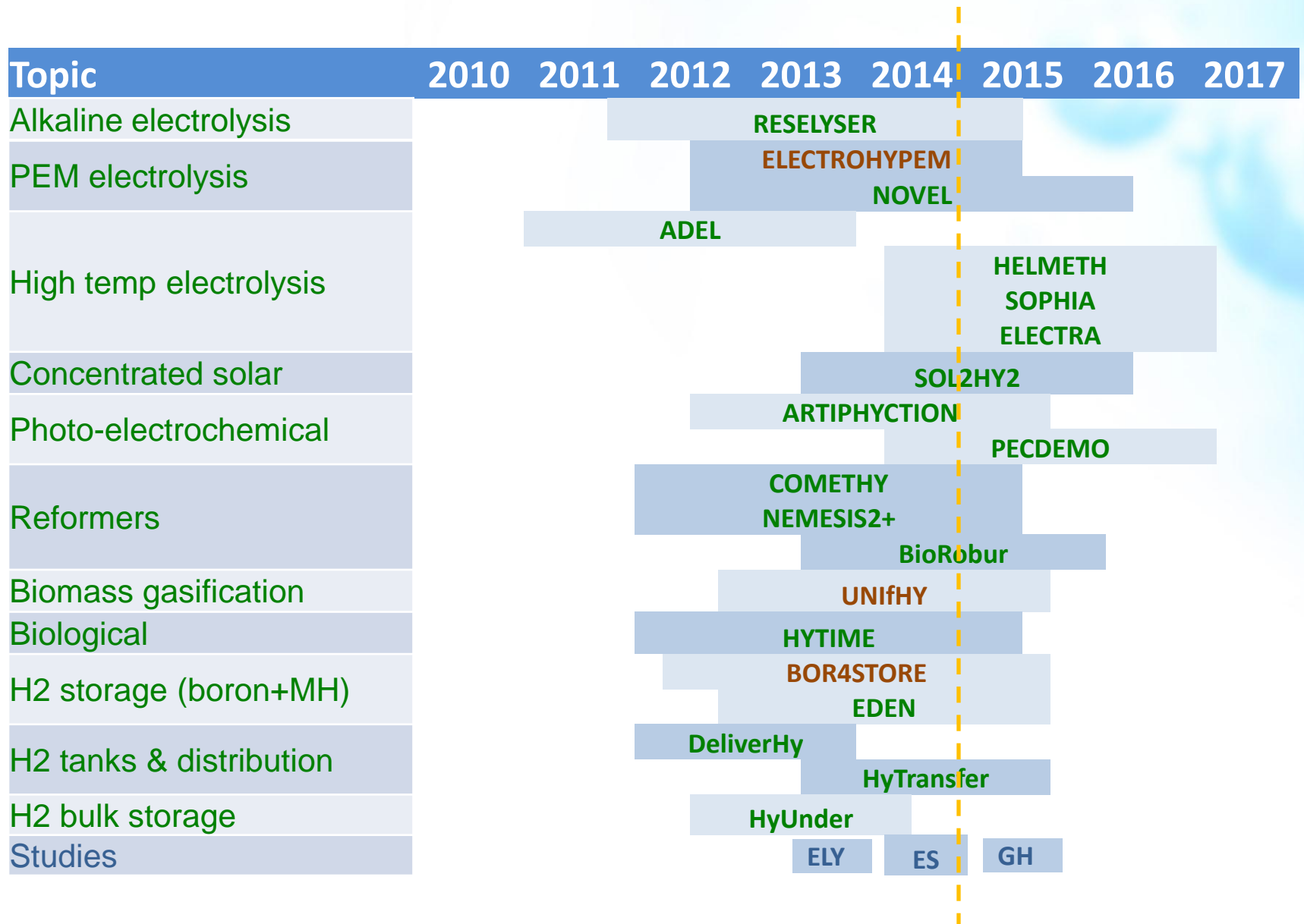
Application Area	Targets 2010	Targets 2015	
		Volume	Cost and Technology
Hydrogen Production & Distribution	Appropriate H ₂ supply chain (including fuel purity) to match Transport, Stationary and Early Markets requirements. For 2015 10 - 20% of general H ₂ demand should be produced via carbon free/carbon lean processes		Cost of H ₂ delivered at refuelling station < €5/kg (€ 0.15/kWh) Improved system density for H ₂ storage (9 %wt of H ₂)

	FCH JU Funding by Action Categories					
Application Areas	Break-through research	Research & technological development	Demonstrations	Support actions	TOTAL	
					€m	%
Hydrogen Production & Distribution	17-20	16-19	12-15	0	45-54	10-12%
Actual	43		9.6		52.6	12.1%

