

# Advanced Business & Technologies

## Hydrogen – Transporting the future

### Axane

June 2017 | Advanced Business & Technologies AXANE



This document is **PUBLIC**

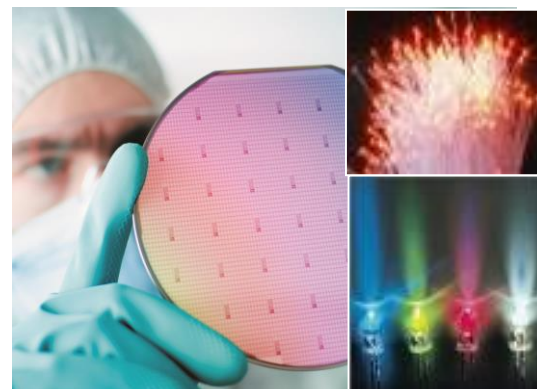
# Hydrogen, many existing applications...



Heat Treatment



Glass



H2 Ultra pure  
<1ppb



Chemicals &  
Petroleum refining



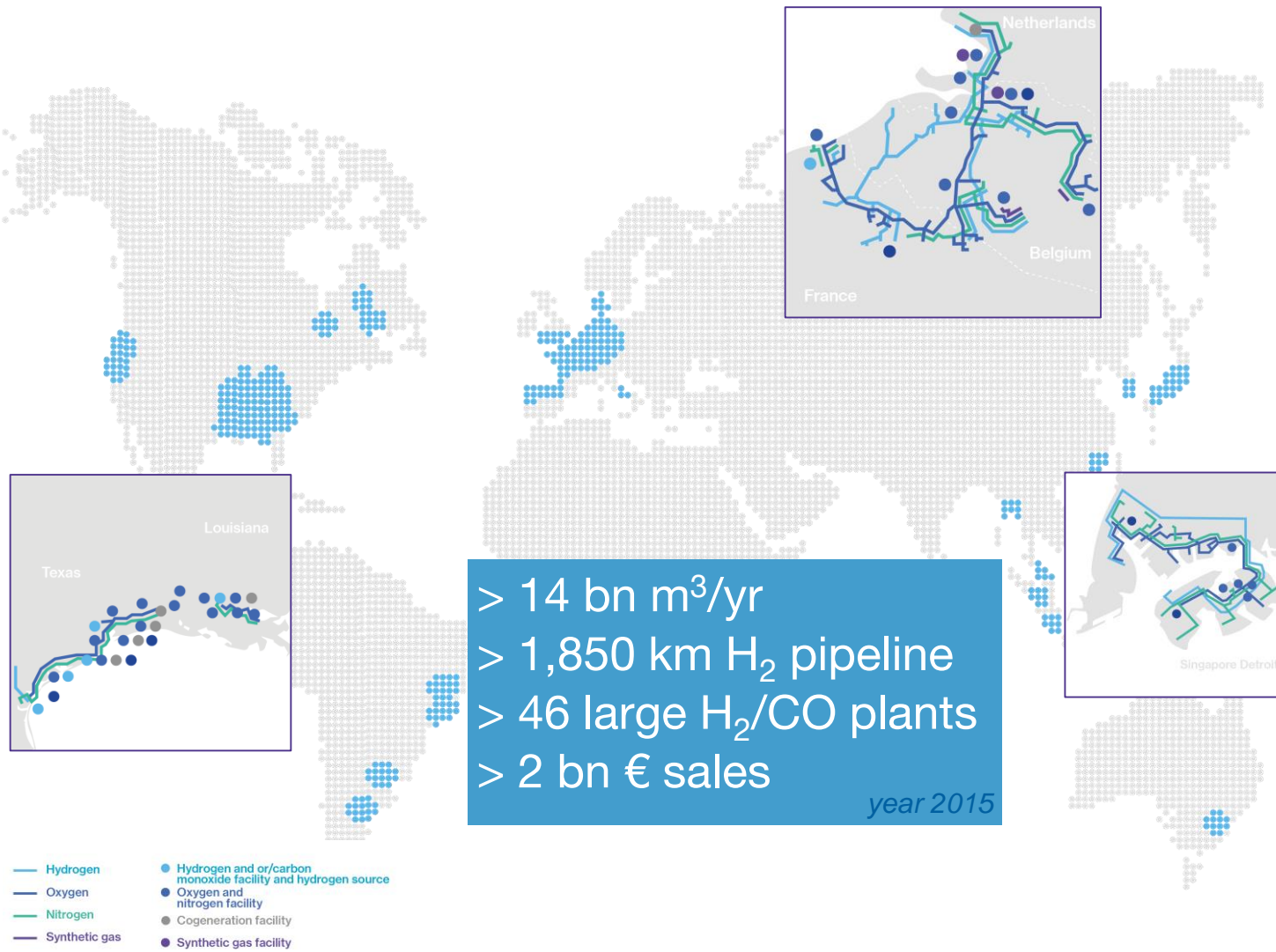
Rockets



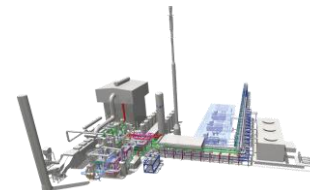
Fuel cell vehicle



# 40 years of global investment in Hydrogen



## Production



## Distribution



## Applications



This document is **PUBLIC**

# Our ambition: leadership in H<sub>2</sub> Mobility

- Lead **activation of H<sub>2</sub> Energy Markets**  
in particular H<sub>2</sub> Mobility
- **Be Major Mobility player**  
Maintain leadership across the full value chain  
