



# L'hidrogen dins el nou escenari energètic

Jordi Llorca



## Visió general

L'hidrogen en el context actual

## Piles de combustible

Funcionament, tipus, aplicacions estacionàries, aplicacions mòbils, aplicacions portàtils

## Producció d'hidrogen

A partir de fonts convencionals, a partir d'energies renovables

## Emmagatzematge i distribució d'hidrogen

Mètodes físics, mètodes químics

Augment progressiu de la demanda energètica

Esgotament progressiu dels combustibles fòssils

+ Dependència energètica envers altres països

Deteriorament de l'entorn

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Energies eficaces, renovables, adaptables i sostenibles

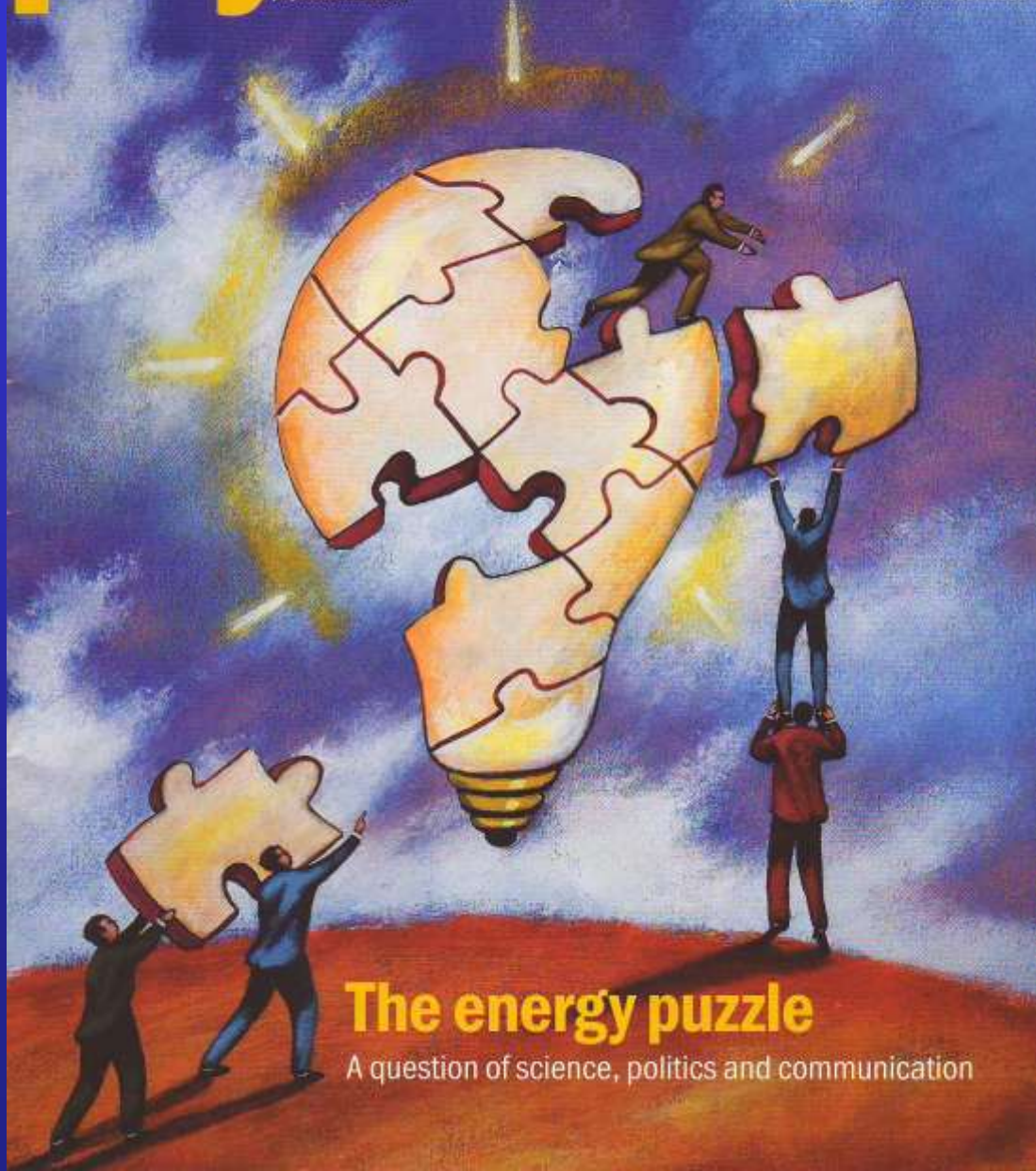


H<sub>2</sub>

# physicsworld

physicsworld.com

Volume 22 No 10 October 2009



## The energy puzzle

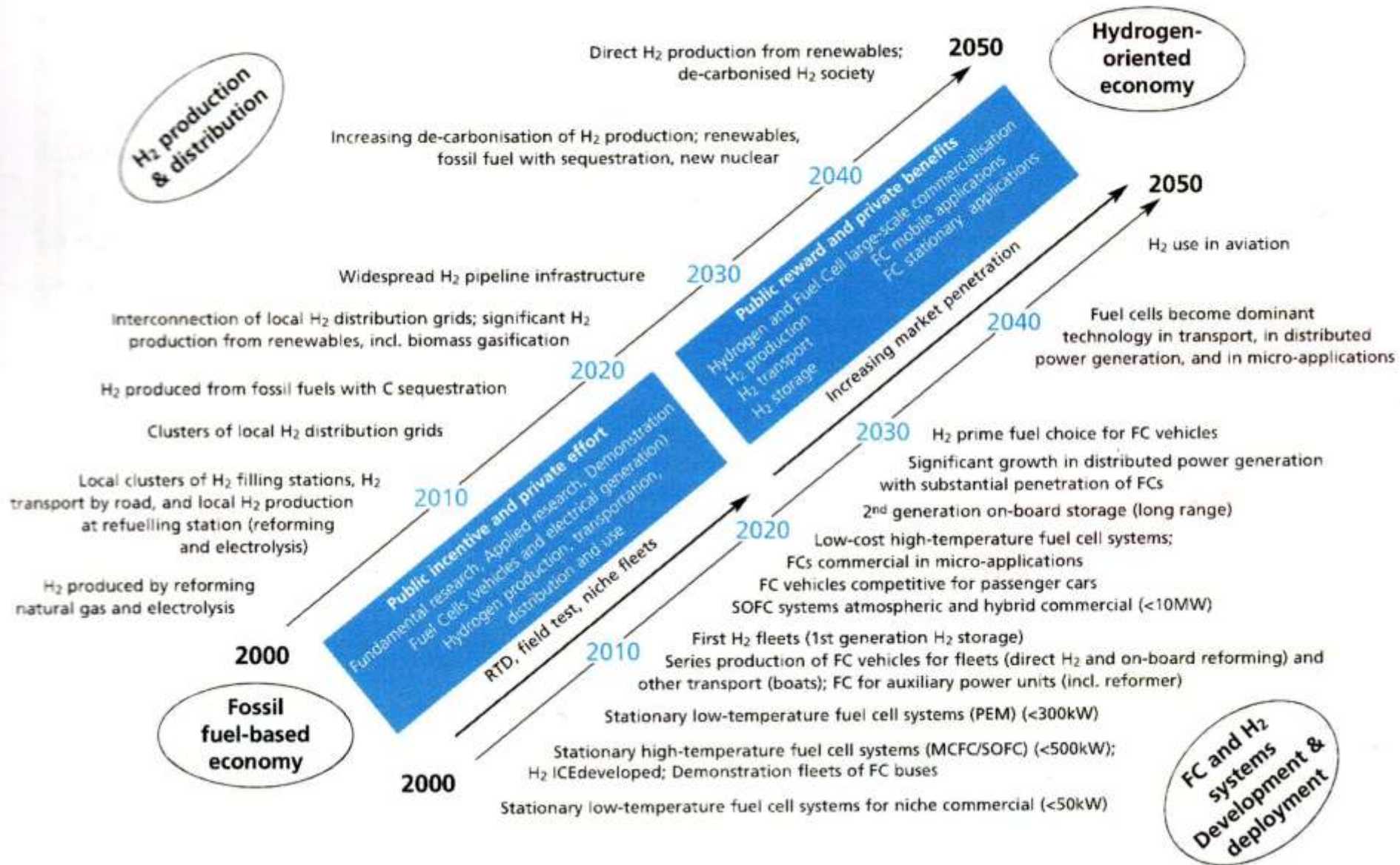
A question of science, politics and communication