- Energy - RTD - H₂ Production & Distribution



Overview of Panel 5 Projects



PROGRAMME TARGETS AND ACHIEVEMENTS

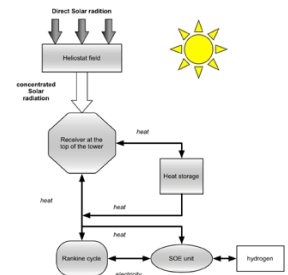
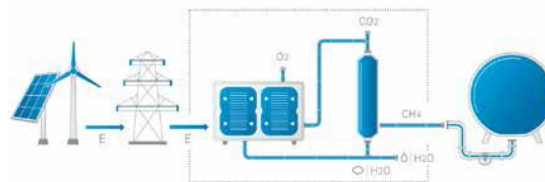
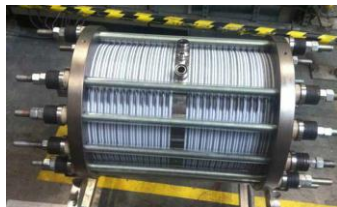
- Electrolysers - 1

- Alkaline (RESELYSER)

- Novel cells for variable operation minimizing gas cross-over at low current density to 25%
 - Aiming for $>80\%$ η retention $>90\%$ over 1,000 on/off

- High temperature (ADEL, HELMETH, SOPHIA, ELECTRA)

- Completed: € 6-17/kg H₂, 1.33 A/cm², 1-5% degradation / 1,000 hours
 - Recent: 0.5-1% degradation / 1,000 hours, total $\eta >85\%$ electricity -> syngas, coupling to concentrated solar source

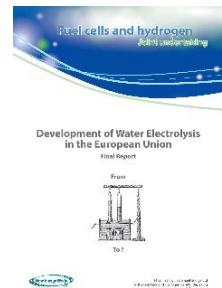


PROGRAMME TARGETS AND ACHIEVEMENTS

- Electrolysers - 2

- Study: Development of water electrolysis in the EU

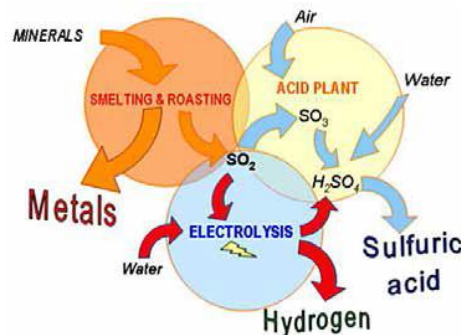
- Energy system R&D – interaction of el. with grid, benchmarks, test cycles
 - Electrolyser system R&D – part-load & dynamic operation for H₂ customers and provision of energy services
 - Electrolyser technology - reduce capex while maintaining reliability, increase performance (catalysts, membranes, systems)
 - <http://www.fch-ju.eu/page/publications>



PROGRAMME TARGETS AND ACHIEVEMENTS

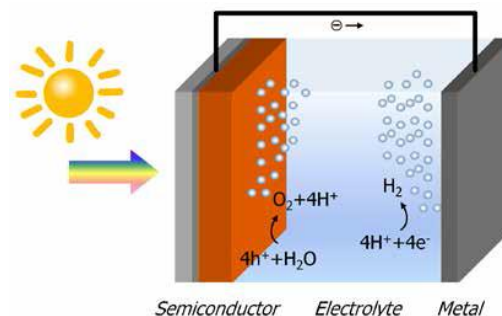
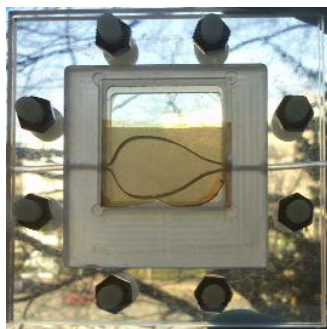
- **Concentrated Solar** (SOL2HY2)

- Modelling, multi-objective design and optimisation and testing of improved critical materials solutions and processes, leading to a virtual plant model
- Sulphur depolarised electrolyser (selected), solar-powered H_2SO_4 cracker (sun-tested) and heat storage (molten salts)
- 3 concepts chosen, critical BoP units selected, main blocks built using Aspen Plus S/W.