from H<sub>2</sub> production to delivery at the pump

TECHNOLOGY

INVESTMENT

CUSTOMER  
EXPERIENCE

# Technology leveraged at every step in the chain



This document is **PUBLIC**

# Everything we do leads to CO<sub>2</sub>- free H<sub>2</sub> mobility

**50% of H<sub>2</sub> energy  
from carbon-free processes by 2020**

A commitment to meet  
both **environmental requirements**  
and **economic constraints**

## Achieving “Blue H<sub>2</sub>”

1. Natural gas reforming + CCS
2. Water electrolysis (renewable, nuclear)
3. Biomass gasification
4. Biogas reforming





# Pioneering innovative H<sub>2</sub> mobility projects worldwide

## Air Liquide Hydrogen Stations

75

delivered  
*end 2015*

12

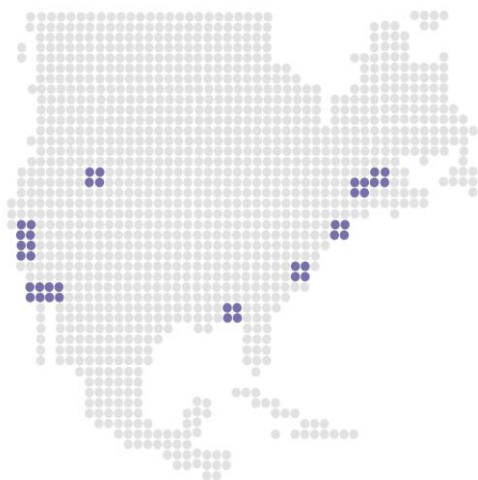
invested and operated  
by Air Liquide in 2015

