



HYDROGEN AND FUEL CELLS IN FRANCE

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France prepares the energy transition towards a carbon free energy mix



Energy Transition Law (Aug 18, 2015)



-40% of GHG emissions in 2030 vs 1990



-30% of fossil energy consumption in 2030 vs 1990



Bring RE part to 32% of energy consumption in 2030 and to 40% of electricity production



Reduce energy consumption by 50% in 2050 vs 2012



-50% of wastes by 2025



Diversify electricity production and reduce nuclear part to 50%

- Energy Storage is a key priority
- Hydrogen opens new opportunities for energy & transport



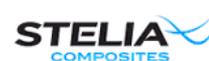
■ R&D



Universities
Engineer Schools



■ Industry



■ Regions



...

■ National association





12,000 jobs in 20 km radius





E. Macron
Minister of Economy&Industry

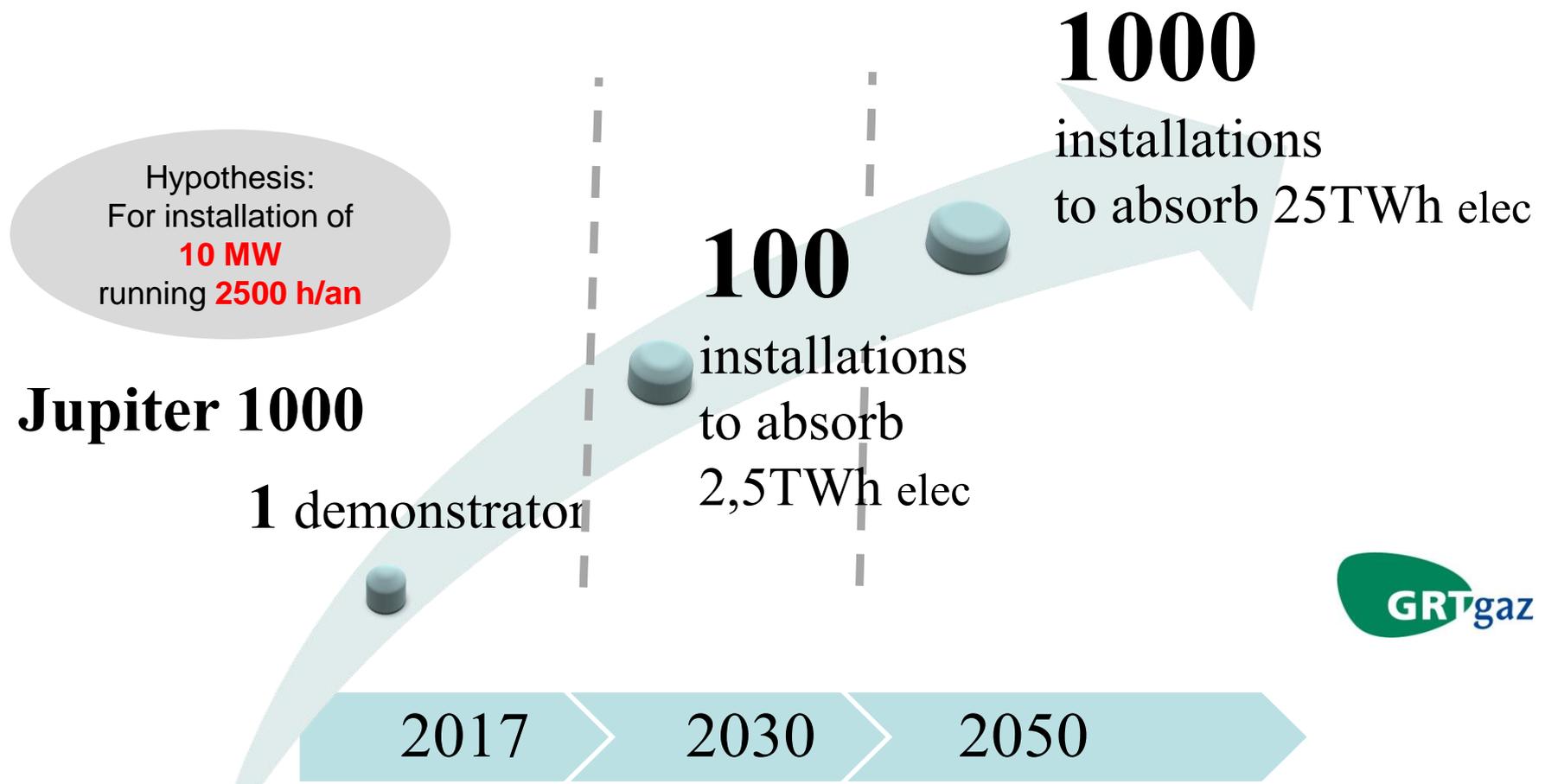
Ecological Mobility Objectives



- 20 000 new charging points by end 2016
- Decrease of 30% of CO₂ emissions of new vehicles built in France by 2021
