



NWV-6th National Hydrogen Congress

Hydrogen storage: Challenges and status

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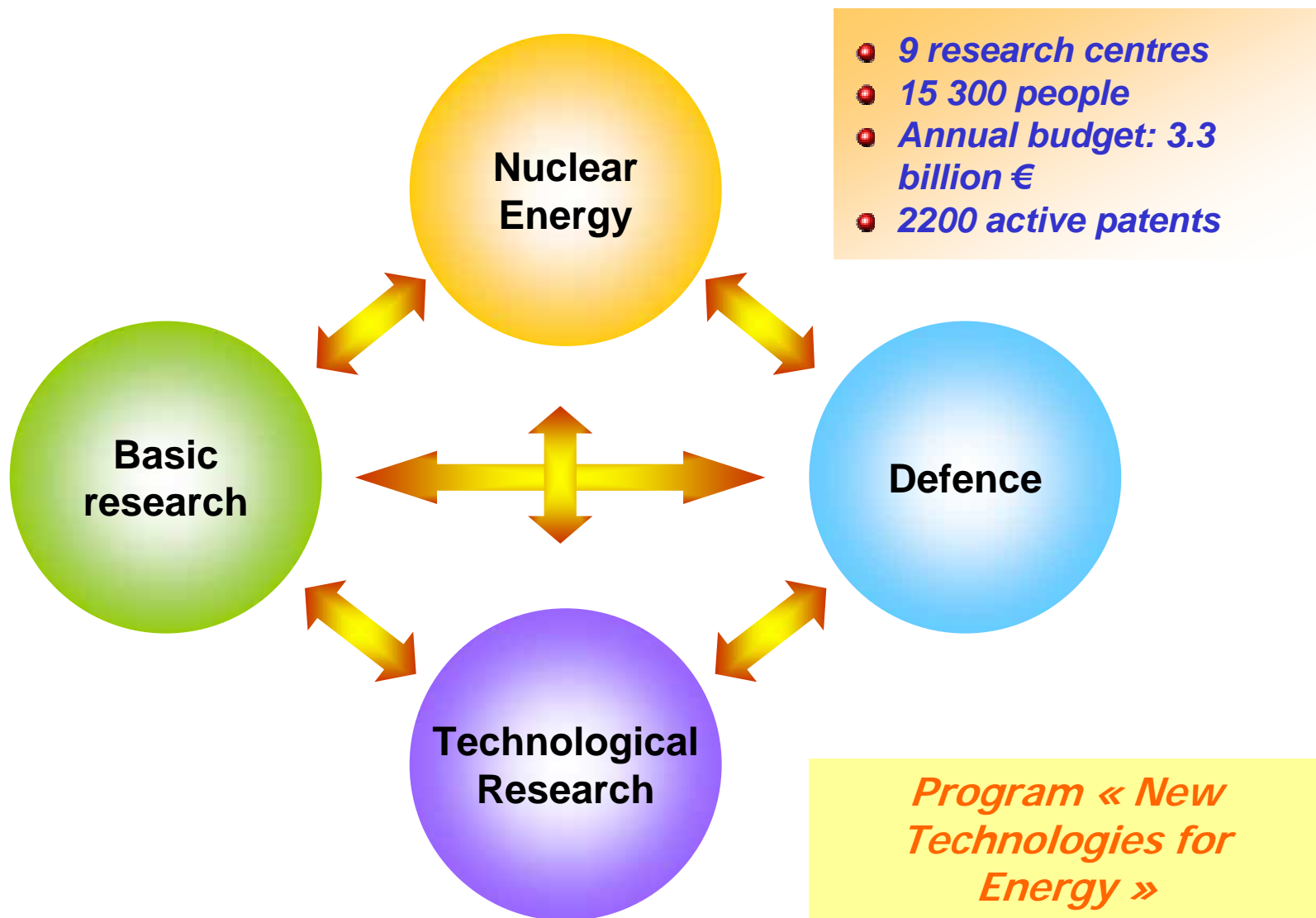
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CONTENT



- SOME WORDS ON CEA
- BOTTLENECKS
- CHALLENGES vs APPLICATION
- WAYS FOR SUCCESS
- PROGRESS IN FRANCE
 - COMPRESSED GAS TECHNOLOGY
 - SOLID STORAGE TECHNOLOGY
- PERSPECTIVES

CEA Organisation



« New Technologies for Energy » program

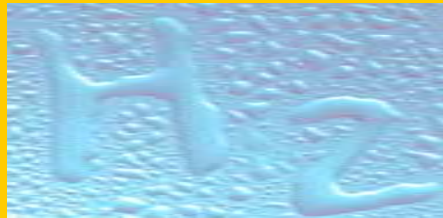
1999: Creation of « NTE » program

Objectives of « Hydrogen and Fuel Cells »

- **Improve performances, robustness and lifetime**
- **Decrease component and system costs**
- **Develop high performance hydrogen storage**
- **Manage hydrogen transportation**
- **Demonstrate safety**
- **Deal with codes, standards and public acceptance**

In 2008

- ✦ **People: 180**
- ✦ **Annual budget: 28.6 M€**
- ✦ **External funding: 13.5 M€**



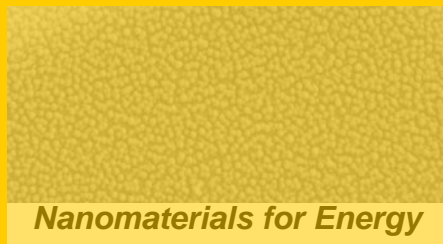
Hydrogen



Solar energy (INES)



Biomass



Nanomaterials for Energy

BOTTLENECKS (1/4)



- **Specific behaviours:**
 - **Compressibility : this gaz is not perfect**
 - **Hydrogen - Material Interaction**
- **Concerns:**
 - **Transportation**
 - **Distribution**
 - **Storage**
- **Impacts:**
 - **Technology**
 - **Cost**
 - **Safety**

BOTTLENECKS (2/4)