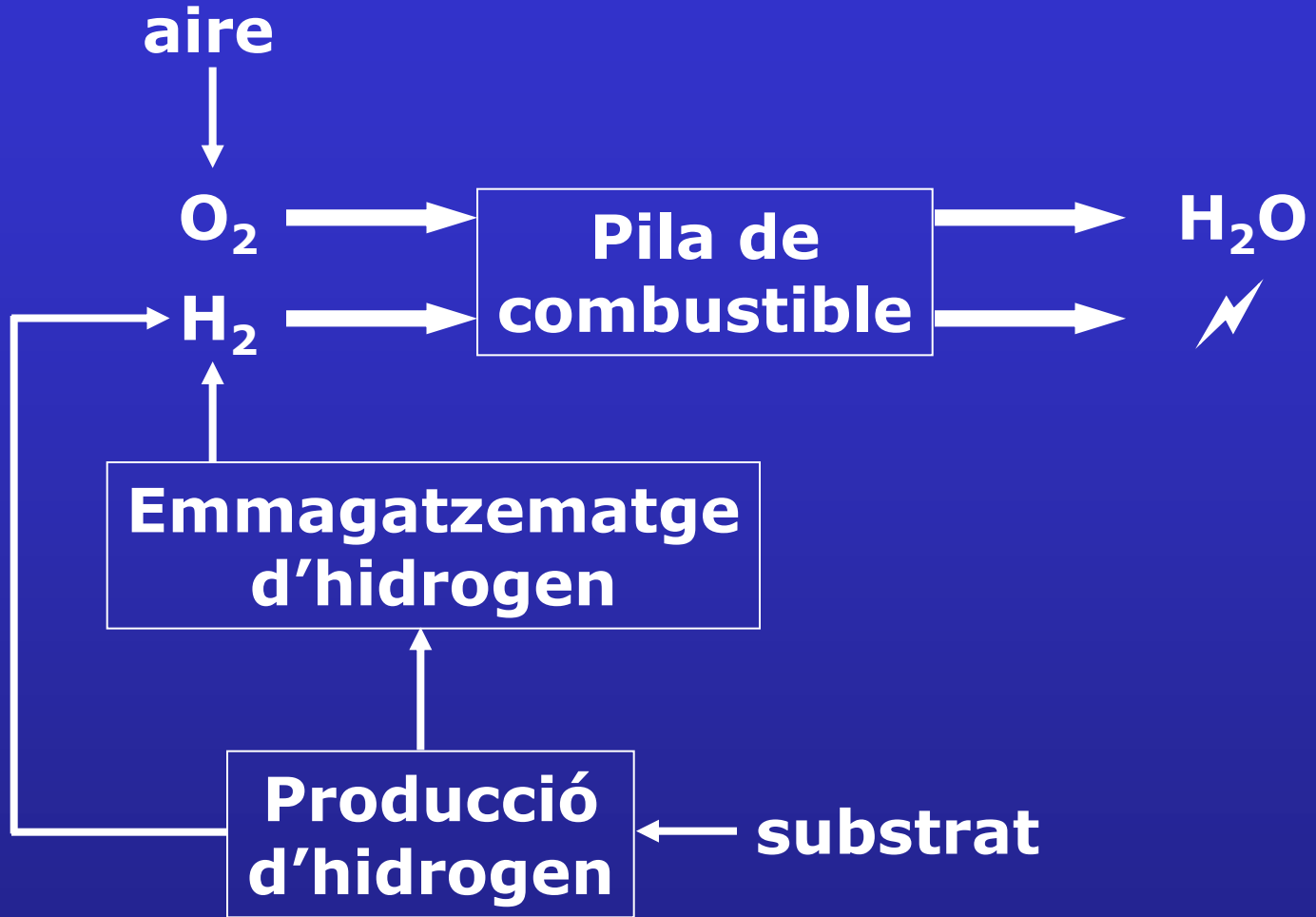






# A challenging European hydrogen vision





## Ús energètic de l'H<sub>2</sub>:

- per combustió ( $\Delta H = -241,8 \text{ kJmol}^{-1}$ )
- en piles de combustible