- Creation of 2 industrial sites in France in Battery & Hydrogen
- Creation of 8 to 25 000 jobs in France by 2030 in the Energy Storage sector



Hydrogen appears to be the most appropriate technology to **store electricity over long periods of time**





Inside

Capitalize on surplus electricity produced by a 200 MW windfarm that is under construction

Power to Gas with 2 H₂ production and storage lines

- Latest generation McLyzer 2MW electrolyzer producing H₂ @30 bar
- Transportable solid storage unit used alongside traditional reservoirs

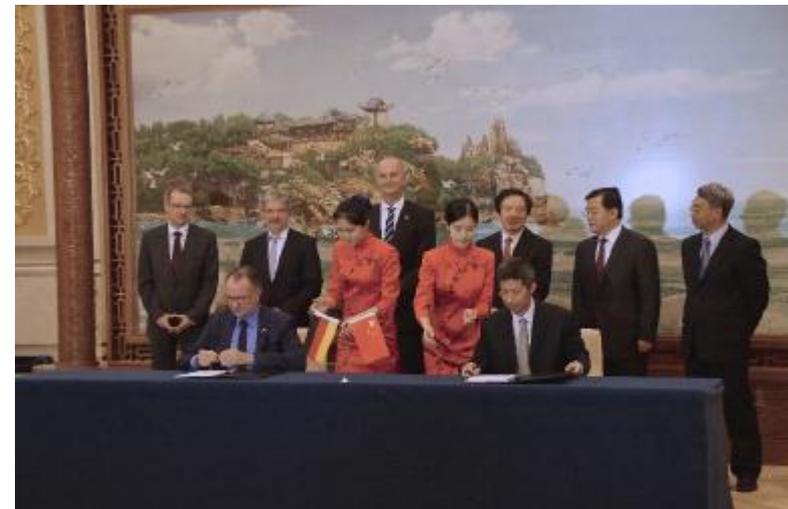
Timeline

- Contact effective end July
- Delivery in July 2016
- Commissioning in January 2017

Hebei province in China



Contract officially signed on June 3, 2015





- French and European public entities



- Vehicle OEMs



- Hydrogen providers/ producers and utilities



- Technology & equipment providers



- Regional representatives

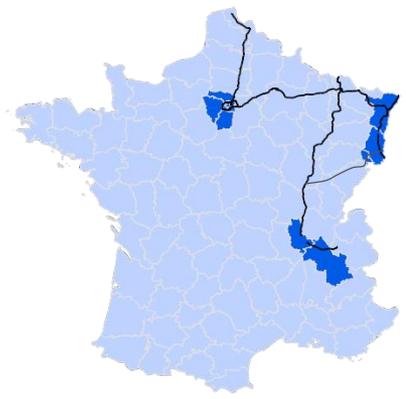




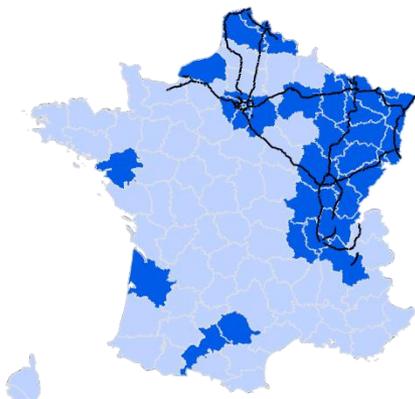
Symbio FCell Kangoo with fuel cell range extender