Compressibility

The most energetic element

•1kgH2 # 2.75kg gasoline

But it's a gaz

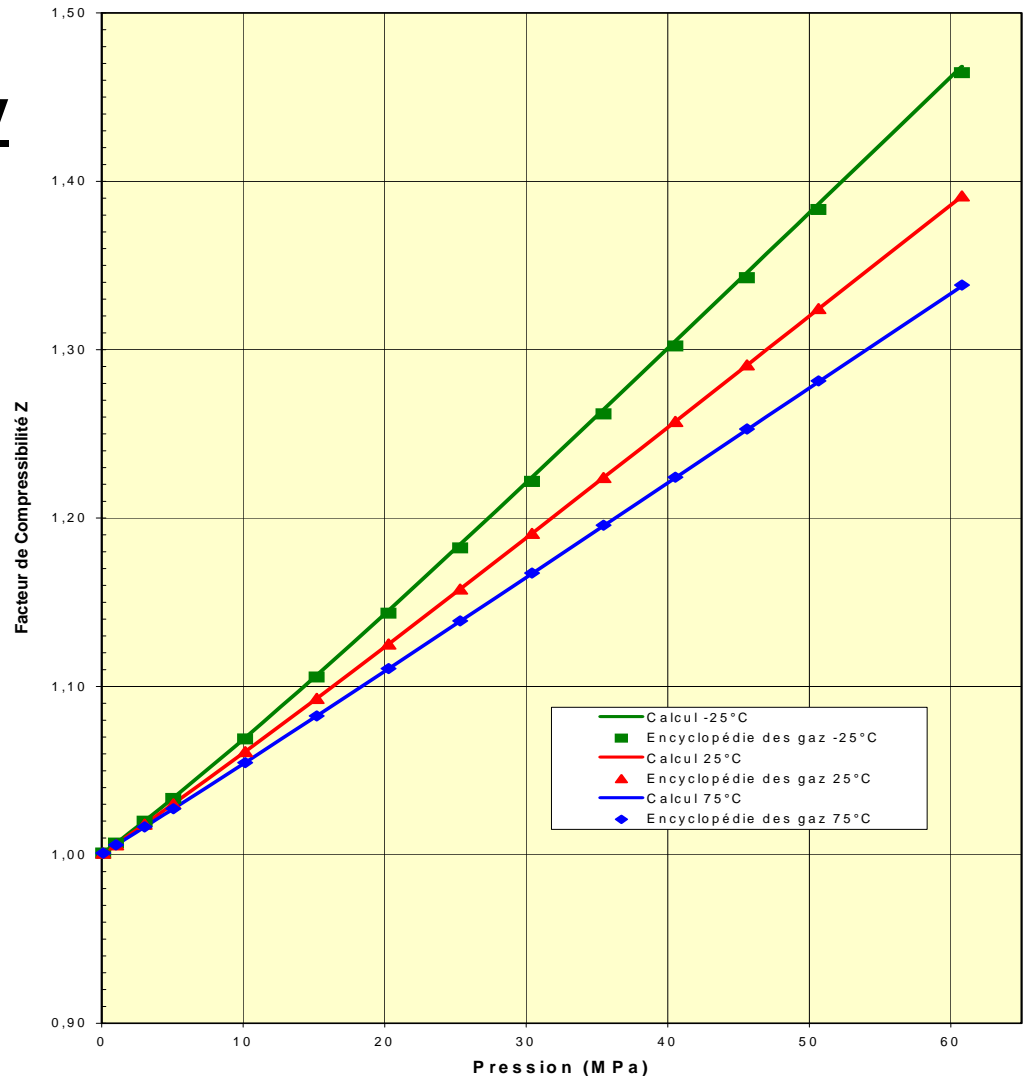
•1Nm3 H2 # 0.34 L gasoline

And it's not perfect

• $PV = ZnRT$

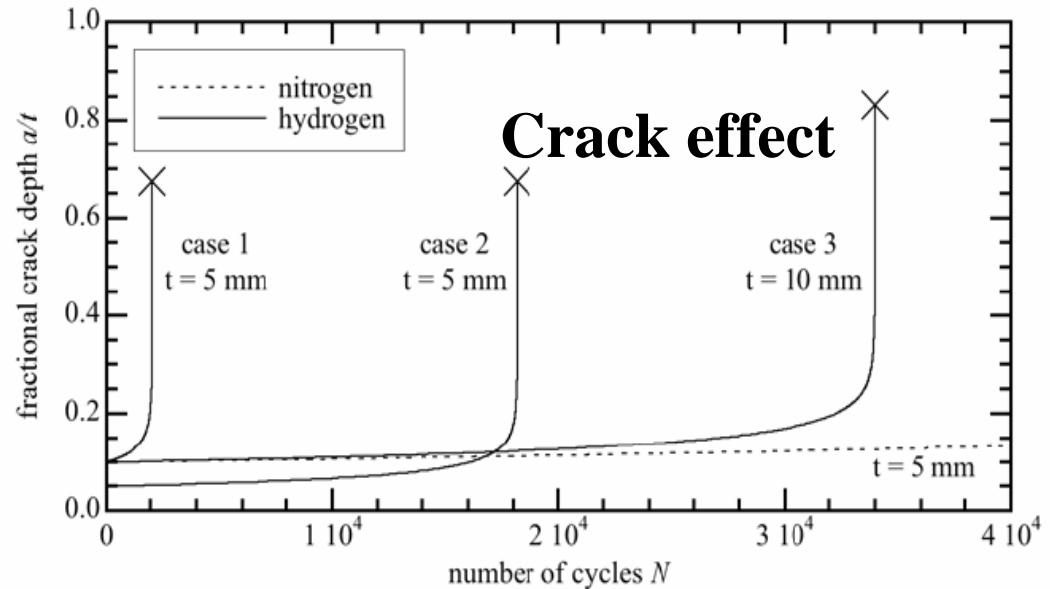
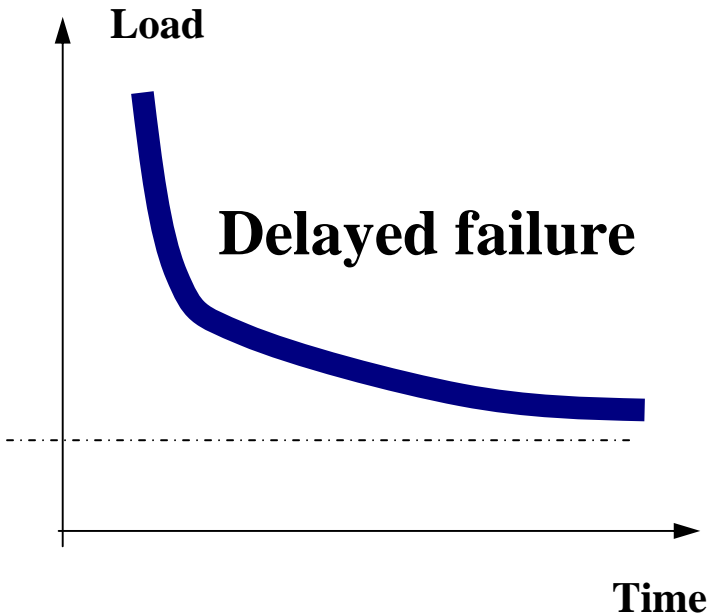
•Pressure x2 =>70% d'H2
more

