

AREVA H₂Gen

“Water PEM electrolysis: used of GD-OES for fast characterization of innovative coating”



GD-Days 15-16 september 2016

**Nicolas Quéromès
Test Manager**



AREVA H₂Gen company overview

► 2014 : The merge of :

- ◆ An industrial start-up



(owned by



- ◆ The electrolysis division of former



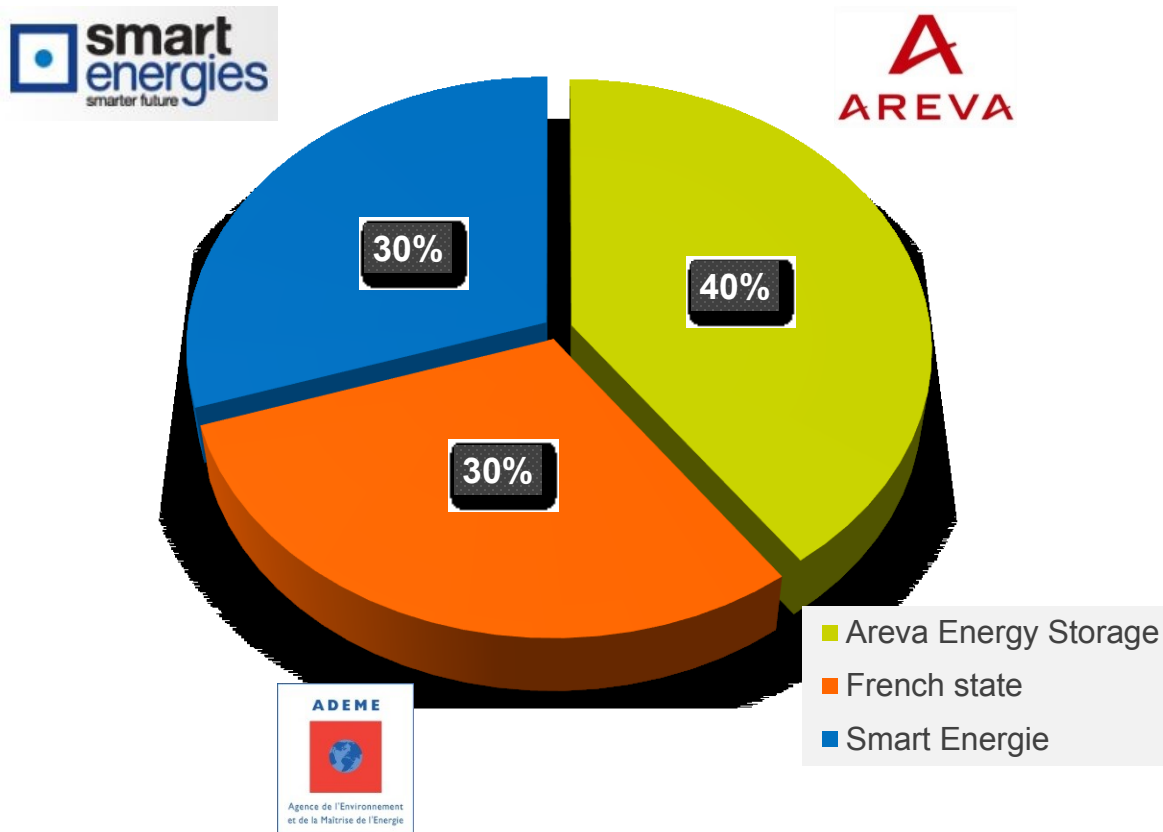
► And venture capital funds from the French State



A PEM electrolyser division within the AREVA Group

Capital Structure

► 3 shareholders :

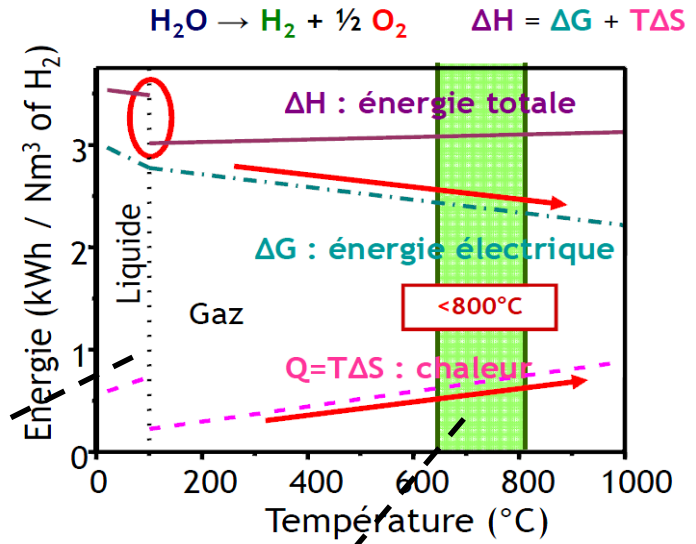
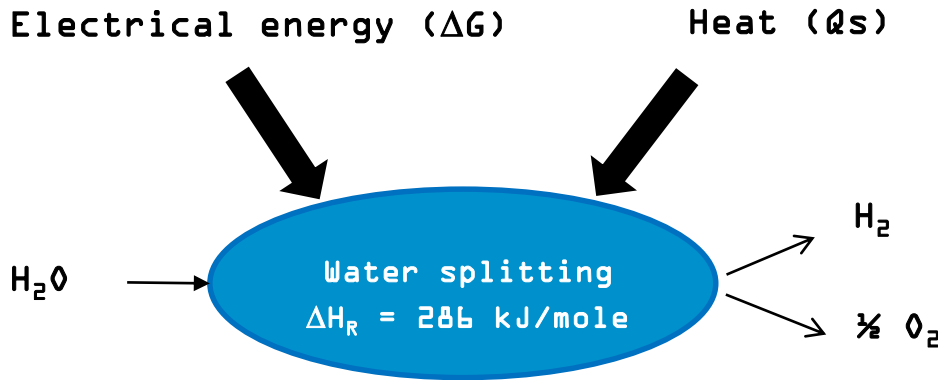


