CETH2

Technology roadmap and lifetime expectations in PEM electrolysis

Dr. Fabien AUPRÊTRE – CTO

International Workshop on Durability and Degradation Issues in
PEM Electrolysis Cells and its Components
Fraunhofer ISE : Freiburg, March the 12th 2013

The Company

Grounded in 1997, $CETH_2$ has an expertise of more than 15 years on PEM water electrolysis.

- A structured product line of **5** Nm^3/h to **40** Nm^3/h, based on **5 & 10** Nm^3/h Stacks




- A strategic industrial manufacturing partnership in Germany : iGas Gas Engineering
- A world wide industrial solution network.

The Markets

Industry

- Alternator cooling
- Float Glass
- Heat Treatment

Hydrogen Mobility

- OnSite H2 for HRS

Renewable Energy Storage

- Power2gas
- FC Re-electrification

Ongoing Devlopments

$CETH_2$ has developed PEM electrolysers based on 4 stack management system

Various cell assembling tests have shown :

- with the actual architecture
- under iso electrical conditions

The capability to build : 15 Nm^3/h stacks

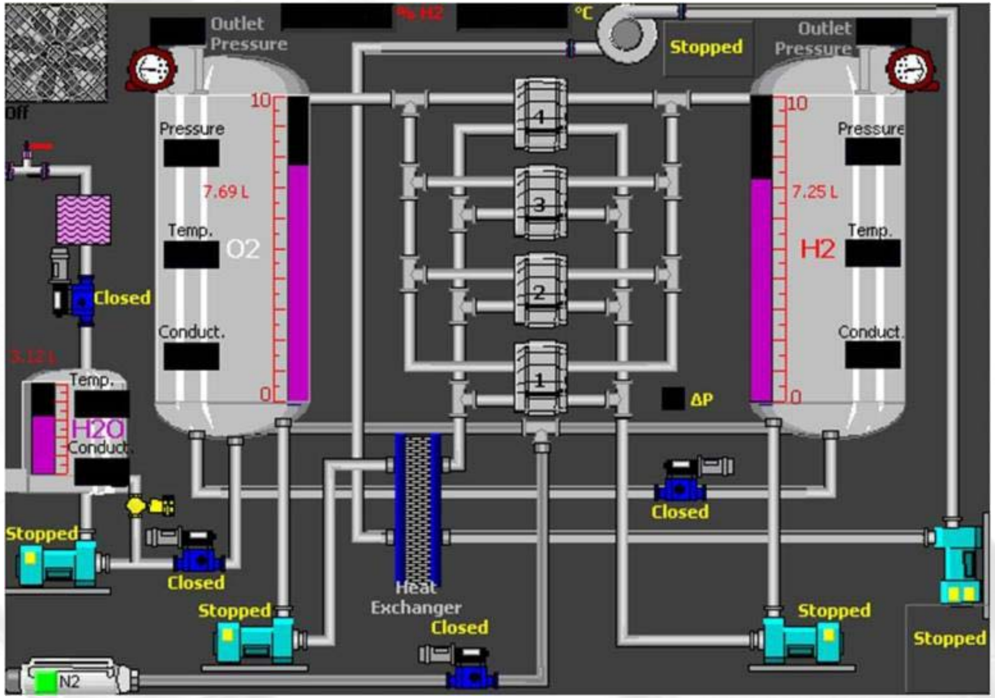
Allowing a competitive PEM Electrolysis offer of 60 Nm^3/h

The BOP of the first 60 Nm3/h PEM electrolyser shall be finalized in April

THE STATE OF THE ART

Stack : PEM technology

- Membranes
  - Surface : 600 cm^2
  - Current density : 0.8 A/cm^2
  - Cathode Pressure : 15 Bar
  - Differential pressure : 1 Bar
  - Working temperature : 70°C