turbina de hidrógeno

Separación del depósito de hidrógeno y oxígeno



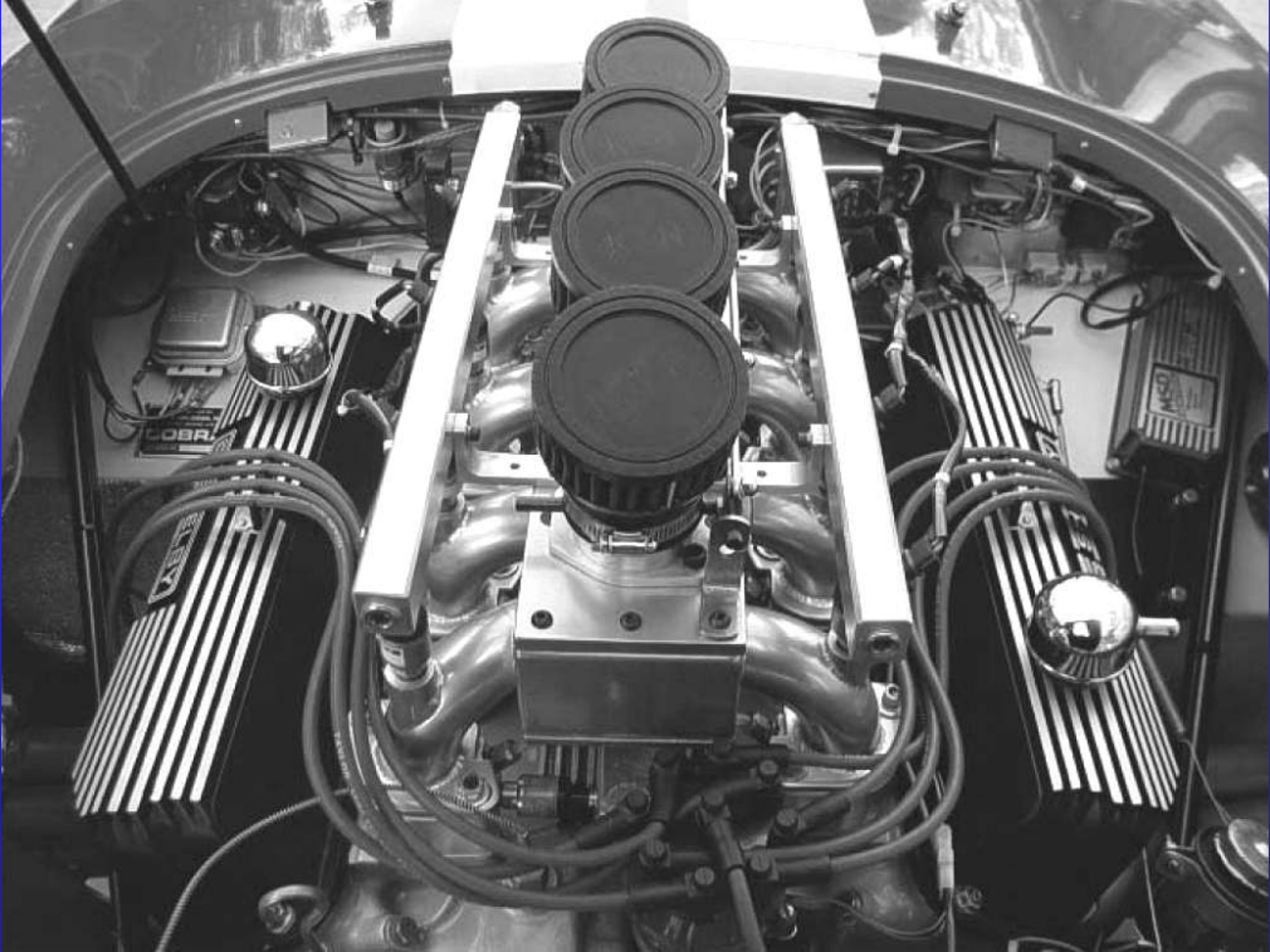
Separación de los motores convencionales