AREVA H₂Gen

GD Days / 15-16 September 2016



Water electrolysis



Source: Chase NIST-JANAF Thermochemical Tables (1998) Monograph 9, 1325

Low temperature electrolysis

- Alkaline electrolysis (liquid electrolyte)
- Acid electrolysis (solid polymer electrolyte – PEM)

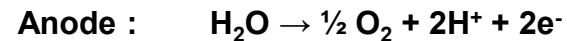
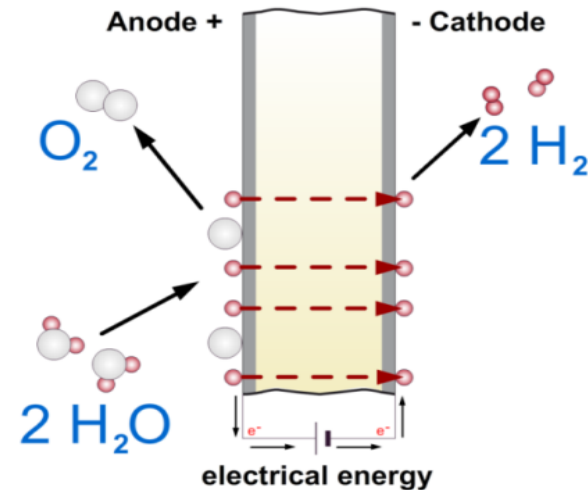
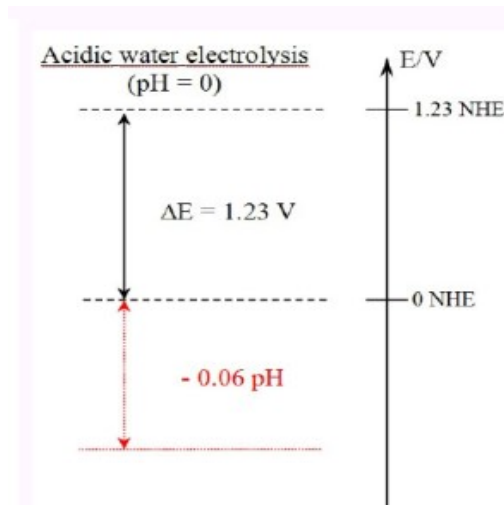
High temperature electrolysis

- Vapor electrolysis (EVHT)

Background

- 1962-66 : Programme Gemini-Apollo space program and first polymer cell
- 1966 : First SPE electrolyzer by GE
- 1987 : First 100 kW electrolyzer by BBC (ABB)

