AREVA H_2Gen
PEM Electrolyser cost reduction strategy

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AREVA
forward-looking energy

AREVA H_2Gen

- **The merge of :**
  - **An industrial start-up** CETH2 **(owned by** smart energies **)**
  - **The electrolysis division of former** AREVA / HELION HYDROGEN POWER
- **And venture capital funds from the French State**

ADEME – Agence de l'Environnement et de la Maîtrise de l'Energie

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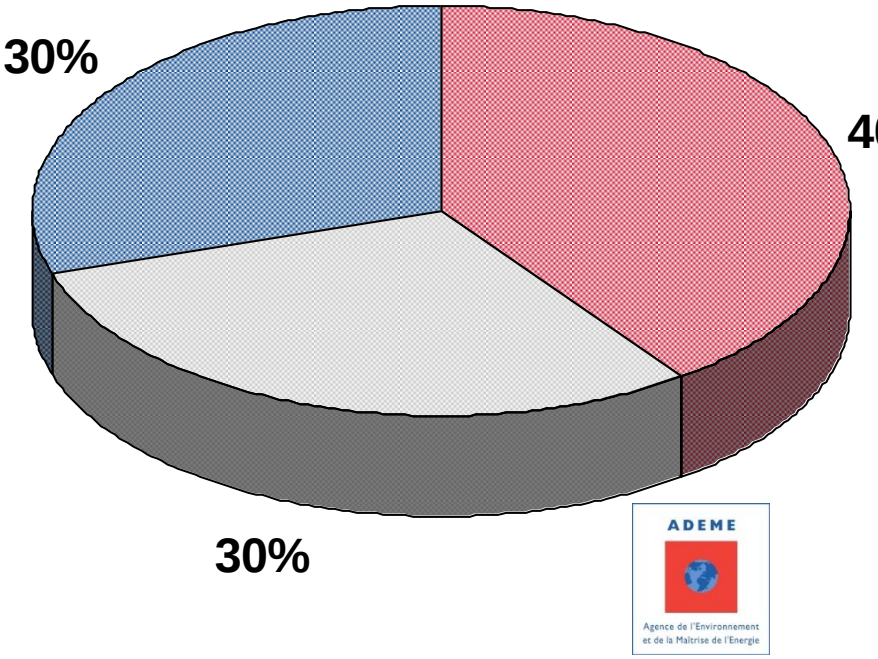
INVESTISSEMENTS D'AVENIR

A PEM electrolyser division within the AREVA Group

Capital Structure

- **Three shareholders**



Product Line

A commercial product line from 5 to 120 Nm^3/h at 15 Bar

PEM Electrolysers

Today's flexible & cost effective technology

For a reliable, easy, clean and safe on site hydrogen generation

Advantages

SAFETY : Physical separation of the H_2 and O_2 production

RELIABILITY : Progressive and discontinuous operation possible

EFFICIENCY : The current density on PEM electrolyzers can reach more than 1 A/cm^2

SIMPLICITY : Reduced maintenance and autonomous working process

Technical Specifications

Standard Supply

Gas Production	Hydrogen		Oxygen	
Output pressure	14 Barg		13 Barg	
Purity	> 99.9 %		> 99 %	
Output connection	H_2 & Drain H_2 : G1/2		G1/2	
Feeding water (Tap water)				
Conductivity	< 2000 µS/cm (T 25 °C)		Pressure	2 to 6 Bar
PH	4-10		Temperature	+5 / +40 °C
Water treatment	Integrated RO System			
Process Cooling Water				
Max Pressure	5 bar			
Input Temperature	+ 5 °C to + 50°C			
Quality	Bactericide, anticorrosive and antifreezing fluid			
Installed Power				
Voltage	400 V AC (3 Phase 1 Ground)			
Frequency	50 Hz / 60 Hz			
Stack consumption	4,4 kWh/Nm^3 of H_2			
Control System				
PLC	Industrial SIL 1 PLC with analogic I/O modules associated to a 10' color tactile screen; Process can be controlled by input of : H_2 flow, pressure, available power			
Communication	Ethernet / IP ; RS232 ; analogic and serial communications; modular communication interface for easy add-on capability; others : on demand			
Environmental & Operating conditions				
Storage & Transport temperature	3 - 60°C	Humidity	0 to 95 % non-condensing	
Operating temperature	3 - 40°C	Ventilation	Provided from a non-hazardous area	
Safety Norms & Regulations				
Compliance	CE (PED , LVD, Machine, EMC), ISO 22734-1			