26

in 2016

40

in 2017



Americas



Europe

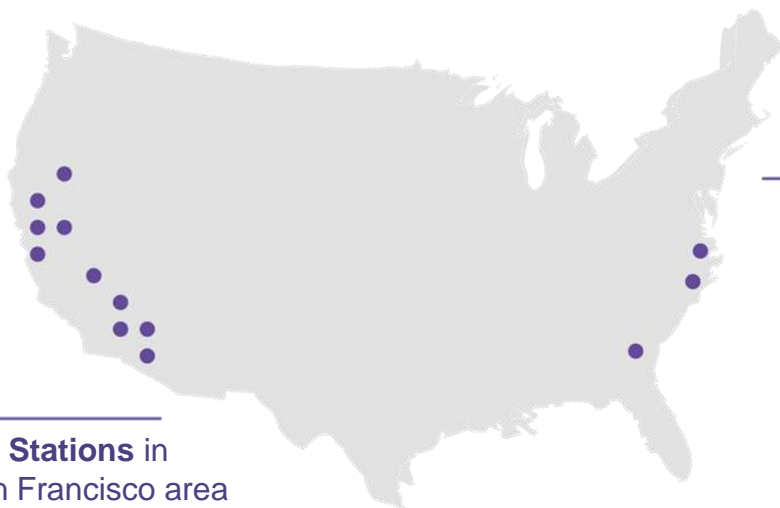


Asia



This document is **PUBLIC**

# U.S. – California & ‘Zero Emission Vehicles’ States



**4 Hydrogen Stations** in  
L.A. and San Francisco area  
More under development, with  
**active support from  
California State**



Collaboration with  **TOYOTA**

**12 Hydrogen Stations** in  
New York City, Boston,  
New Jersey, Connecticut  
and Rhode Island



**1<sup>st</sup> Hydrogen Station**  
**start-up Q1 2017**



**Dedicated H<sub>2</sub> supply  
chain** implemented by Air  
Liquide for Toyota's roll-out  
of the Mirai





# Japan – Deployments through the National Plan

Saga



**2 Hydrogen Stations**  
in Kyushu region (started  
march 2016)

**JV created with Toyota Tsusho**  
to invest 2 Hydrogen Stations  
(started in 2015)



*Nagoya Atsuta*

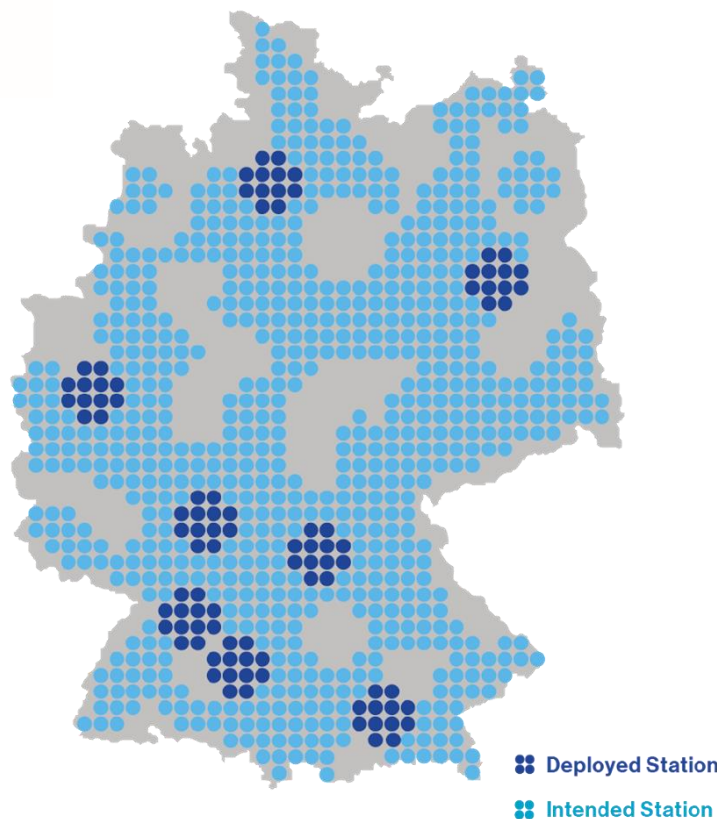
This document is **PUBLIC**

# Germany – H<sub>2</sub> Mobility Consortium



**Air Liquide, Daimler, Linde, OMV, Shell and Total** have agreed an action plan for the construction of a hydrogen station network in Germany