PEM Water Electrolysis



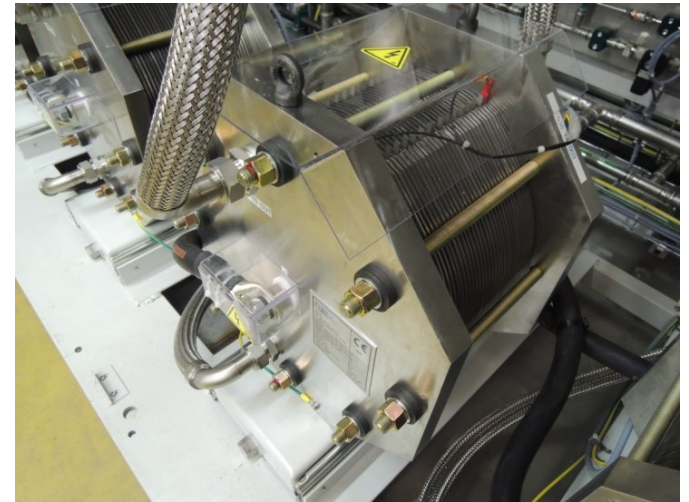
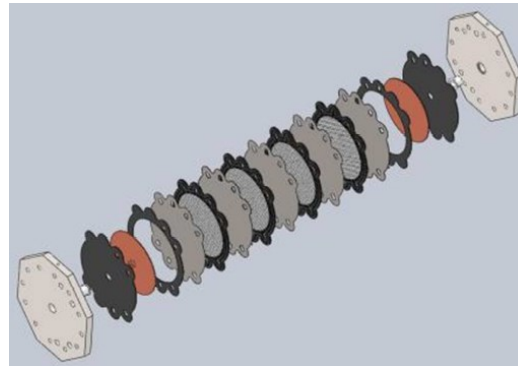
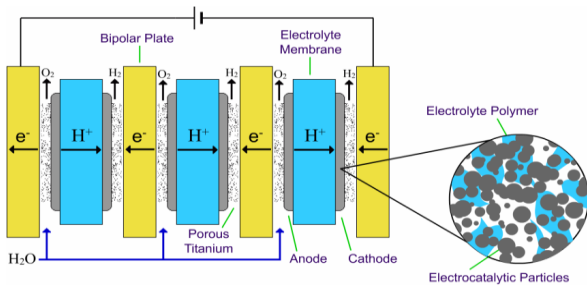
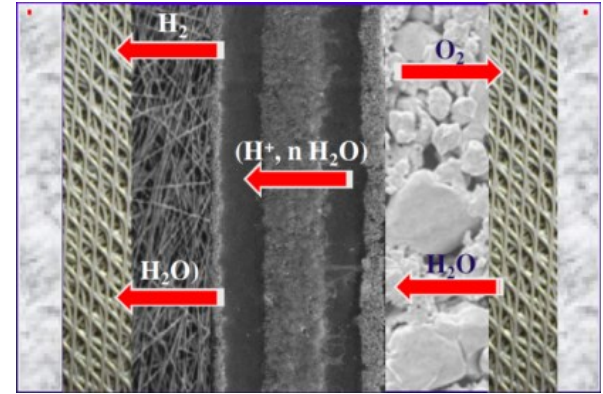
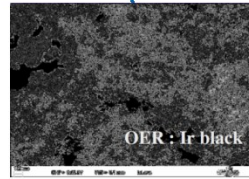
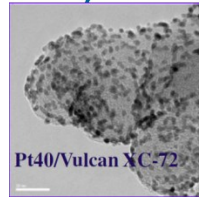
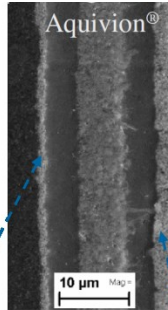
Compare to other electrolysis technology, PEM electrolysis advantage are fast dynamic response times, high pressure operation ability, large operational ranges, high efficiencies, and very high gas purities (99.999%)