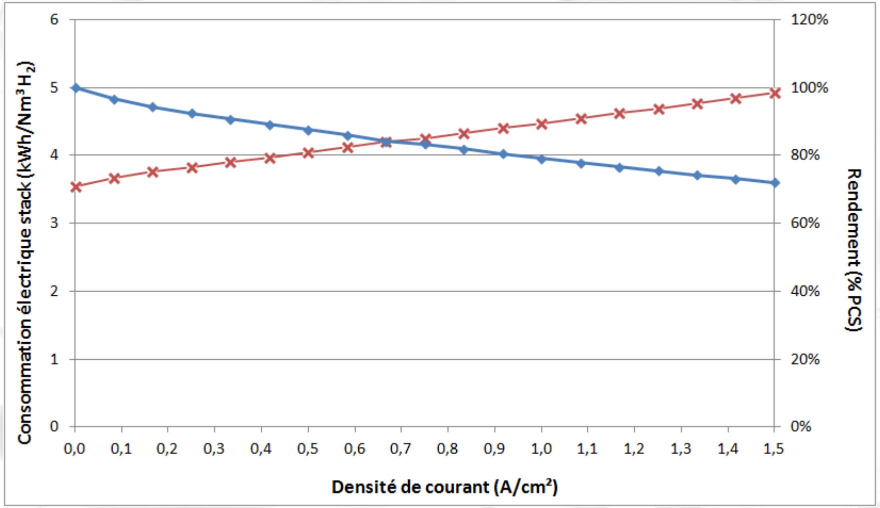


System

With a water loop on the cathode side for a better thermal management required by the use of 600 cm^2 membranes

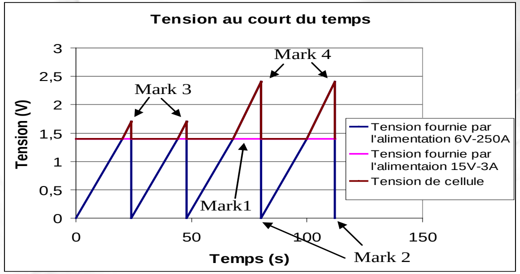
THE STATE OF THE ART

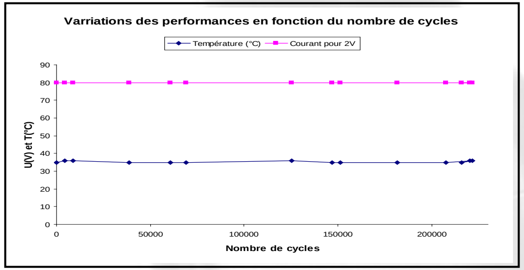
Performances :
- Stack efficiency : 83 % (HHV)
- System efficiency : 70 % (HHV)



Stack cost per installed Nm³/h: 5 000 €

Lifetime
- Up to 10% efficiency loss : 35 000 h
- Cell Voltage increase : <5,4μV/h
- No effect due to cycling : 500 000 Cycles