Product Line Specifications

Standard	E5	E10	E20	E30	E40	E60	E120
Hydrogen Production							
H_2 Flow Rate Nm^3/h	5	10	20	30	40	60	120
Oxygen Production							
O_2 Flow Rate Nm^3/h	2,5	5	10	15	20	30	60
Feeding wate							
Consumption L/hr (Including RO System)	< 10	< 20	< 40	< 60	< 80	< 120	< 240
Process Cooling water							
Flow Rate m^3/h (*indicative with delta T of 10°C)	1	2	4	6	8	12	24
Installed Power							
Power kVA	40	80	160	240	320	480	960
System Consumption (kWh/Nm^3 of H_2)	5,7	5,3	5,2	5,1	5	4,9	4,8
Dimensions & Weight							
Gas Skid	1800x1900x2200 mm				2400x1900x2200 mm		
	900 kg	1000 kg	1260 kg	1860 kg	1980 kg	2300 kg	3200 kg
Appendix: Rectifier, PLC, Chiller, Water Purification (mm)	1800x1800x2200			1900x2900x2200		1900x3900x2200	

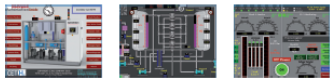
Options

Gas Purification System	
Industrial purification system with automatic regeneration based on a deoxidizer & dryer	
H_2 Quality	Up to 99,999% (Water vapor < 5 ppm, O_2 < 5 ppm, N_2 < 2 ppm)
Dimensions & Weight	1800x600x2200 mm, 300 kg

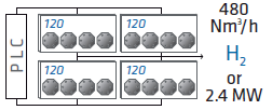
Fully integrated outdoor unit

H_2GEN offers a wide selection of optional components to meet customer specific requirements

PLC with an intuitive and user friendly interface



Generator cluster architecture



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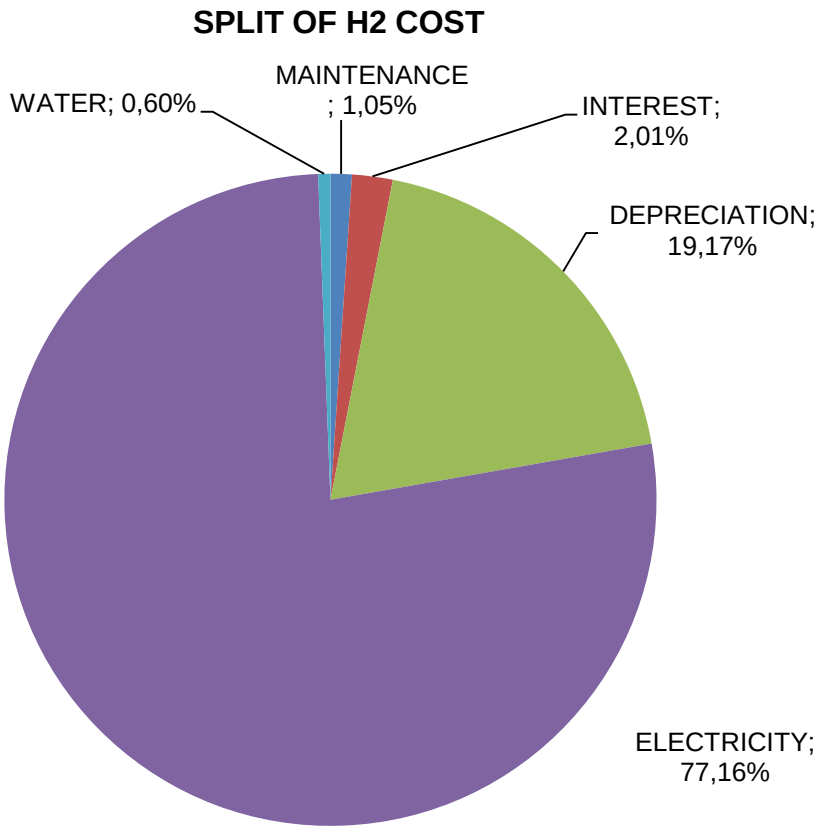
Technical synergy on PEM Stack Technology