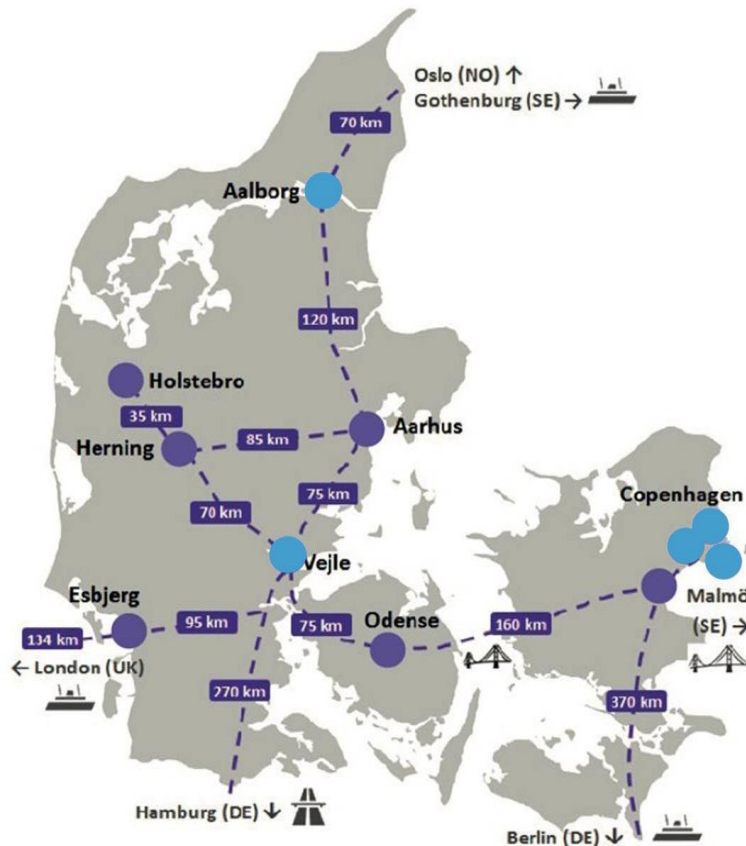
- **400 Hydrogen Stations by 2023** (100 by 2017)
- **350m €** investment
- **Max. 90 km distance between each station on motorways**
- **10 Hydrogen Stations** in each metropolitan area



This document is **PUBLIC**

# Denmark – Copenhagen Hydrogen Network (CHN)

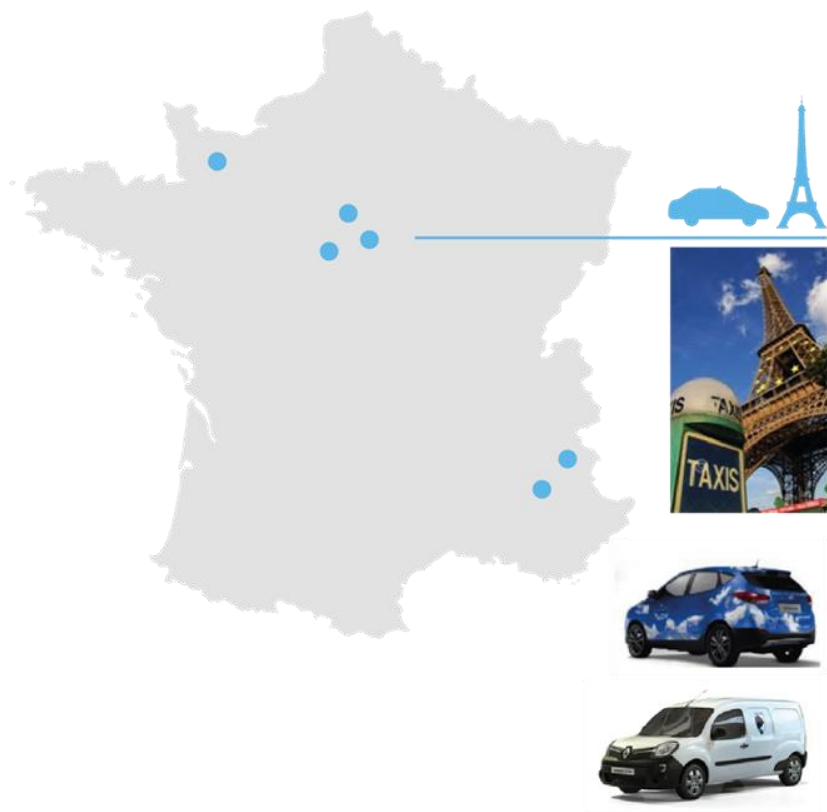
- **5 Hydrogen Stations** owned by Air Liquide
- Hydrogen to be produced from renewables :  
HyBalance “**Power to Hydrogen**” project