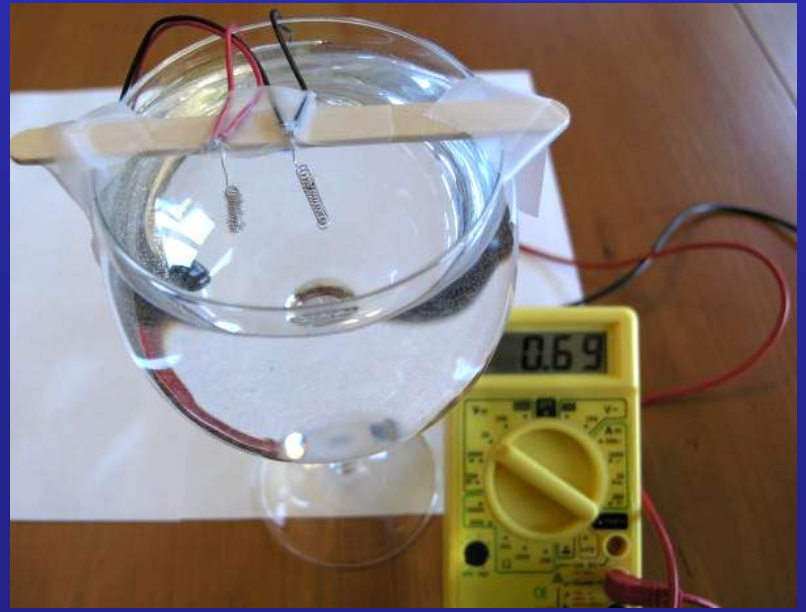
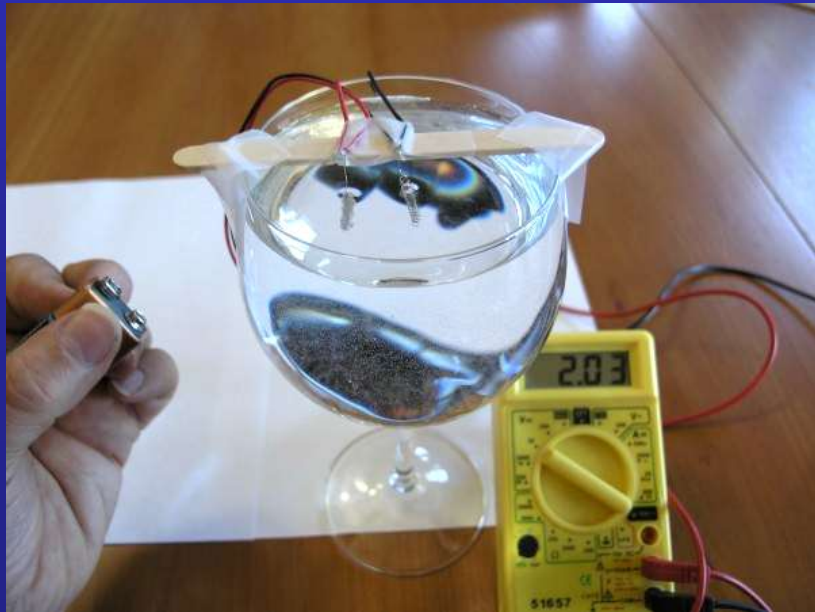
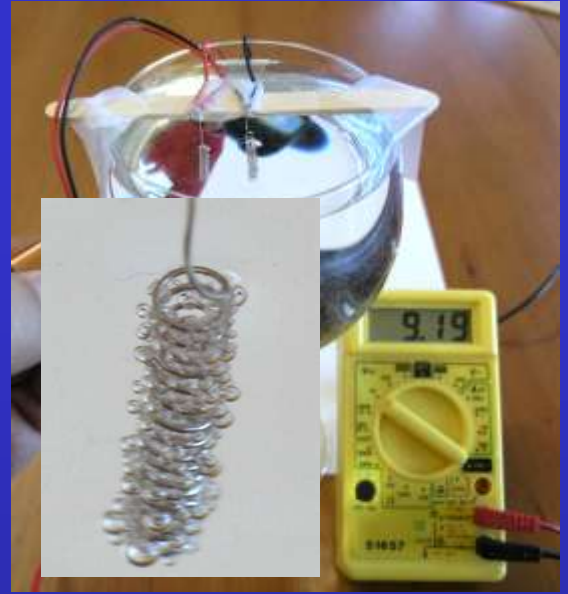
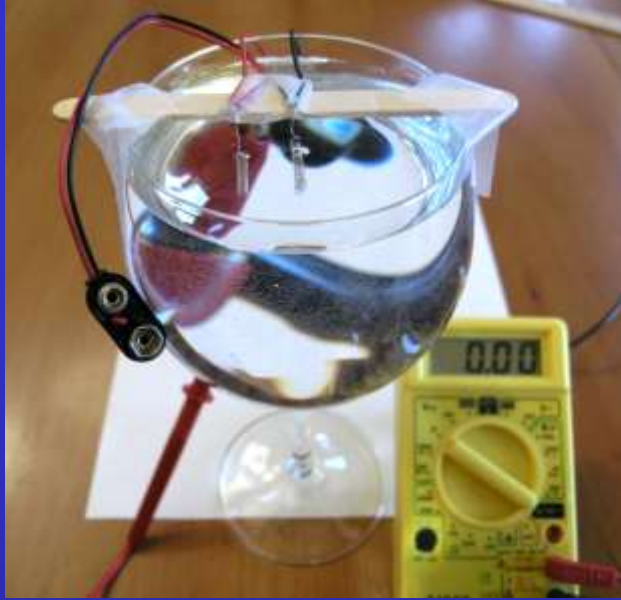
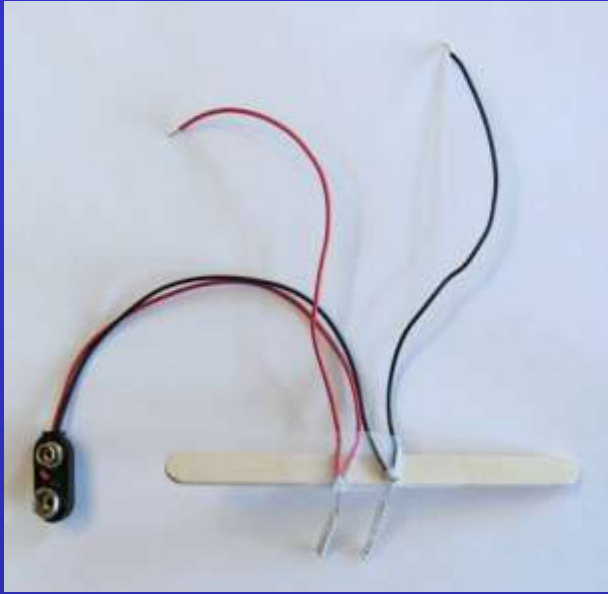