Inside



2017



2020



2025



2030

Area where HRS provide coverage



Germany, UK, France and Scandinavia Advanced hydrogen mobility initiatives



With the support of





‘Green Hydrogen Hub’ (H2BER) in Berlin
Partners: Total, Linde, McPhy Energy, Enertrag and 2G Energy



Air Liquide deploys HRS in Europe

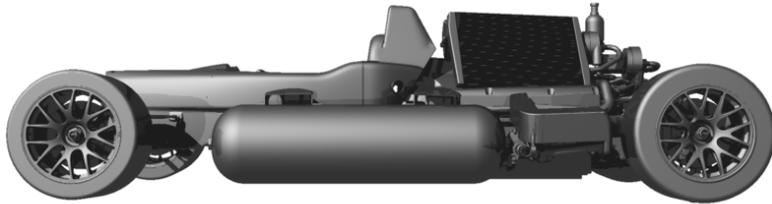


10 HRS/+100 Vehicles in 2015
20 HRS/1000 Vehicles in 2016





Inside



Circuit Paul Ricard, June 27, 2015

Engine

Type	2 synchronous three-phase permanent magnet motors
Power	2 x 200 Kw, or 544 hp DIN. RPM max 13 500 r/min
Torque	4000 Nm at the rear wheels

Transmission

Mode	Direct transmission without clutch
Type	GreenGT patented torque vectoring differential gearbox

Energy

Mode	On-board electrical control unit
Type	High temperature membrane 18 stack fuel cells
Power	400 kW
Capacity	264 kWh or 5 times greater than a Li-ION battery
Intake	Two electrical turbochargers
Vector	Hydrogen stored at 350 bar in two composite tanks
Autonomy	40 minutes per relay
Emissions	Air and water vapour

Speed: over 250 km/h
 Reliability: +50 runs, 1 fail
 Durability: 2 years, +200h on track
 Only piece unchanged: PEMFC STACK
 1 liter water/km