AREVA H₂Gen

GD Days / 15-16 September 2016



PEM Cell & Stack



AREVA H₂Gen

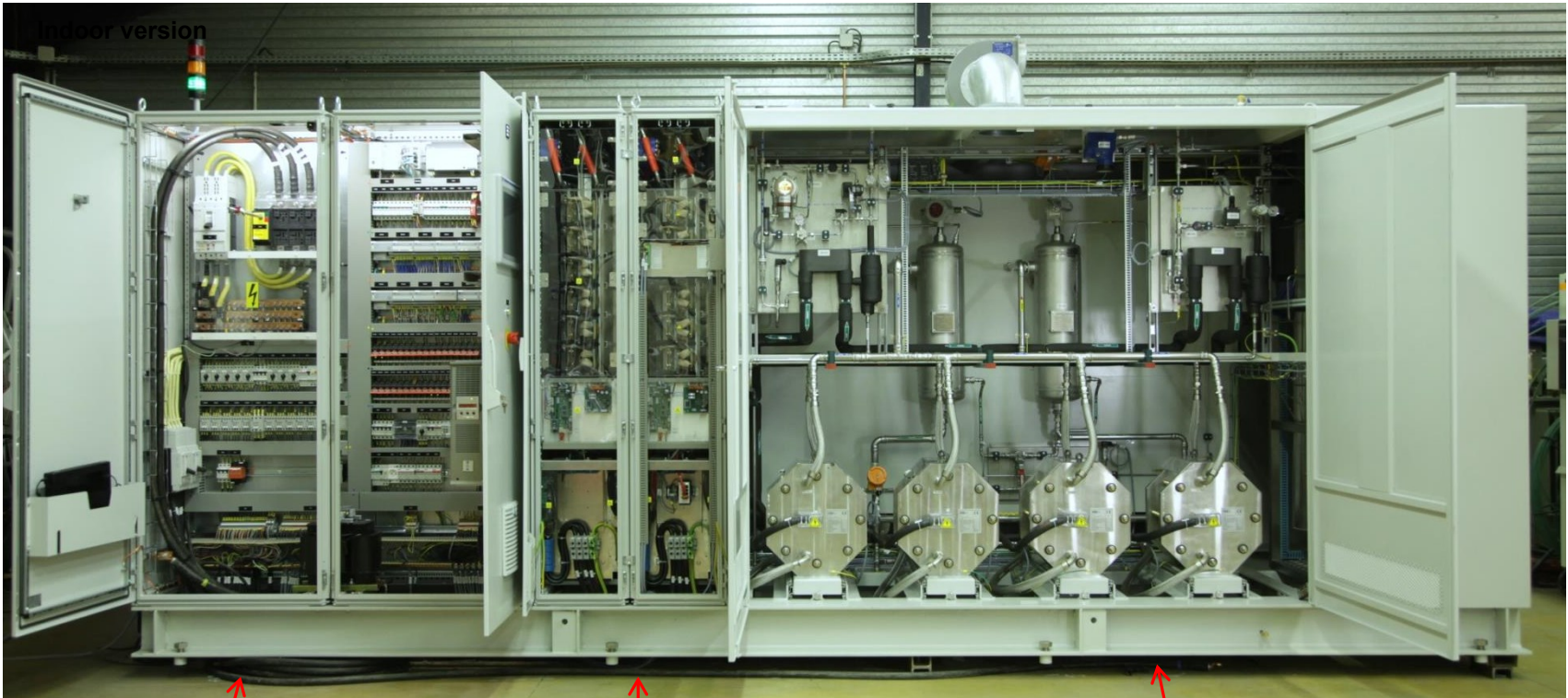
GD Days / 15-16 September 2016



AREVA
forward-looking energy

Products, view of a complete PEM electrolyser

Indoor version



Electrical cabinet

- SIL 1 PLC : Allen Bradley
- UPS : for proper shutdown

Rectifier

- 2 cabinets
- 95 kW each
- 300A / 350 V

Gas Skid

- 4 stacks of 8 Nm³/h each
- Stacks are CE certified
- 2 separator tanks SS316L CE certified

AREVA H₂Gen

GD Days / 15-16 September 2016

NOVEL

AREVA
forward-looking energy

Areva H2Gen Product Line

- ▶ A commercial product line from 5 to 120 Nm³/h at 15 Bar and up to 240 Nm³/h at 35 Bar
- ▶ Custom solutions multi MW projects :
 - ◆ Grid balancing services
 - ◆ Renewable hydrogen for petro-chemicals



PEM[®] ELECTROLYSERS **AREVA H₂Gen**
Today's flexible, cost effective technology

A reliable, easy, clean and safe on site hydrogen generation

PEM[®] Proton Exchange Membrane

STANDARD SUPPLY		TECHNICAL SPECIFICATIONS	
CAPEX PRODUCTION	PRODUCTION	EFFICIENCY	
Operated pressure	Up to 35 Bar	33 Bar	
Purity	> 99.9%	> 99%	

GAS PURIFICATION SYSTEM
Industrial purification system with automatic regeneration based on adsorbent & Temperature Swing Adsorption Drums

H₂ Quality
Up to 99.999%
(cleaner option: < 1 ppm, O₂ < 1 ppm, N₂ < 1 ppm)

FEEDING WATER (TAP WATER)

Conductivity	< 2000µS/cm (25°C)	Pressure	2 to 6 Bar
pH	6-8	Temperature	< 40-60°C

Water treatment: Integrated Reverse Osmosis System (RO) + electric de-ionisation system

PROCESS COOLING WATER

Max pressure	5 bar
Liquid temperature	15°C to 40°C
Quality	Electrolyte, anticorrosive and antiretaining fluid

INSTALLED POWER

Voltage	400 V AC
Frequency	50 Hz
Stack consumption	6.8 Nm ³ /h of H ₂

CONTROL SYSTEM

PLC: Industrial SIL 2 PLC with analog and digital I/O modules associated to a 15" colour tactile screen. Protocol can be extended by mod of. H₂ flow, pressure, available power

Communication: Modbus / Ethernet / analogue and serial communication; modular communication interface for easy add-on capability; others - on demand

ENVIRONMENTAL & OPERATING CONDITIONS

Storage & Transport temperature	+3 / +40°C	humidity	0 to 95% non-condensing
Operating temperature	+3 / +40°C	Ventilation	Provided from a non-hazardous area

SAFETY NORMS & REGULATIONS

Compliance: EC Compliance - Machinery 2006/42/EC
PED 2014/52/EU - LVD 2006/95/EC - EMC 2004/108/EC
Our equipments comply with major gas companies regulations

ISO 22716 - EC 62061
IEC 61508 - EC 62061

ELECTROLYSERS
cost effective technology

PRODUCT LINE SPECIFICATIONS

Capacity (Nm ³ /h)	15 Bar		35 Bar	
	Elect	Elect	Elect	Elect
5	10	20	30	40
10	20	40	60	80
20	40	80	120	160
30	60	120	180	240
40	80	160	240	320
60	120	240	360	480
80	160	320	480	640
100	200	400	600	800
120	240	480	720	960

AREVA H₂GEN OFFERS A WIDE SELECTION OF OPTIONAL COMPONENTS TO MEET CUSTOMER SPECIFIC REQUIREMENTS

ADVANTAGES

- SAFETY: Environmentally friendly, ATEX certified components
- EFFICIENCY: Stack free design, Full system over 70%
- COMPACT: On 24V 300W On 24V 300W
- SMALL SIZE: 400 mm high, 400 mm wide, 400 mm deep

AREVA H₂Gen

8 Avenue de l'Europe - 91960 Les Ulis France
Tel: +33 1 81 87 12 80
www.aveva.com

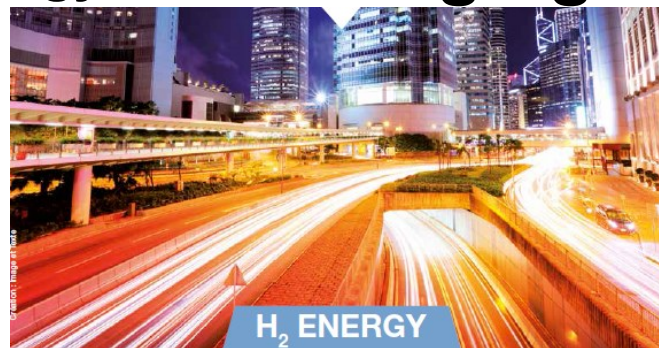
Munich 137 - 10815 Köln - Karlsruhe
Tel: +49 201 80 42 40 00 - Fax: +49 201 80 42 40 40
www.aveva.com - www.aveva.com/germany