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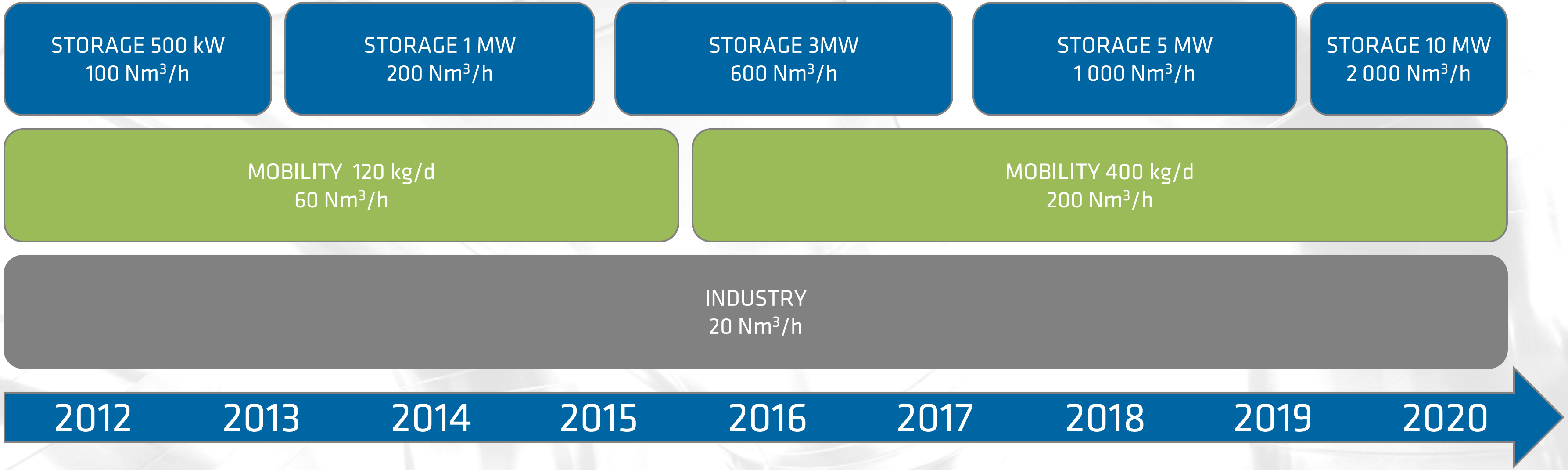
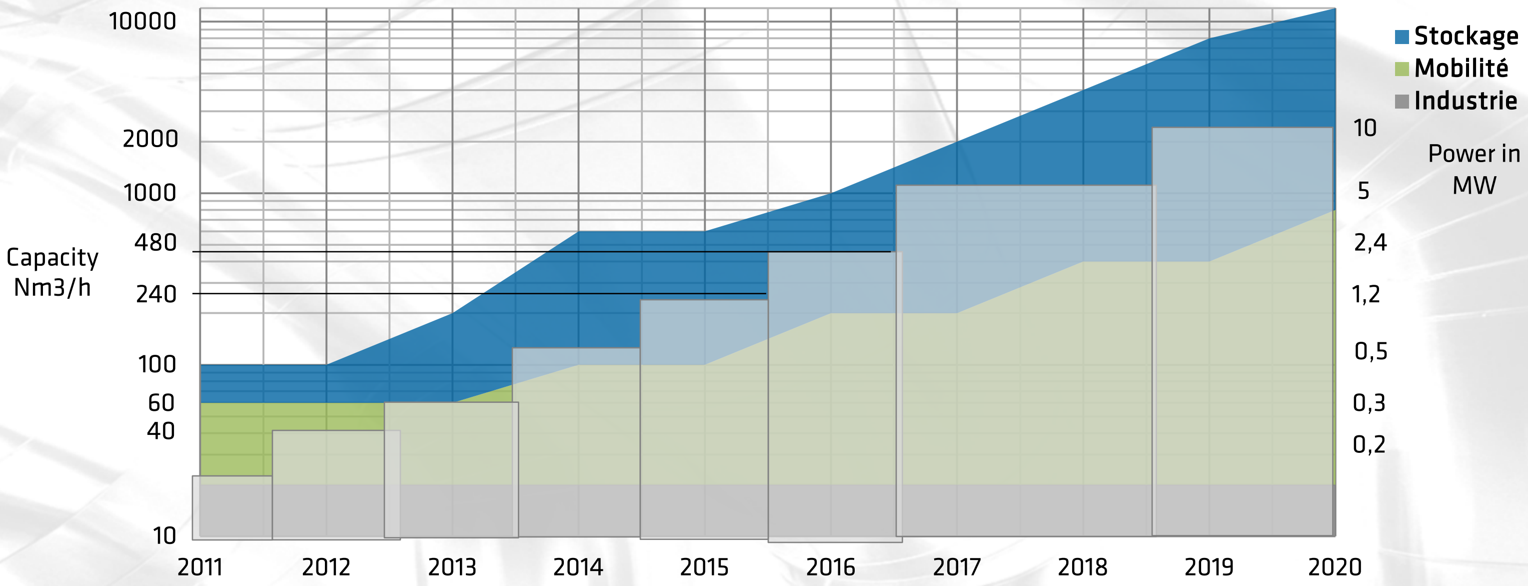
THE DEVELOPMENT ROADMAP