Comparaison avec l'Encyclopédie des Gaz
(avec facteur correctif)



BOTTLENECKS (3/4)

- Interaction Hydrogen-Materials: Embrittlement of metallic pipe for H₂ Transportation

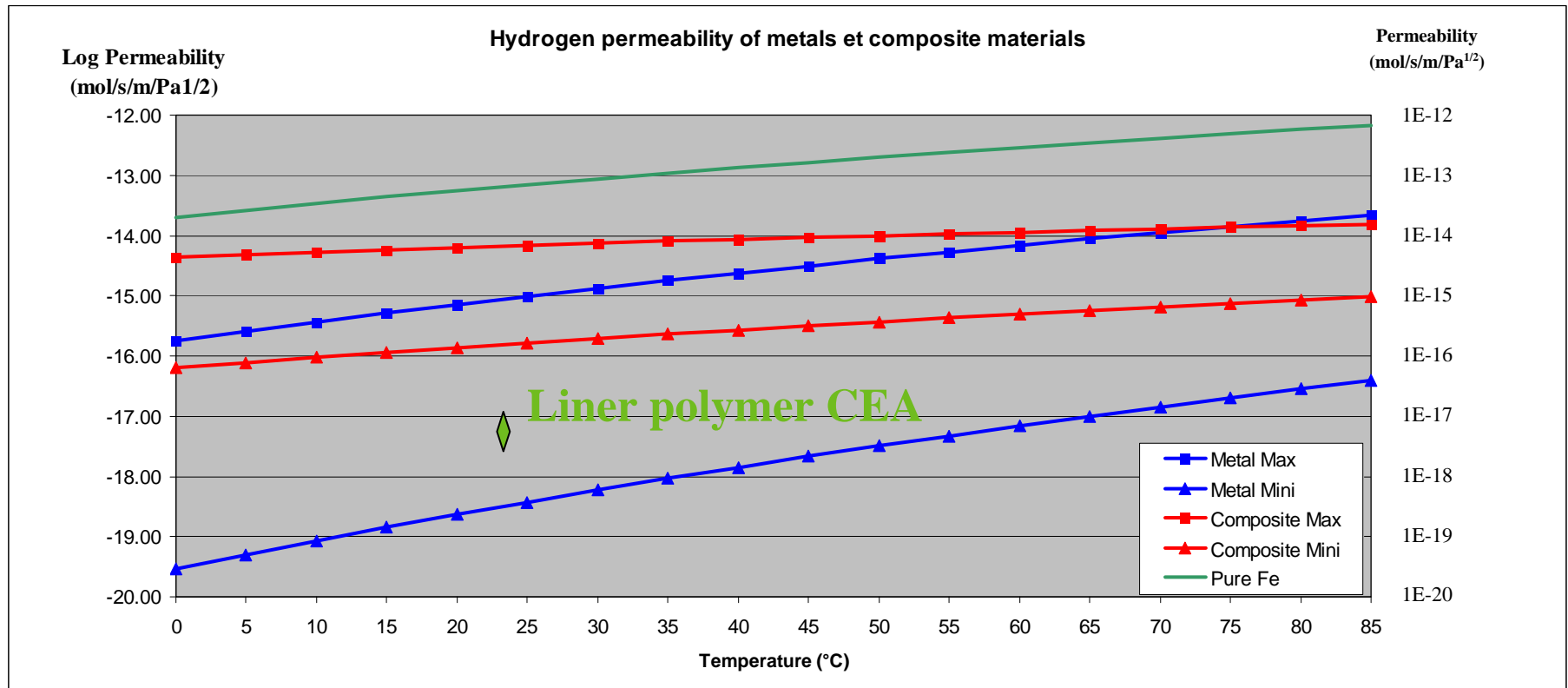


$$I = P_{\text{He}} / P_{\text{H}_2} < 2$$

(16 observed !)

BOTTLENECKS - (4/4)

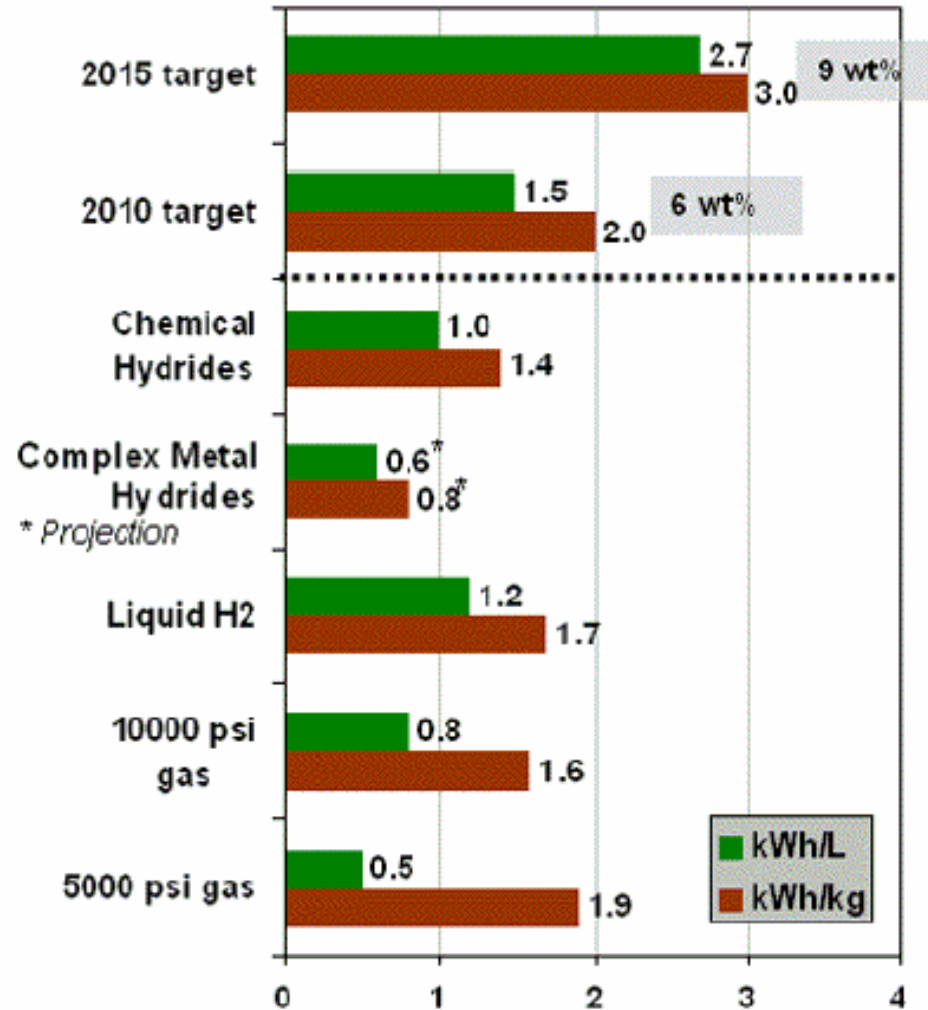
- Interaction Hydrogen-Materials : Permeation of polymeric liner and tube for H₂ Distribution and Storage vessel