Space Shuttle en órbita



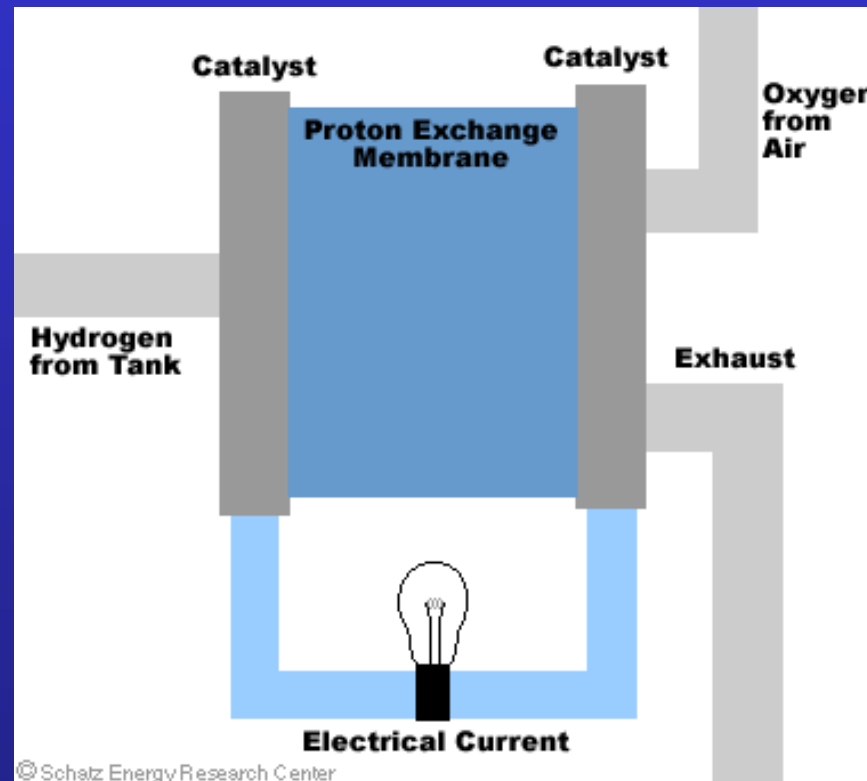
Despegue







Les piles de combustible transformen l'energia d'una reacció química directament en electricitat (i calor)