- CETH2 technology
  - 600 cm² active surface
  - 15 bar working pressure
  - Water circulation on the hydrogen side
- AREVA HELION HYDROGEN POWER technology
  - 300 cm² active surface
  - 50 bar working pressure
  - No water circulation on the hydrogen side

Target : A product line from 5 to 240 Nm³/h at 35 bar

Targets to address future markets

- **Increasing demand for MW Stacks**
  - **Grid balancing services**
  - **P2G Projects**
  - **Large HRS**
- **Need for Cost competitive Hydrogen**
- **Ensure Lifetime : 80 000 hours**



MW Stacks should have efficiencies above 80 to 85% HHV

Cell surface increase

- **Our targets**
  - **Active area squared 600 – 1200 – 2400 cm²**
- **Cost reduction expectation**
  - **From 600 to 1200 cm² : -25% / Nm³**
  - **From 1200 to 2400 cm² : -16% / Nm³**
- **Technical difficulties with potential negative impact on the cost**
  - **Temperature management**
  - **Mechanical architecture, more complex current distribution : impact on efficiency and life time**

Current density increase

- **Our targets**
  - **Current density from 1 to 1.5 A/cm²**
  - **And from 1.5 to 2 A/cm²**
- **Cost reduction expectation**
  - **From 1 to 1.5 A/cm² : -30% / Nm³**
  - **From 1.5 to 2 A/cm² : -20% / Nm³**
- **Technical difficulties with potential negative impact on the cost**
  - **Maintain voltage bellow 1.8 V in order to ensure more than 80% efficiency**
  - **Maintain life time and degradation speed in order to ensure less than 10% efficiency loss after 60 000 hours**

Temperature increase

- **Our targets**
  - **Temperature from 65 to 80°C**
- **Cost reduction expectation**
  - **From 65 to 80°C : -9% / Nm^3**
- **Technical difficulties with potential negative impact on the cost**
  - **Polymer degradation risk : requires very accurate temperature management particularly on larger active surfaces**
  - **Maintain life time and degradation speed in order to ensure less than 10% efficiency loss after 60 000 hours**

Increase of the number of cells

- **Our targets**
  - **From 120 to 240 Cells**
- **Cost reduction expectation**
  - **From 120 to 240 Cells : -1% / Nm^3 on the stack, major impact on BOP**
- **Technical difficulties with potential negative impact on the cost**
  - **Temperature management**
  - **Mechanical architecture, more complex to ensure cell homogeneity**

Impact on stack Cost

- **For 120 Cells : 30 Nm^3/h**
  - **1 A**
  - **600 cm^2**
  - **Cost basis : 100 /Nm^3**
- **For 120 Cells : 90 Nm^3/h**
  - **1,5 A**
  - **1 200 cm^2**
  - **Cost basis : 52,5 /Nm^3**
- **For 120 Cells : 240 Nm^3/h**
  - **2 A**
  - **2 400 cm^2**
  - **Cost basis : 35,2 /Nm^3**

Thank you for your attention !

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