Estimated evolution of the machine capacities



THE DEVELOPMENT ROADMAP

CETH$_2$ Electrolyser capacity evolution to address the market needs



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Steps to be taken - Stack

- Increase of the amount of cells

50 200

- Increase of the active cell area

600 cm^2 1 200 cm^2 2 500 cm^2

- Increase of the current density

0.8 A/cm^2 1.6 A/cm^2

BUT

Keep the efficiency above 80%

4 Cylinders, 6 l/100km

12 Cylinders, 6 l/100km

STEPS TO BE TAKEN - SYSTEM

Balance Of Plant design:

- High efficiency

- High reactivity

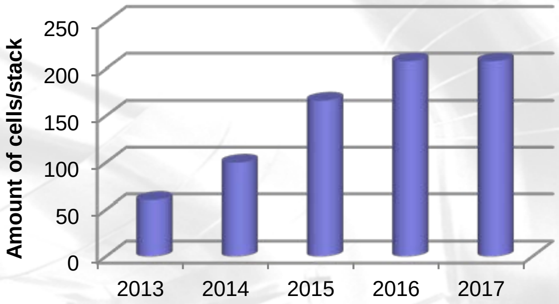
- High reliability

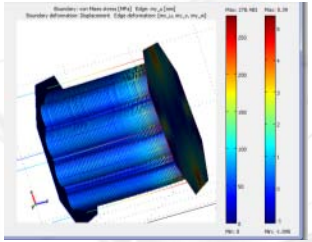
- Low maintenance

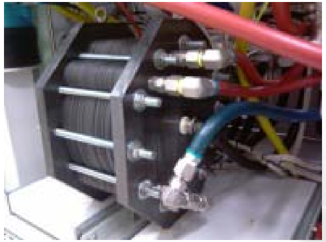
- More pressure but reliability, safety and cost efficient

INCREASE THE NUMBER OF CELLS

Challenges	Expectations
Stack assembly	- Clamping forces - Good alignment of frame or sealing joints
Water distribution & fluid removal	- Low & homogeneous cell pressure drop - Water distribution profile - Fluid removal profile
Heat management of the stack	- Heat profile







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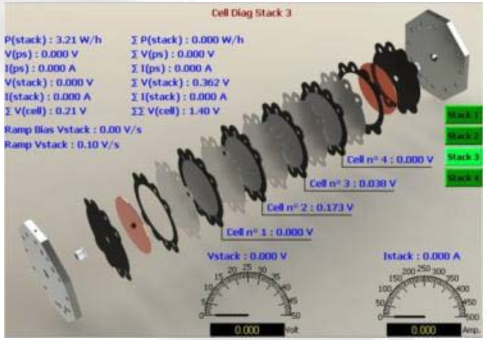
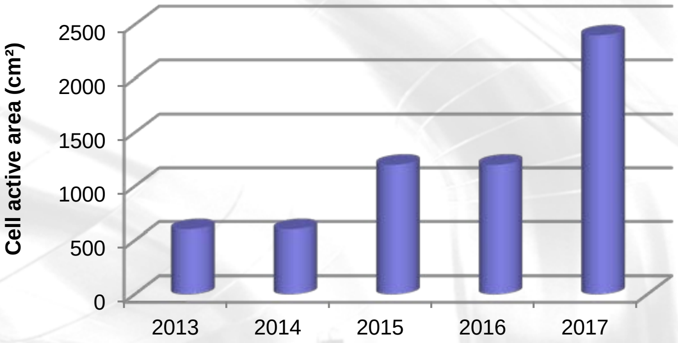
INCREASE THE CELLS SURFACE

	Challenges	Expectations
Design	Pressure tightness	- Design (square, round, ...) - Clamping forces
	Water distribution	- Design of flow field & bipolar plate
	Heat management	- Heat profile in the cell - Fluid distribution and removal
	Electrical distribution	- Materials - Design of current distributor & flow field & bipolar plate for optimal contact resistances



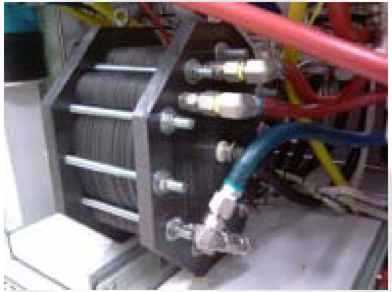
Increase the cells surface

	Challenges	Expectations
Manufacturing	Mechanical parts (current distributor, flow field, bipolar plate)	- Materials - Industrial process without machining - Good accuracy of the dimensions
	CCM	- Process of catalyst coating - Reproducibility