CHALLENGES vs APPLICATION

Main Target for automobile application :

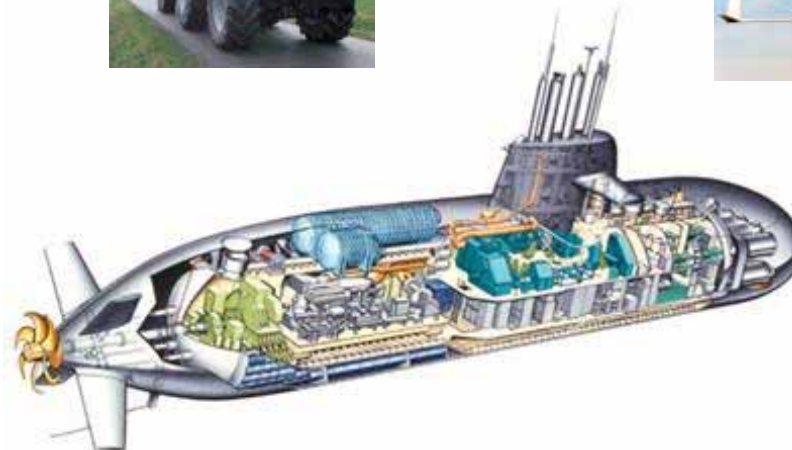
- Compact
- Light
- Safe
- Cheap
- Quick filling
- Durability



CHALLENGES vs APPLICATION

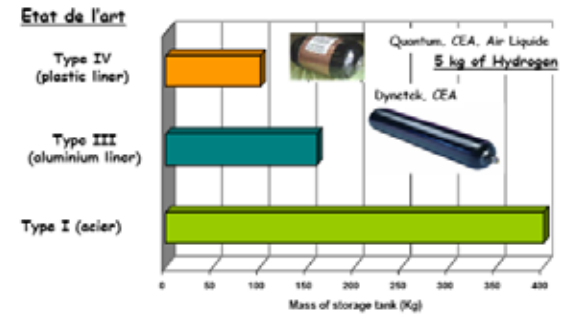
Main Target for Stationary & niche market application : High Specific Value

- Compact vs light (ex submarine)
- Compact vs light
- Safe
- Cheap
- Quick filling
- Durability

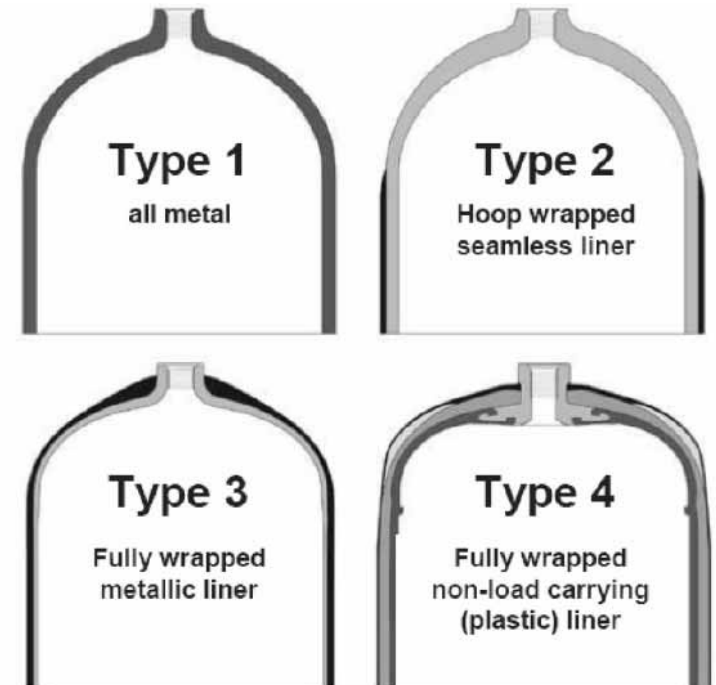


WAYS FOR SUCCESS (1/3)