PROGRAMME TARGETS AND ACHIEVEMENTS

- **Photoelectrochemical** (ARTIPHYCTION, PECDEMO)
 - 2.5% - 5.2% sun-to-H₂ conversion η , 5 - 8% aim, 5% target
 - 1,000h is aim, 10,000h target
 - 100W – 3g/h aim, 100W-100kW target



PROGRAMME TARGETS AND ACHIEVEMENTS

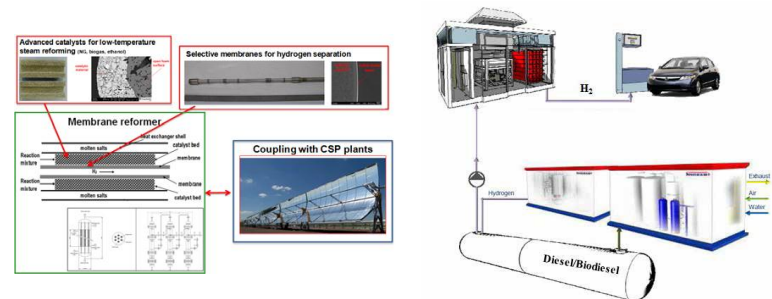
- Reformers -1

- Membrane reformer, 550°C, integrating RE heat sources (COMETHY)

- Centralised SMR $\eta > 70\%$ aim, 72% target
 - $>2\text{Nm}^3/\text{h}$ aim, 2-750 Nm^3/h target
 - $<3\text{vol}\%$ CO, $<10\text{vol}\%$ CO target

- Diesel, biodiesel reforming (NEMESIS2+)

- 70% η aim, 80% target, $>1,000$ h durability, $50\text{Nm}^3/\text{h}$ prototype

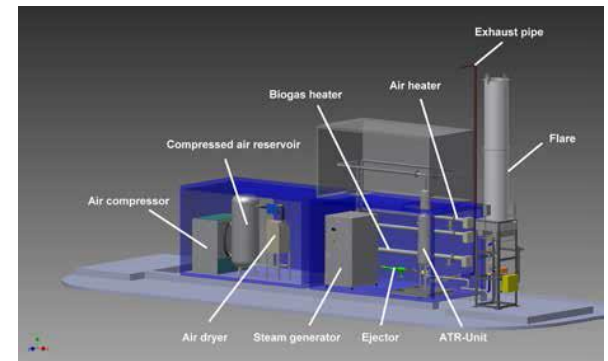
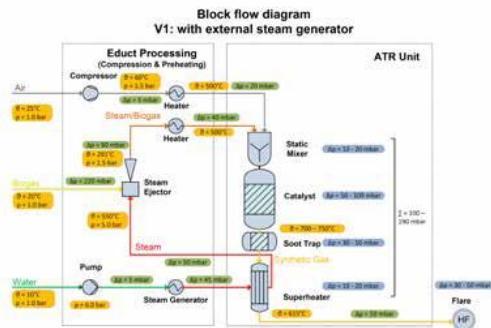


PROGRAMME TARGETS AND ACHIEVEMENTS

- Reformers -2

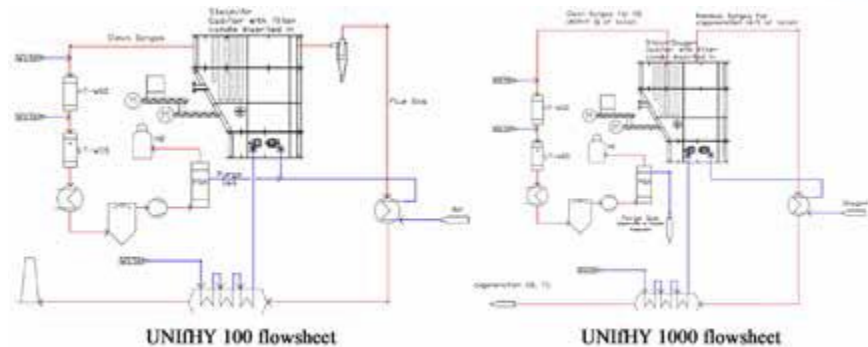
- Biogas reformer (BIOROBUR)

- 100 kg/day aim, 50-250 kg/day target
 - CO < 10 vol% aim and target
 - Materials costs for 50 Nm³/h 150 k€, target 250 k€
 - >65% η aim and target



PROGRAMME TARGETS AND ACHIEVEMENTS

- Biomass gasification (UNIFHY)
 - Continuous process for pure H_2 production from biomass (gasifier+WGS+PSA+thermal int)
 - H_2 cost < € 5/kg for 6,000h/year operation on plant, as per target
 - 70% η aim, > 66% target