This document is **PUBLIC**



# France - H<sub>2</sub> Mobility initiative



## H<sub>2</sub> Stations Network under development to supply Range Extender Electric Vehicles (REEV)

- St-Lo (1) → 10 REEV & 5 Hyundai ix-35
- Hyway (3) → 50 REEV in Lyon & Grenoble
- H2ME1 (3) → 100 REEV
- Eas-Hymob (15) → in Normandy
- H2ME2 (9) → up to 1,000 REEV & 20 FCEV

## Current Air Liquide developments

- Hyway - Grenoble (2)
- **Hype - Paris**
  - H2ME1 (1) → South Paris
  - H2ME2 (2) → North & West Paris

# Innovative business models to accompany new usages...

## Captive fleets are catalysts for take-off



The «taxi of tomorrow»

An emission-free Paris



**Targeting  
70 taxis**

by the end of 2017

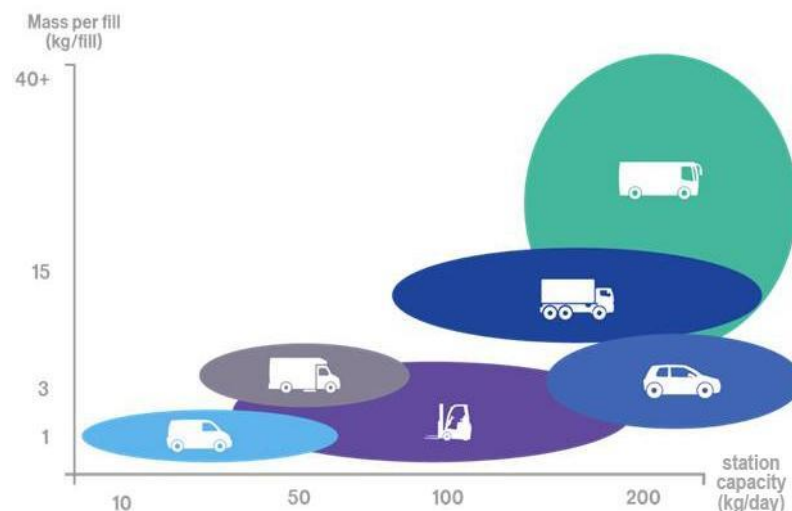
**and 600**

within 3 years

Speeding-up energy  
transition for taxis



## Captive fleet niches: buses, light commercial vehicles, taxis



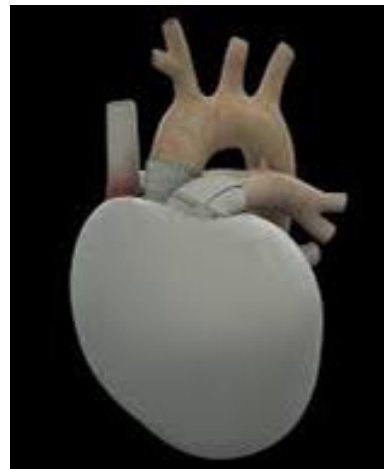
Value is created by mutualising Hydrogen Stations infrastructure with private users