• Compressed Gaz Technology

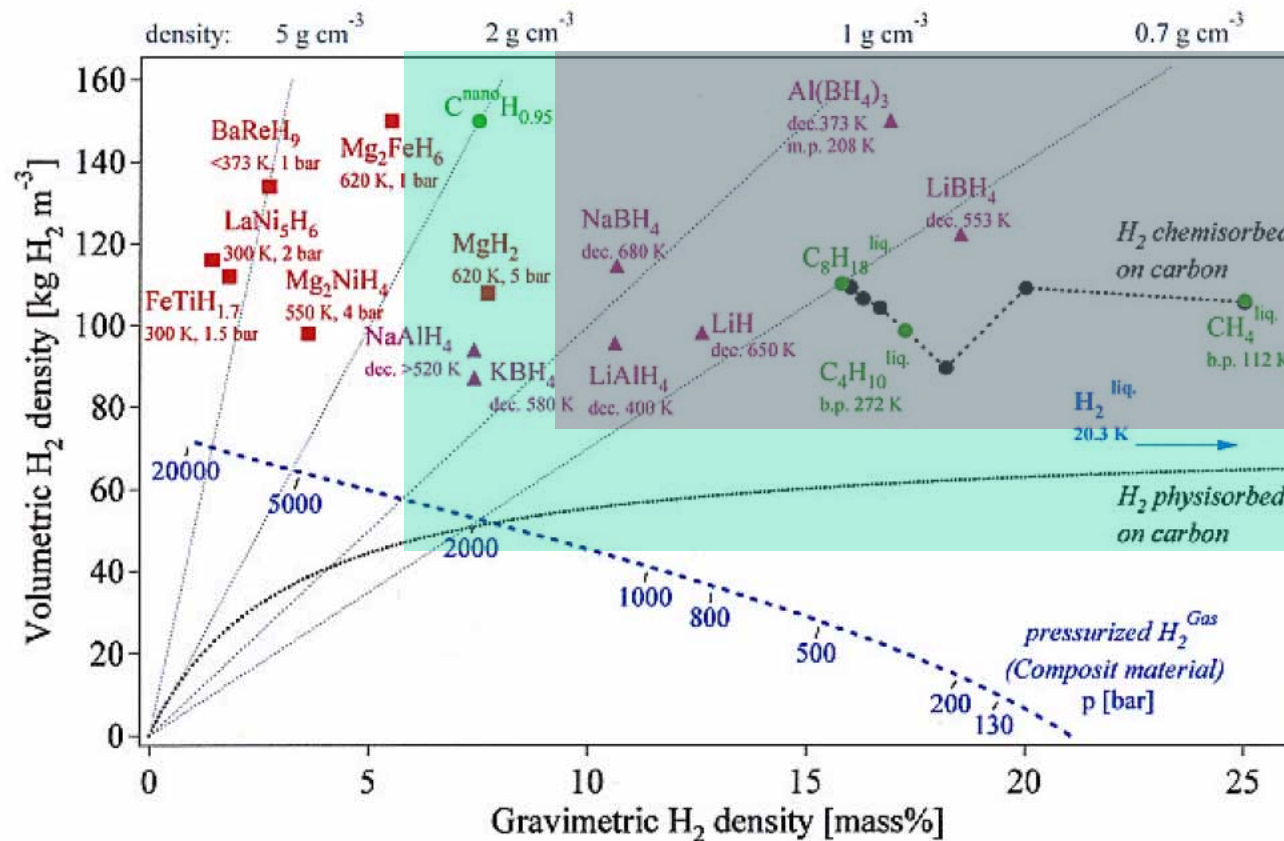


- Type I: Made of **metal**. These are currently the most spread and cheapest high pressure vessels. They are widely used in industry to store hydrogen as an industrial gas from 150 to 300 bar;
- Type II: Made of a thick **metallic liner** hoop wrapped with a fiber-resin composite, used for stationary application when higher pressures are required;
- Type III: Made of a **metallic liner** fully-wrapped with a fiber-resin composite and is intended for portable applications;
- Type IV: Made of **polymeric liner** fully-wrapped with a fiber-resin composite and is intended for portable applications. The port is metallic and integrated in the structure (called boss).^[1]



WAYS FOR SUCCESS (2/3)

- Solid Storage technology
 - PhysicalHydrid -> no way for automobile
 - Chemical Hydrid -> recycling problem-> NaBH4 stopped by DOE
 - Adsorption, MOF, nanotube, ..., -> breakthrough



2015 System Target

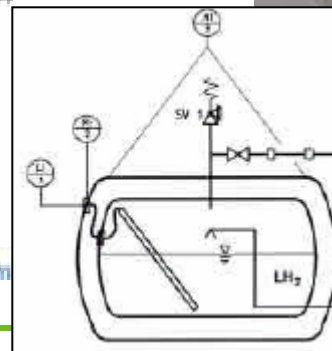
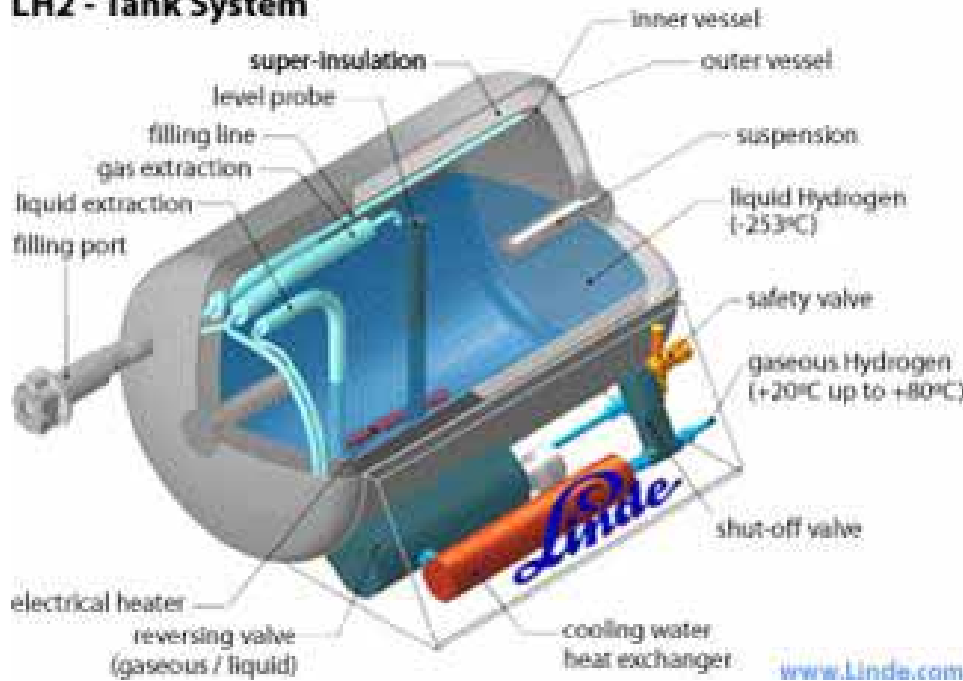
2010 System Target

WAYS FOR SUCCESS (3/3)