75 cm^2

300 cm^2



600 cm^2

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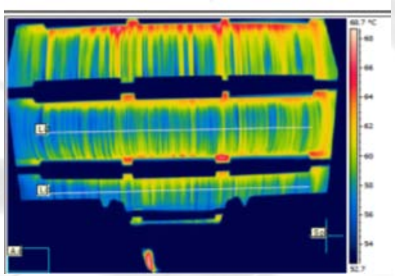
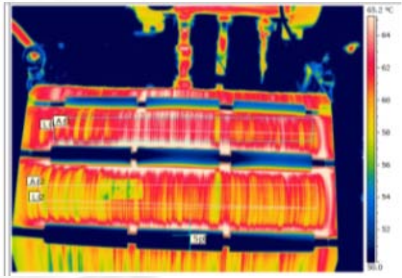
INCREASE THE CURRENT DENSITY

Challenges	Expectations
High electrical conductivity	– Materials of current distributor, flow field, bipolar plate – High conductivity of catalyst layers
Heat management at the CCM/current distributor interface	– Heat profile in the cell – High heat removal process (materials & design)



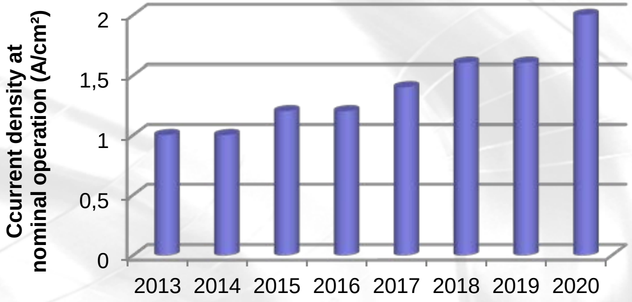
External heat profile at 5 Nm3/h

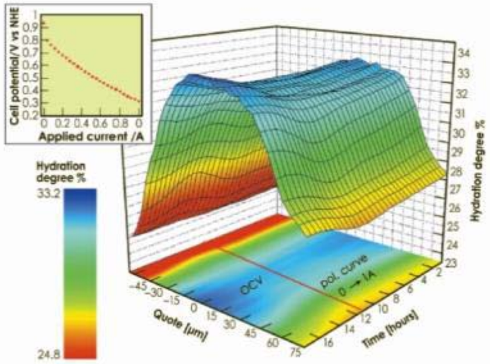


External heat profile at 5 Nm3/h

INCREASE THE CURRENT DENSITY

Challenges	Expectations
CCM with higher efficiency	– Lowering membrane resistance vs lifetime & safety – OER catalyst with higher efficiency – Catalyst loading vs efficiency (OER & HER)
CCM with high stability	– Of catalyst coating layer – Lowering compound released





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Aging indicators

	Life time indicator	Aging parameters
Performances	Efficiency loss	- Aging of materials (oxydation, ...) - Loss of electrical contact - Catalyst deactivation (sintering, poisoning) - Membrane deactivation (poisoning)
	CCM degradation	- Catalyst layer removal - Fluoride (or other compound) release - Hot spot (local high current densities)

AGING INDICATORS

	Life time indicator	Aging parameters
Safety	Gas cross over	- Thinning of the membrane - Internal pressure tightness loss - Other?
	Pressure tightness loss	-Fast and frequent temperature change -Fast and frequent pressure change
	Mechanical structure	- Material embrittlement

AGING CHALLENGES & LIFE TIME EXPECTATIONS

Most critical components	CCM & materials
Most important part to improve	CCM performances & stability Standardization of CCM available on the market Materials for mechanical parts of the stack
Most limited operating condition(s) by today	Operation at very low / very high current density Operation at temperature higher than 70°C
Lack of understanding	Membrane degradation mechanism Gas cross over mechanism
Expectation from accelerated stress tests	Better comprehension of CCM degradation for long time operation

THANK YOU FOR YOUR ATTENTION

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