Auto Hebdo, November 18, 2015



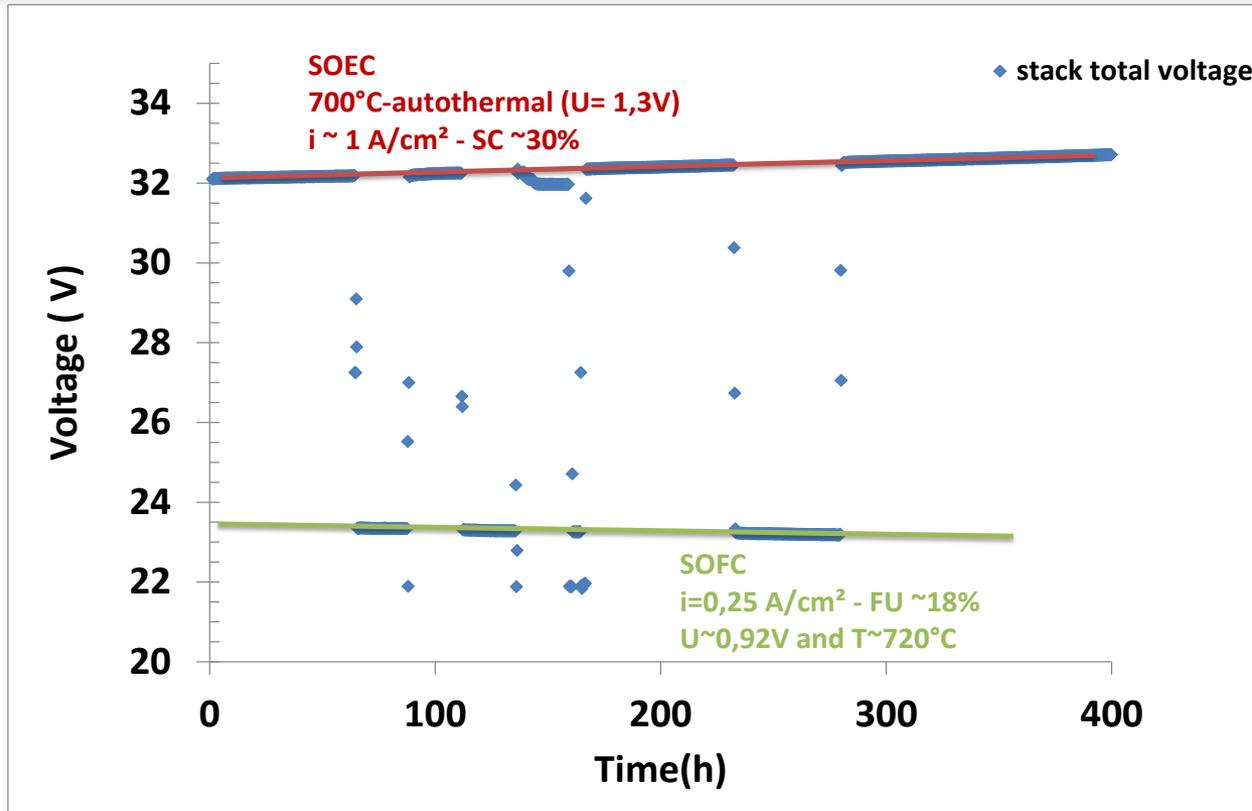
Universities
Engineer Schools



French Research grouping
coordinated by CNRS

HySPàC

- More than 100 research teams
- 4 main research axis
 - H₂ Storage, Purification et Production
 - Polymer Electrolyte Fuel Cells & Electrolysors
 - Solid Oxid Fuel Cells & Electrolysors
 - Energetic systems based on Fuel Cells & Electrolysors



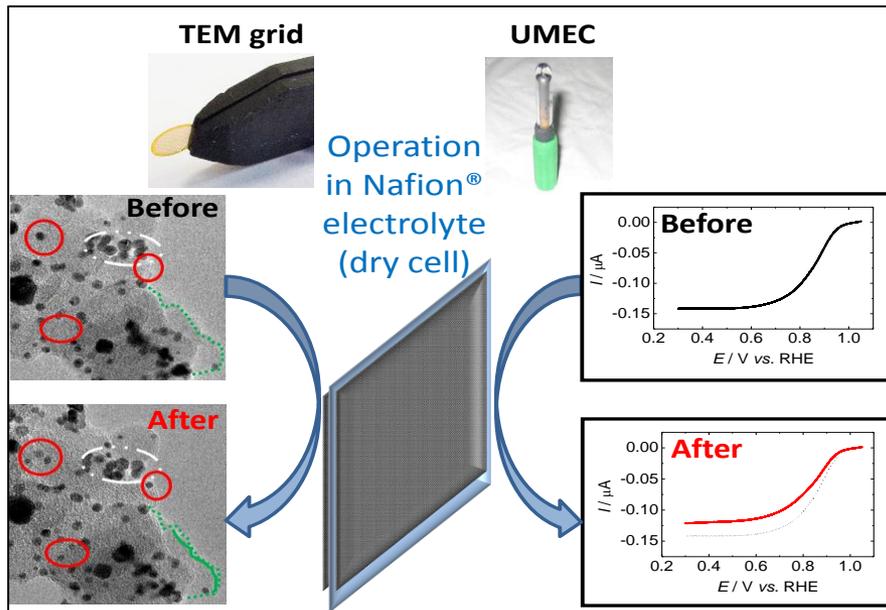
- 1.2 Nm³ H₂/h produced at 700° C with a 25-cell stack
- Successful operation in reversible SOEC/SOFC mode
- No accelerated degradation due to reversible cycling
- Efficiency: 92% (HHV)