Two Major markets

▶ Hydrogen for Industry : a mature market



▶ Hydrogen for Energy : an emerging market



NOVEL Project

Novel Materials and System Designs for Low Cost, Efficient and Durable PEM Electrolysers

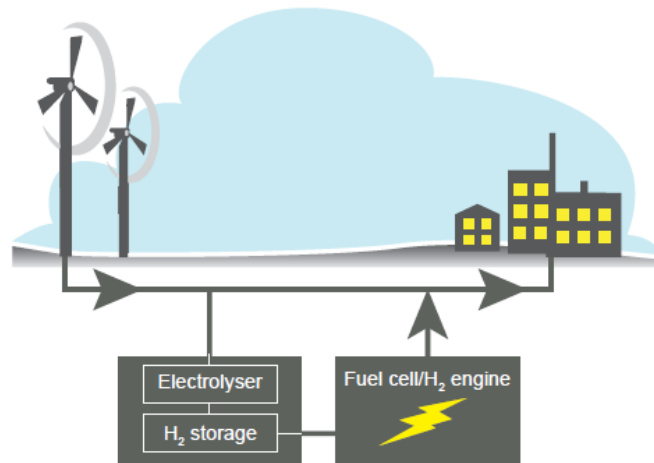


The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) for the Fuel Cells and Hydrogen Joint Technology Initiative under grant agreement n°303484.

Novel Main objectives

Develop and demonstrate a PEM water electrolyser using beyond state of the art materials.

75% Efficiency (LHV), electrolyser stack cost < €2,500 / Nm³h⁻¹, target lifetime of 40,000 h (< 15 μVh⁻¹)



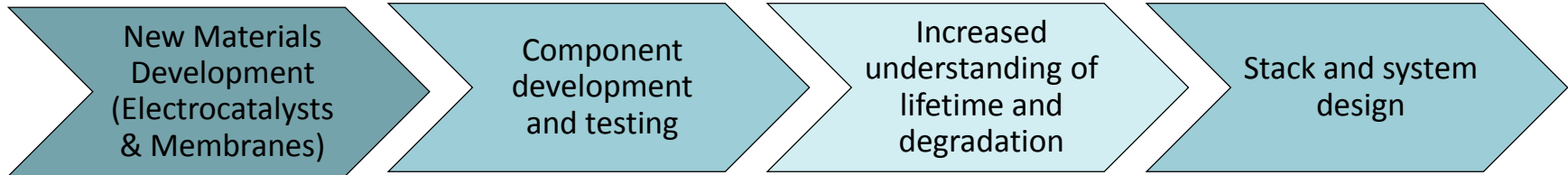
Novel Consortium



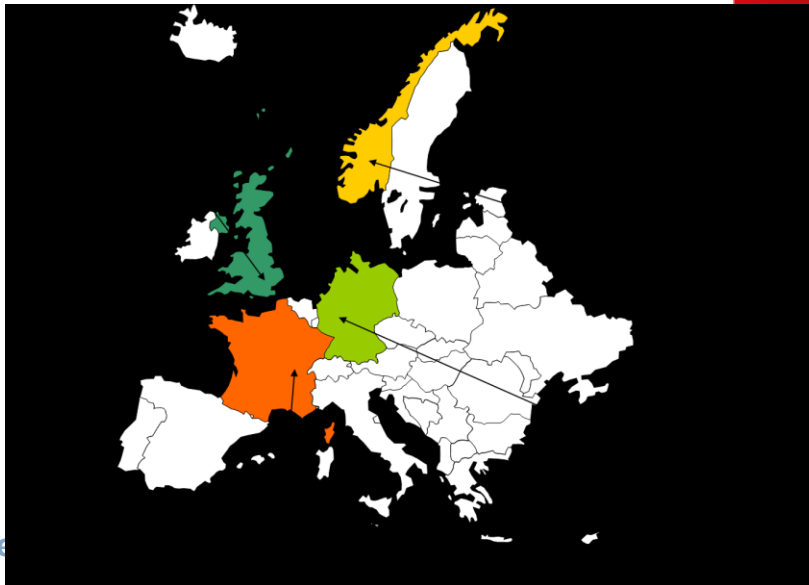
Johnson Matthey Fuel Cells
the power within