- LIQUID STORAGE : more compact but
 - Boil-off
 - Cost
 - Energy to liquify

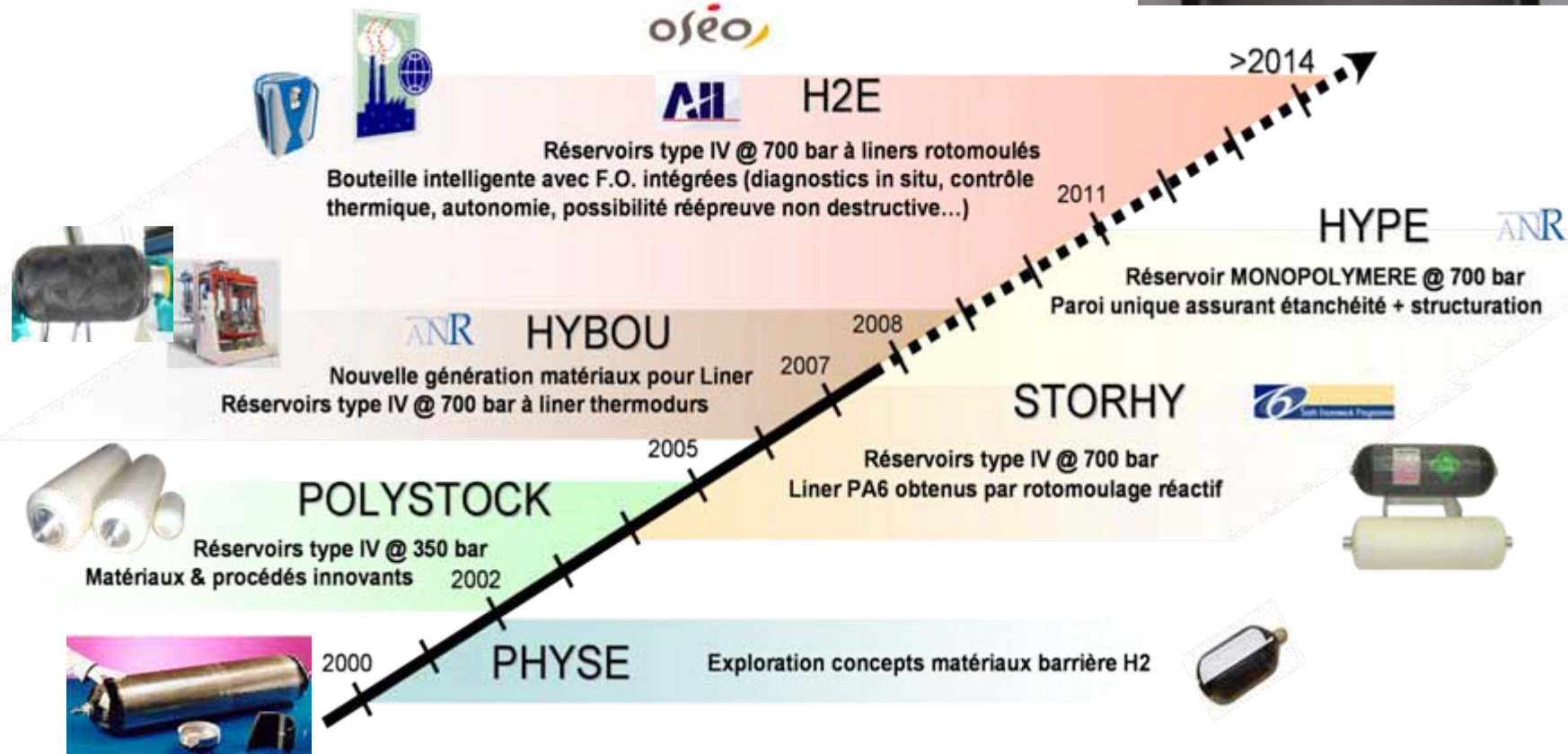
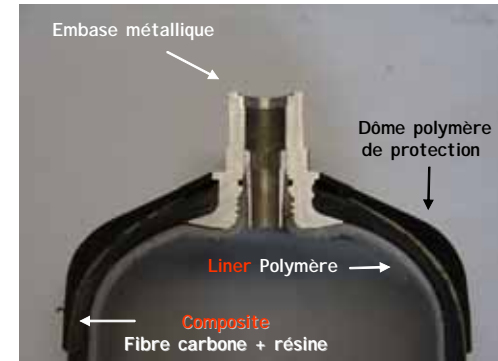


LH2 - Tank System



PROGRESS IN FRANCE

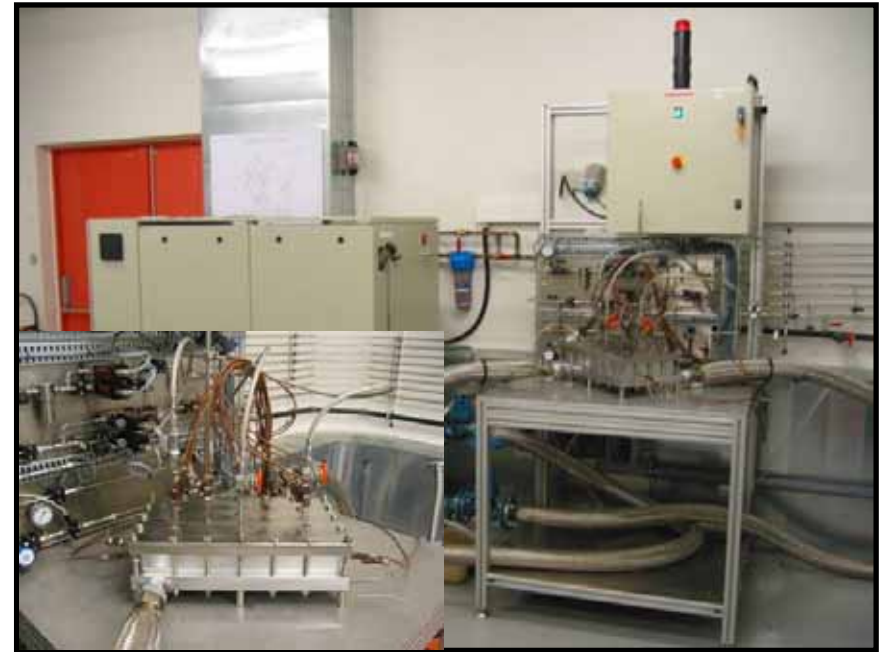
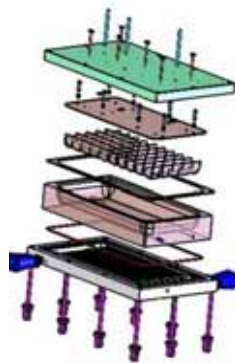
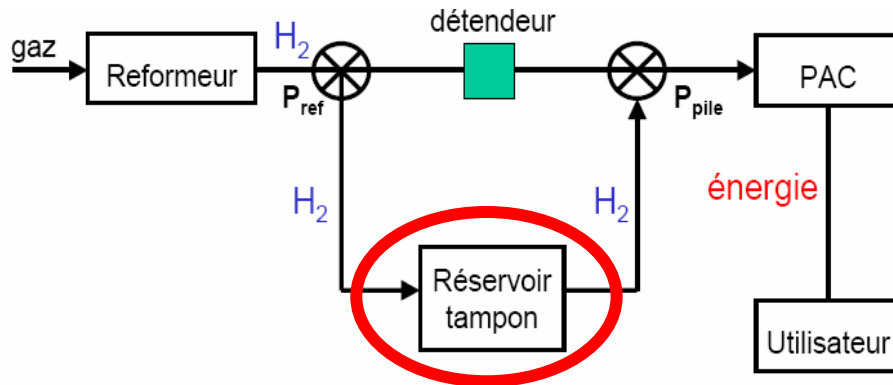
- **Compressed Gaz Technology:**
 - 10 years permanent improvement
 - 8 patents, 1 licensing, TÜV Certified