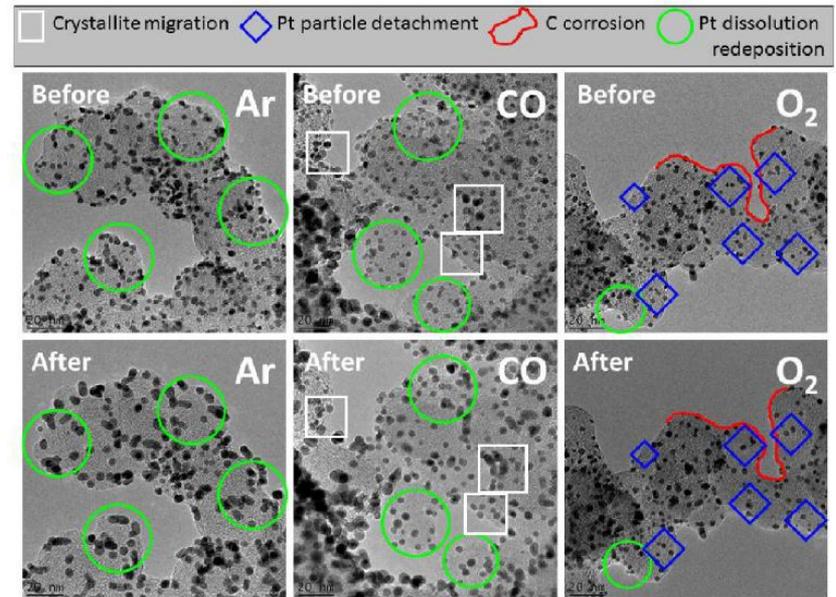
Electrochemical and microscopic tools to unveil the aging mechanisms of PEMFC electrodes



Identical Location-TEM performed



at the PEM interface...



in various environments...



- more durable **MEA materials**
- optimized PEMFC **operating conditions**

➔ Increased PEMFC performances



Densité de puissance des Assemblages Membrane – Electrodes (AME) en fin de vie						
0,25 W/cm ²	0,30 W/cm ²	0,36 W/cm ²			0,50 W/cm ²	0,70 W/cm ²
Durée de vie terrain						
-	~ 800 h	~ 1.500 h	> 8.000 h (~ 12.000 h)		12.000 h	→ 20.000 h
Consommation Hydrogène @ Puissance Nominale (48 V DC)						
-	0,9 Nm ³ /kWh		0,8 Nm ³ /kWh		0,7 Nm ³ /kWh	0,65 Nm ³ /kWh
Plage de températures de fonctionnement et de démarrage						
+5/+ 30°C	+1/+ 40°C	+1/+45°C	-10/+ 45°C		-10/+50°C	-20/+55°C
Taux de disponibilité terrain						
-	-	-	~ 80 % en 2009 → 99,5 % en 2012		> 99,5 %	

Power density

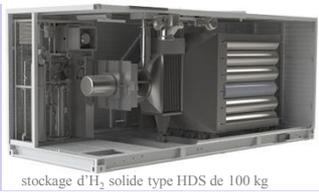
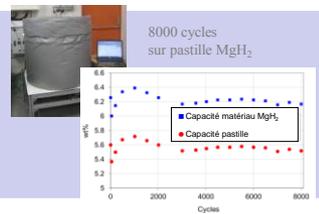
Durability

H₂ consumption

Availability



H₂ Solid Storage: McPhy Energy



2010



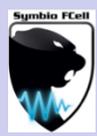
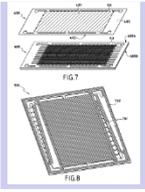
2011

2013

2013

2015

Fuel Cell: SYMBIO FCELL



2010

2012

2013

2013

2015



Perspectives

- France has a law on the energy transition that includes hydrogen technologies in the domains of Energy and Transport
- French hydrogen industry is present in Europe and worldwide
- 100 FCEV's deployed in 2015, 1000 in 2016...
- Strong R&D activities supports HFC technologies deployment