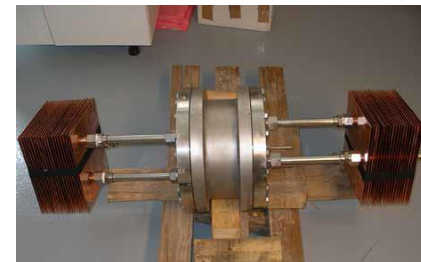
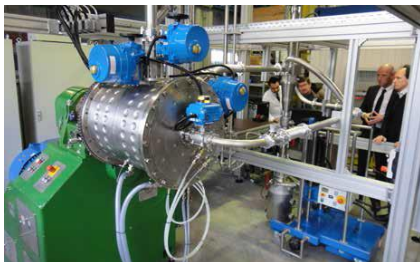
PROGRAMME TARGETS AND ACHIEVEMENTS

- Biological routes (HYTIME)
 - Dark fermentation of 2nd gen biomass, continuous process
 - 5L (6gr H₂/day) reactor in operation, 50L ready for tests, 300L just purchased
 - 1-10 kg H₂/d aim and target
 - 71% η from straw, 36% from grass, <10% kitchen waste, > 75% aim



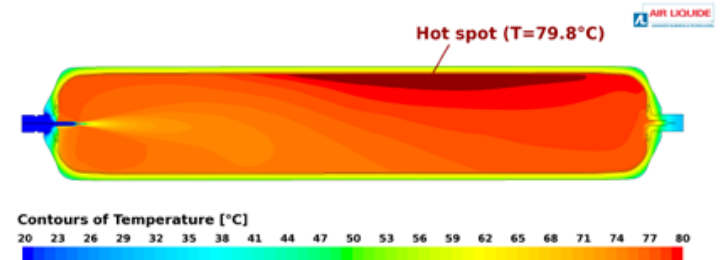
PROGRAMME TARGETS AND ACHIEVEMENTS

- H₂ storage : MH
 - Boron hydride-based materials (BOR4STORE)
 - 9-10 wt.% on material basis, >6 wt.%, 4% on system basis target
 - Release temp 350-450°C, 450 °C target
 - Mg-based materials (EDEN)
 - 7 wt.% on material basis, >6 wt.% target
 - SOFC compatible, > 1.5 lt/min release



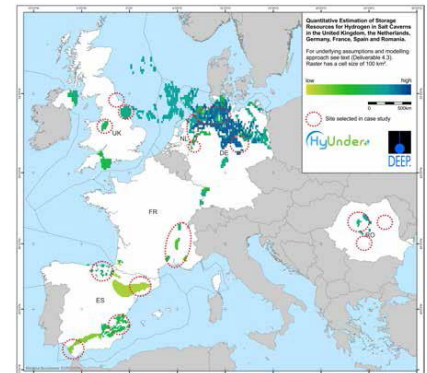
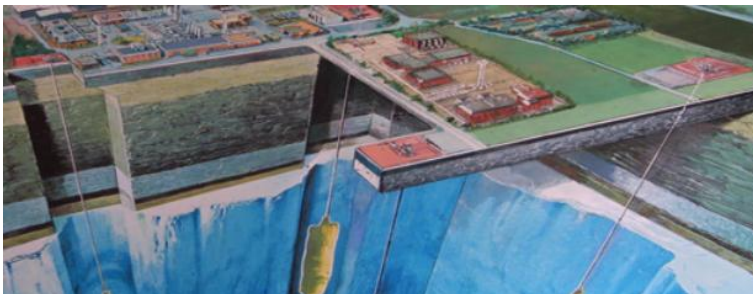
PROGRAMME TARGETS AND ACHIEVEMENTS

- H₂ distribution
 - Composite material trailers (DELIVERHY)
 - Applicable safety factors from SF=3.0 -> SF=2.25
 - 52.5 MPa most suitable, >40MPa target
 - Delivery freq. ↓x3, CO₂ ↓x4, cost = LH₂
 - Faster filling (HYTRANSFER)
 - CFD and lab testing
 - Reduction of HRS OPEX and CAPEX



PROGRAMME TARGETS AND ACHIEVEMENTS

- H₂ bulk storage
 - Underground storage in salt caverns (HYUNDER)
 - Technically feasible, suitable geology, public acceptance
 - Cavern contributes €0.5/kg to cost of H₂
 - Short term: Transport sector only market for commercial operation of H₂ plant (electrolyser and storage)



PROGRAMME TARGETS AND ACHIEVEMENTS

- Studies

- Energy Storage
- Green Hydrogen (just launched, 1/12/2014 deadline)
 - <http://www.fch-ju.eu/page/vacancies-procurement>



Thank you for your
attention!