PROGRESS IN FRANCE

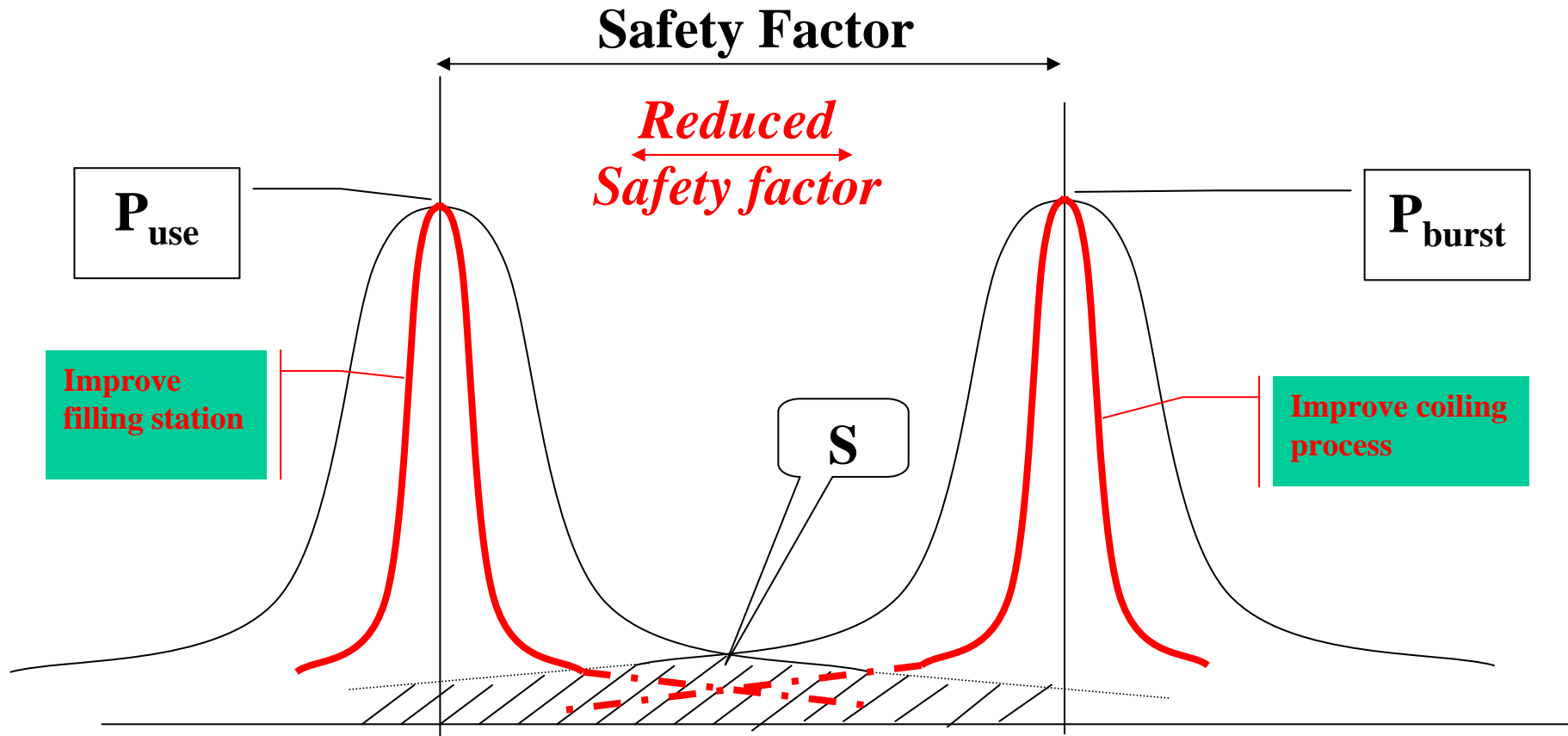
• Solid Storage Technology:

- Fit metallic alloys with works specification at system level
- 10 kg LaNi_5 /100g H_2
- 15h load at 3.5 bar/9h discharge at 1.5 bar



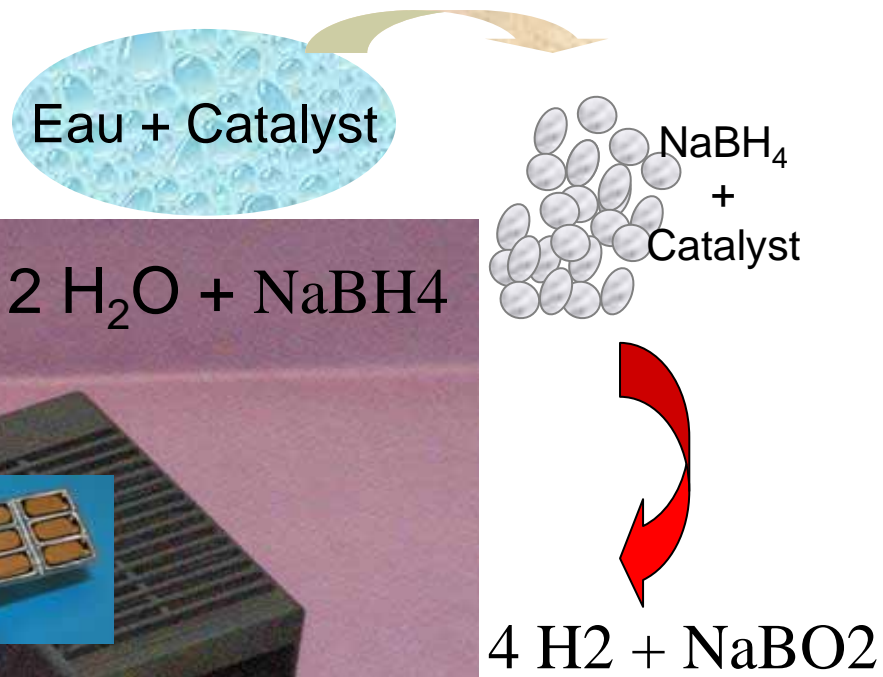
PERSPECTIVES

- Carbon Fiber represents 80% of the total cost
- Low mass production impact
 - Use glass fiber ?
 - Reduce safety factor : P_{burst}/P_{use}