Fraunhofer
ISE



AREVA H₂Gen



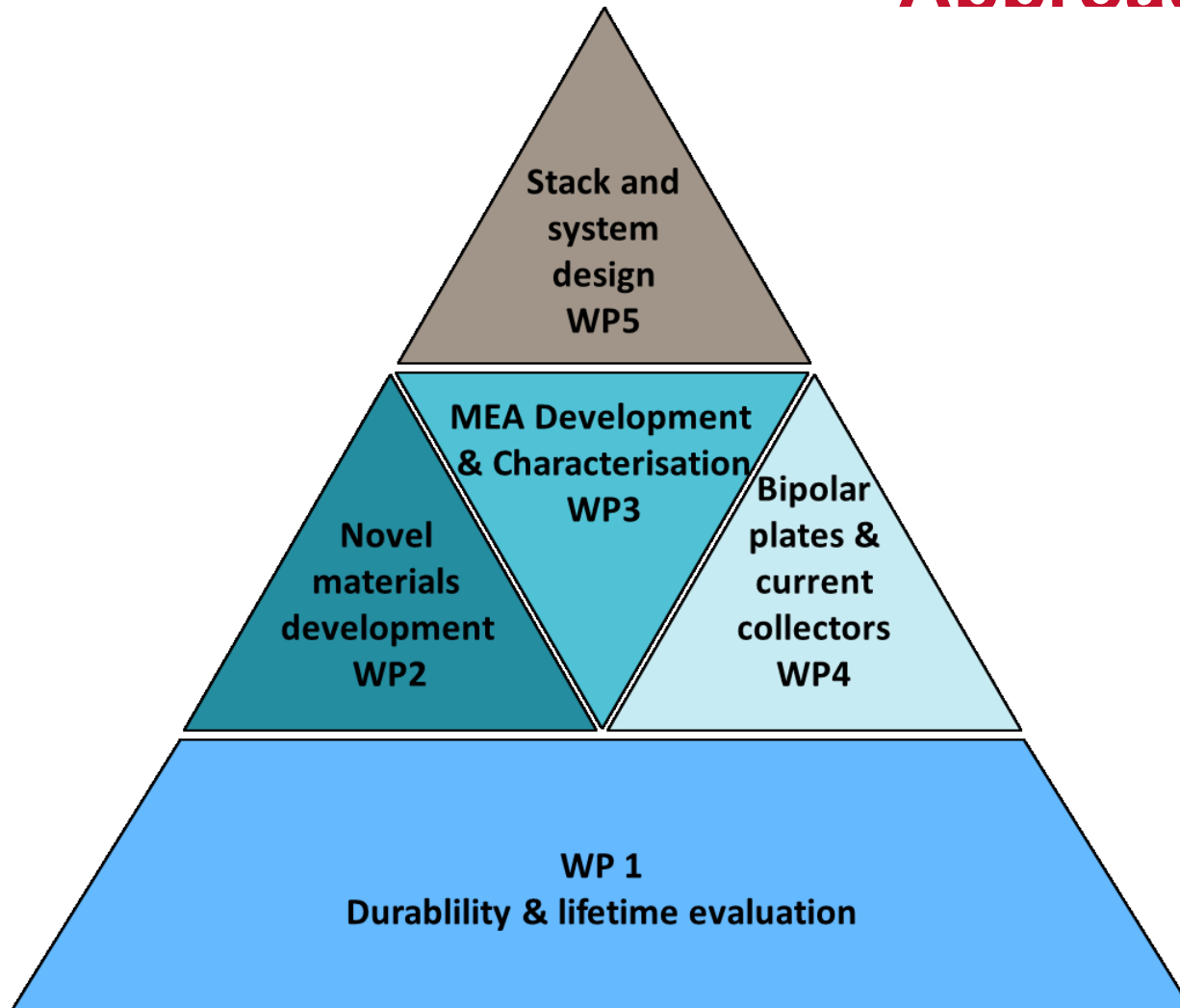
AREVA H₂Gen

GD Days / 15-16 September 2016

NOVEL



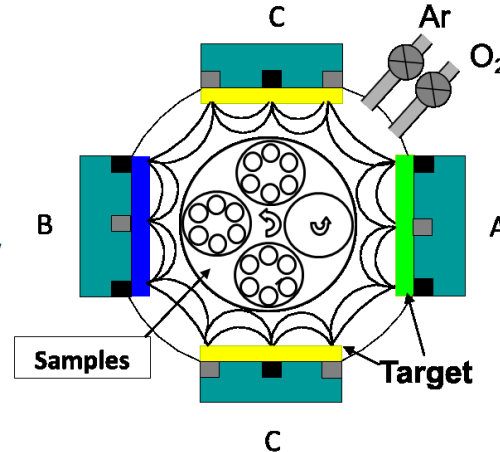
Approach



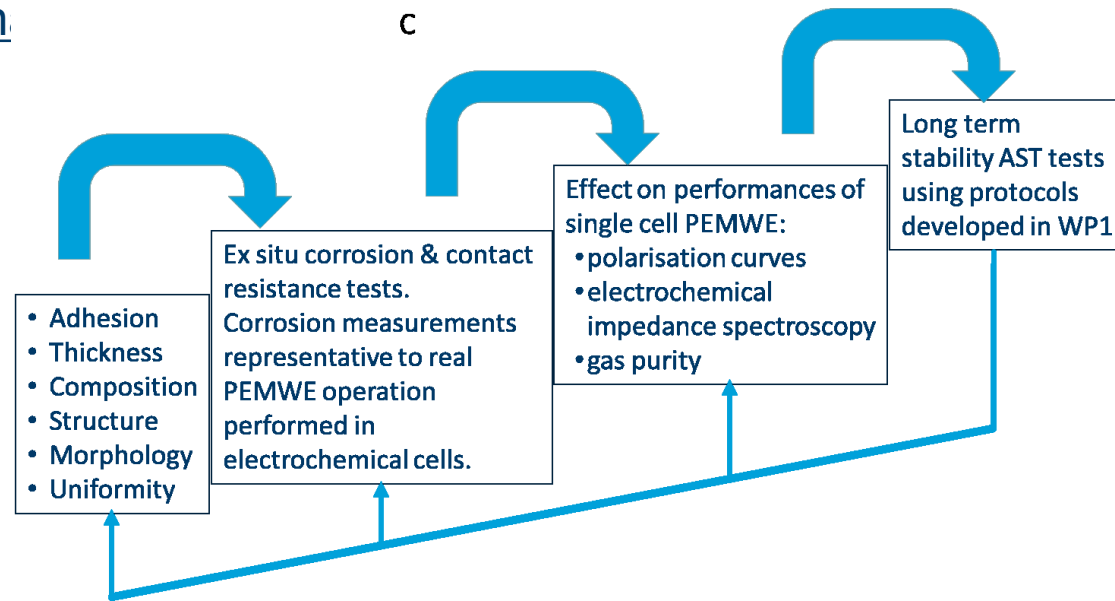
Coating for bipolar plate