# The Hydrogen Society is closer than we think...

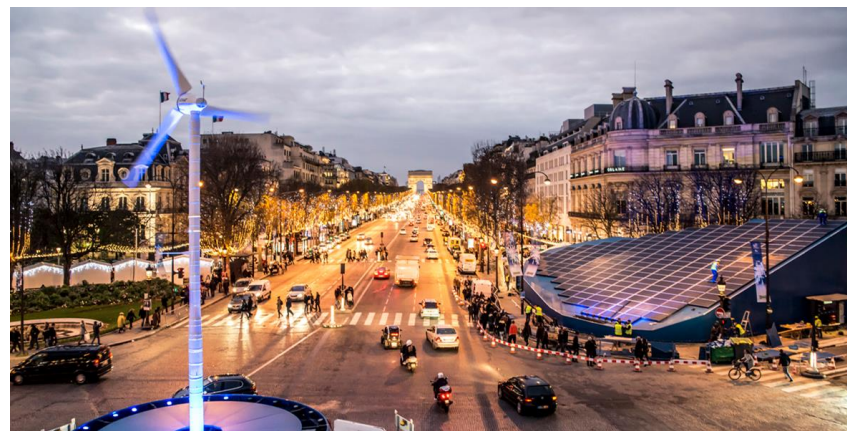
Acting now, we can rapidly  
accelerate a long overdue energy  
transition

As we advance towards an  
emission-free Hydrogen Society,  
we may just have solved the  
ultimate sustainability challenge...

© Carmat



© Pragma



© Ikea / Ubi-Bene



# Technology – Products

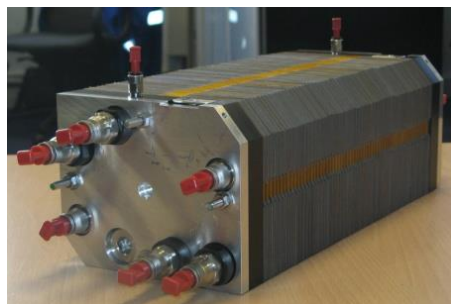


- ❑ Axane designs and manufacture cells, stacks and systems of PEM Fuel Cells  
Close cathode , low temperature, air and liquid cooling.
- ❑ Axane products are designed according to industrial constraints for series production.

✓ 1 kW to 10 kW Range

Based on G1 cell , 76 cm<sup>2</sup> active surface area

Products : **Stack G1**, **FCM G1** and **HyES G1**



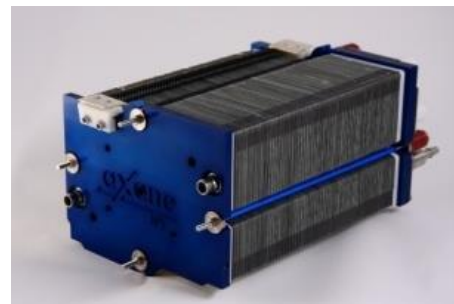
**Stack G1 60 cells**

✓ 10 kW to 100 kW Range

Based on G2 cell, 260 cm<sup>2</sup> of active surface area

Product : **Stack HPS**

(initially dedicated to Plug Power Gendrive)