PERSPECTIVES

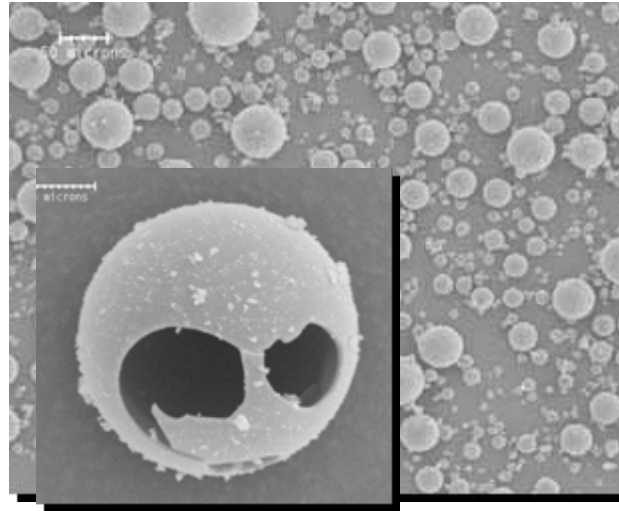
- SHORT TERM APPLICATION : Chemical Hydride for loading Cell Phone



Is there innovative way to investigate?



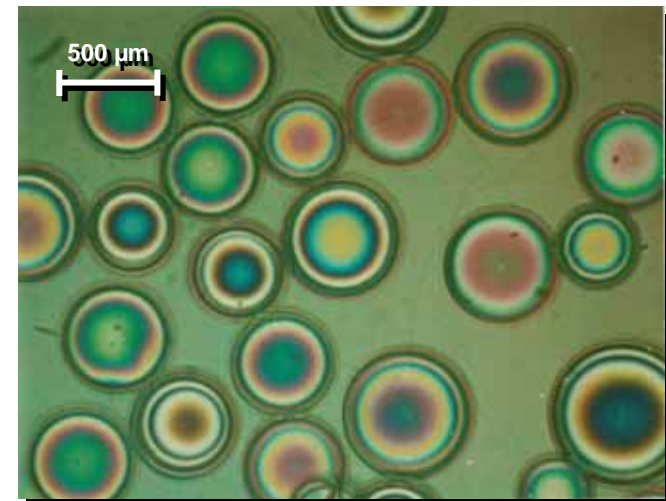
3M : MicroBall of glass



- **Characteristic**
 - ✦ $\varnothing_{\text{moyen}} = 30 \mu\text{m}$
 - ✦ 20 g H₂/ litre of microball
 - ✦ 55 g H₂/ kg of microball
- **Load conditions**
 - ✦ 1000-1500 bar
 - ✦ 300-400 °C
 - ✦ 1-2 h

CEA : MicroBall of glass

- **Charasteristic**
 - ✦ $\varnothing_{\text{average}} = 500 \mu\text{m}$
 - ✦ 2 g H₂/ litre of microball



THANK YOU FOR YOUR ATTENTION AND SEE YOU IN...

ICHS, Ajaccio (France) September 16-18, 2009



EU NoE HySafe

"Safety of Hydrogen as an Energy Carrier"

With the endorsement of:



invites to the:

3rd ICHS

*International Conference
on Hydrogen Safety*

September 16 - 18, 2009

Ajaccio - CORSICA, FRANCE

2nd Call for Paper

Local Organizations:



ICHS, Ajaccio (France) September 16-18, 2009

In Association with:



Canadian Hydrogen Safety Program



HYDROGEN IMPLEMENTING AGREEMENT

Task 19 - Hydrogen Safety



Italian National Fire Corps



NATURALHY

ICHS, Ajaccio (France) September 16-18, 2009

CONFERENCE - SCOPE

The 3rd International Conference on Hydrogen Safety (ICHS) will be conducted on behalf of the European Commission and the International Partnership for the Hydrogen Economy (IPHE) by HySafe (Safety of Hydrogen as an Energy Carrier), a Network of Excellence (NoE) of the VI European FWP (UE contract SES6-CT-2004-502630). The conference will be held in Ajaccio, Corsica on September 16-18, 2009, and is being organized in collaboration with the principal EU and international projects on hydrogen safety. The ICHS **will focus on** the improvement, knowledge, and understanding **of hydrogen safety** to foster removal of safety-related barriers to implementation of hydrogen as an energy carrier. The conference will improve public awareness and trust in hydrogen technologies by communicating a better understanding of both the risks associated with hydrogen and their management. Since the ICHS will focus on safety issues and measures to encourage more extensive use of hydrogen-based technologies, its contents will be different from other hydrogen conferences. All contributions to be included in the ICHS will be evaluated exclusively in the light of their scientific content and relevance to hydrogen safety. **Papers that do not focus on safety issues will not be accepted.**

ICHS CONFERENCE - STRUCTURE

The 3rd ICHS will include invited plenary sessions, - topical lectures, and parallel and poster sessions of contributed papers.

One of the main objectives of the Conference is to provide a platform for the presentation of the final results of projects.

Each day, the Conference will start with a plenary session on themes that are particularly relevant for safe and widespread hydrogen use in contemporary society, such as technologies, infrastructure and public safety, research & development, risk management and insurance. The plenary thematic session will be followed by parallel sessions featuring invited topical presentations and contributed papers.

ICHS 3 THEMES AND TOPICS

Theme 1: Building Public Awareness of Hydrogen Safety

- o Hydrogen as an Energy Carrier; Past, Present and Future
- o Progress in Closing Knowledge Gaps
- o Current Applications; Portable, Mobile and Stationary
- o Safety Training Techniques and Programs
- o Methods for Achieving Public Awareness
- o Technical Progress and Knowledge Building in Codes and Standards