Closed field unbalanced magnetron sputter ion plating (CFUBMSIP) technology has been used as a primary procedure for coating development

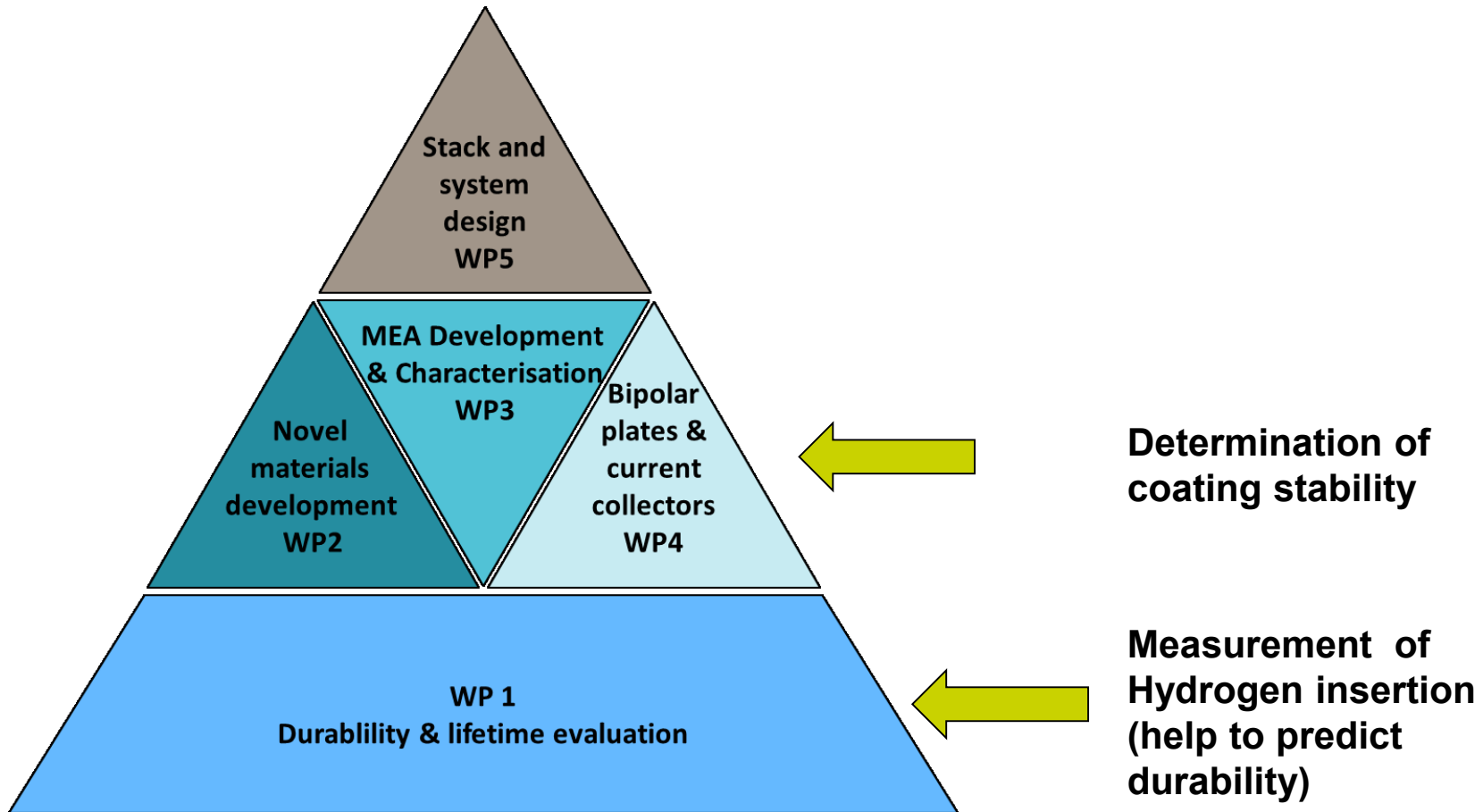
More than 75 different coatings have been investigated