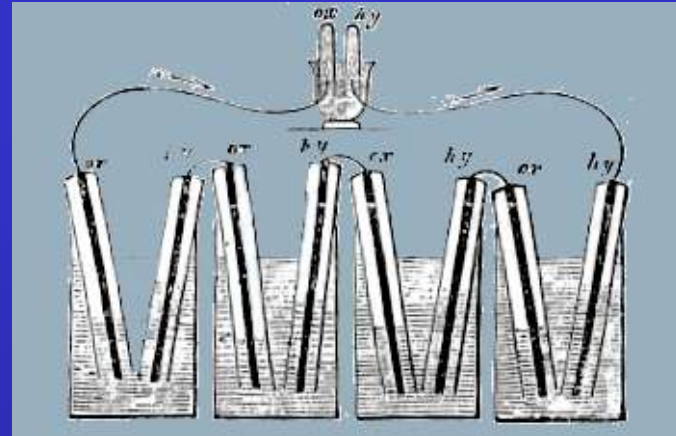


PEMFC



1839: s'inventa la pila de combustible

William Grove



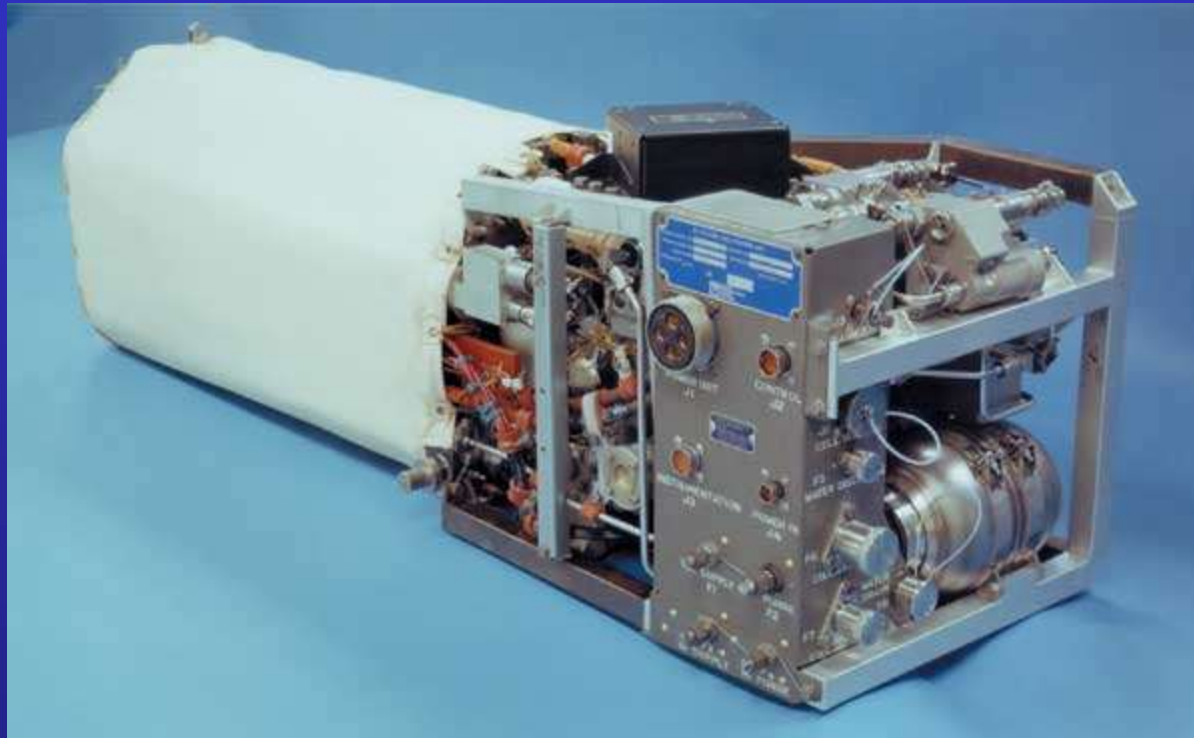
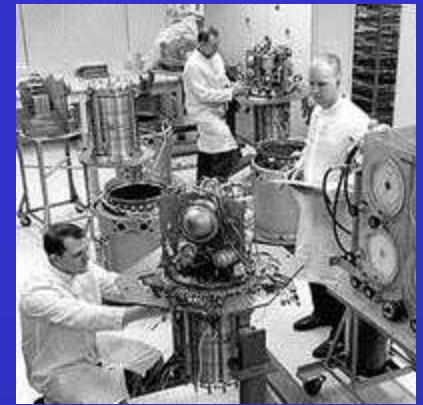
1889: primer intent de produir energia