**Stack HPS 60 cells**

**MEA Power density**  
**Up to 0.99 W/cm<sup>2</sup>**  
@ 0.6V – Patm – 65°C – 60%RH



**FCM G1 Autonomous System**



**Hydrogen Energy System G1 (HyES G1)**



**HyES G1 and 700 bars H2 storage**

This document is PUBLIC

# A laboratory dedicated to Fuel Cell Development

- Test center dedicated to Fuel cell stacks and systems

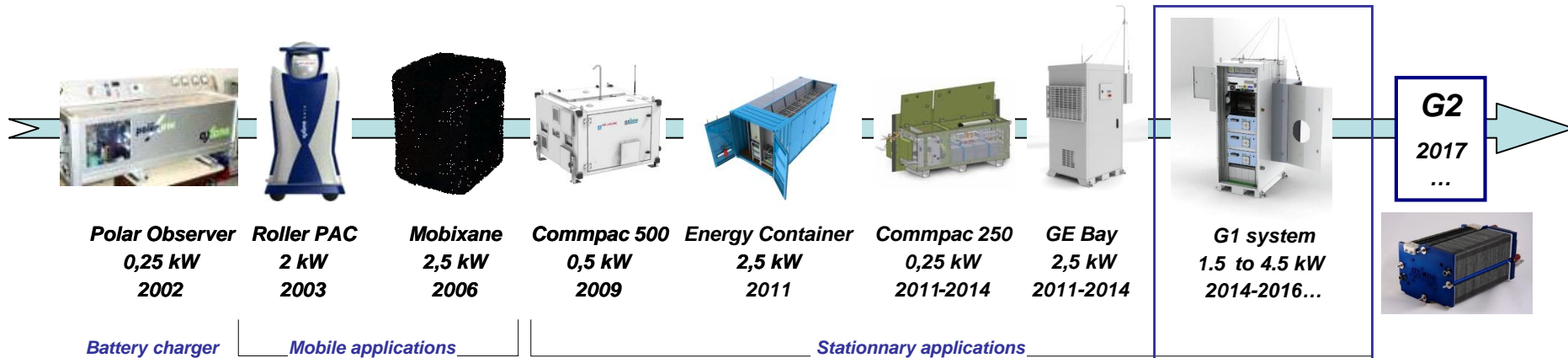


Example of stacks and systems test bench



Environmental chamber

# Towards higher performance and reliability



## Membrane-Electrodes Assemblies (MEA) Power Density **Low P, BT°**

0.25 W/cm <sup>2</sup>	0.30 W/cm <sup>2</sup>	0.36 W/cm <sup>2</sup> → 0.38 W/cm <sup>2</sup>	0.65 W/cm <sup>2</sup>	0.99 W/cm <sup>2</sup>
------------------------	------------------------	---	------------------------	------------------------

## MEA Life Time **on the Field**

-	~ 800 h	~ 1.500 h	8.000 h → 14.000 h in 2014	14.000 h	> 30.000 h <i>perspective</i>
---	---------	-----------	----------------------------	----------	----------------------------------

## Hydrogen Consumption @ Nominal Power (48 V DC)

-	0.9 Nm <sup>3</sup> /kWh	0.8 Nm <sup>3</sup> /kWh	0.7 Nm <sup>3</sup> /kWh	0.65 Nm <sup>3</sup> /kWh
---	--------------------------	--------------------------	--------------------------	---------------------------

## Ambiant Temperature Range for Operation and Start Up

+5/+ 30°C	+1/+ 40°C	+1/+45°C	-10/+ 45°C	-10/+50°C	-20/+55°C	-40/+55°C
-----------	-----------	----------	------------	-----------	-----------	-----------

## Up time on the Field

-	-	-	~ 80 % in 2009 → 99.5 % in 2012	> 99.5 %	> 99.5 %
---	---	---	---------------------------------	----------	----------

This document is **PUBLIC**



# Axane Fuel Cells deploiements



Map of systems deployed in France

**MORE  
THAN 300**  
FUEL CELLS  
DEPLOYED  
WORLDWIDE

This document is **PUBLIC**

2017

aB&T Hydrogen Energy  
Axane

The world leader in gases, technologies and services for Industry and Health



# Deployment example: GSM for High Speed Train Railway



## ■ Antennas along TGV (high speed train) Railways

**LGV1\_THERVAY\_BRANS**

**LGV1\_POINTRE**

**LGV1\_MONTMIREY\_LE\_CHATEAU**

**LGV1\_OUGNEY**

**LGV1\_VITREUX**

**LGV1\_AUXON\_DESSOUS**

**LGV1\_CHEVROZ**

**LGV1\_VORAY\_SUR\_L\_OGNON**

**LGV2\_LES\_MAGNY**

**LGV2\_VILLERS\_LA\_VILLE**

**LGV2\_SAULNOT\_CORCELLES**

**LGV2\_TAVEY**

**LGV2\_VYANS LE VAL**

**LGV2\_CHATENOIS\_2**

**LGV\_MEROUX**

**LGV2\_NOVILLARD**

**LGV2\_RIOZ ANTHON**


This document is **PUBLIC**



# Thank you

Contact aB&T Communication  
Nathalie Simon de Kergunic



[www.airliquide.com](http://www.airliquide.com)  
[@airliquidenergy](https://twitter.com/airliquidenergy) 



This document is **PUBLIC**

2017

aB&T Hydrogen Energy  
Axane

The world leader in gases, technologies and services for Industry and Health