AREVA H₂Gen



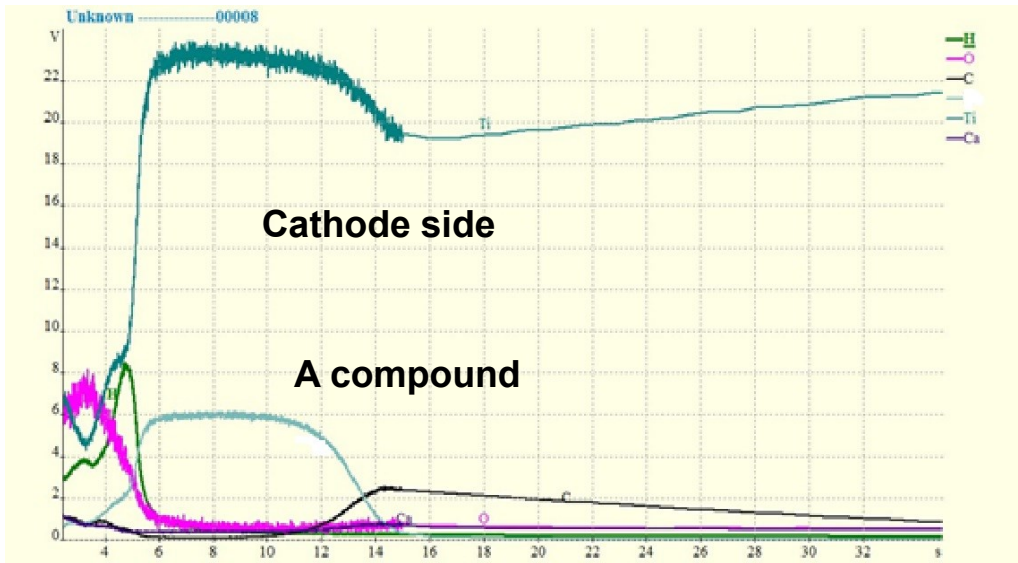
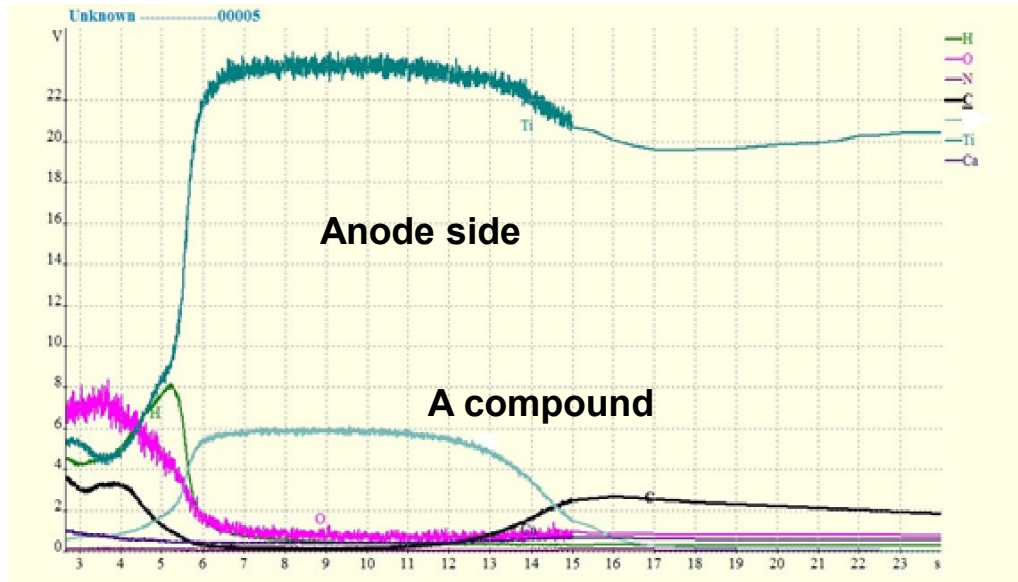
Where GD is used ?



Why GD is used ?

- ▶ **Ability for hydrogen detection**
- ▶ **Detection of element in surface and bulk**
- ▶ **Fast results and no preparation**

GD results: BPP end of life



Investigation of Bimetallic compound: Ti + A (confidential) Substrate in Titanium

Coating act as a diffusion barrier for hydrogen → suppression of hydrogen embrittlement

Coating act as a diffusion barrier for oxygen.

At the end of life, on both side coating is still present and had the same thickness for cathode and anode

Acknowledgements and project member

Many thanks to Patrick Chapon and Sofia Gaiaschi for performing GD analysis

Many thanks for FCHJU to support the NOVEL Project

Project members

SINTEF – Magnus thomasson (coordinator), Tommy Mokkelbost, Alejandro Oyarce,

PSI - Lorenz Gubler, Albert Alber

Johnson Matthey - Emily Price, Jonathan Sharman, Ed Wright

TEER Coatings - Kevin Cooke, Xiaoling Zhang

Fraunhofer ISE - Tom Smolinka, Thomas Lickert, Patricia Gese, Andreas Georg

CEA - Frederic Fouda-Onana

AREVA H2GEN - Fabien Auprêtre, Nicolas Quéromès

AREVA H₂Gen

GD Days / 15-16 September 2016



AREVA
forward-looking energy