Ludwig Mond-Charles Langer

1932: primera pila de combustible operativa

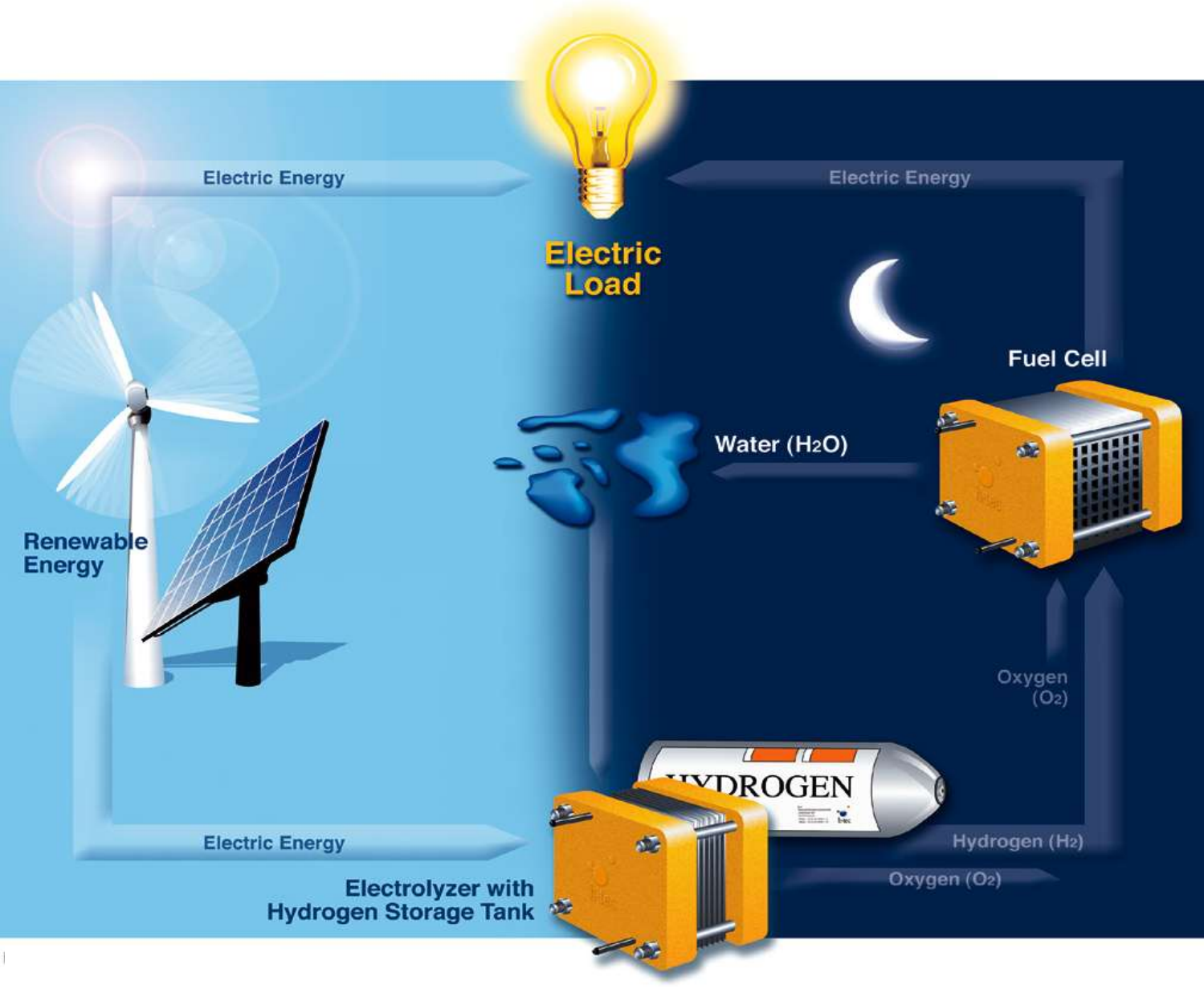
Francis Bacon

1960: primera aplicació NASA



Space shuttle AFC, 12 kW

# I. Aplicacions estacionàries:







Vaillant, 1-4,5 kW

Ballard 250 kW



Long Island, 2001



UTC 200 kW



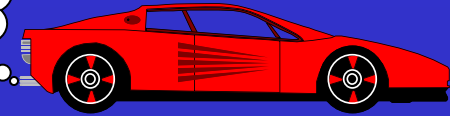
CA0479

Alaska, 2005

## II. Aplicacions mòbils:



H<sub>2</sub>O



## Vehicles d'emissió zero:



Austin A40, 1970 AFC  
Dr. Karl Kordesch  
Union Carbide, Ohio

- Daimler-Benz/Ford/Ballard



- Toyota



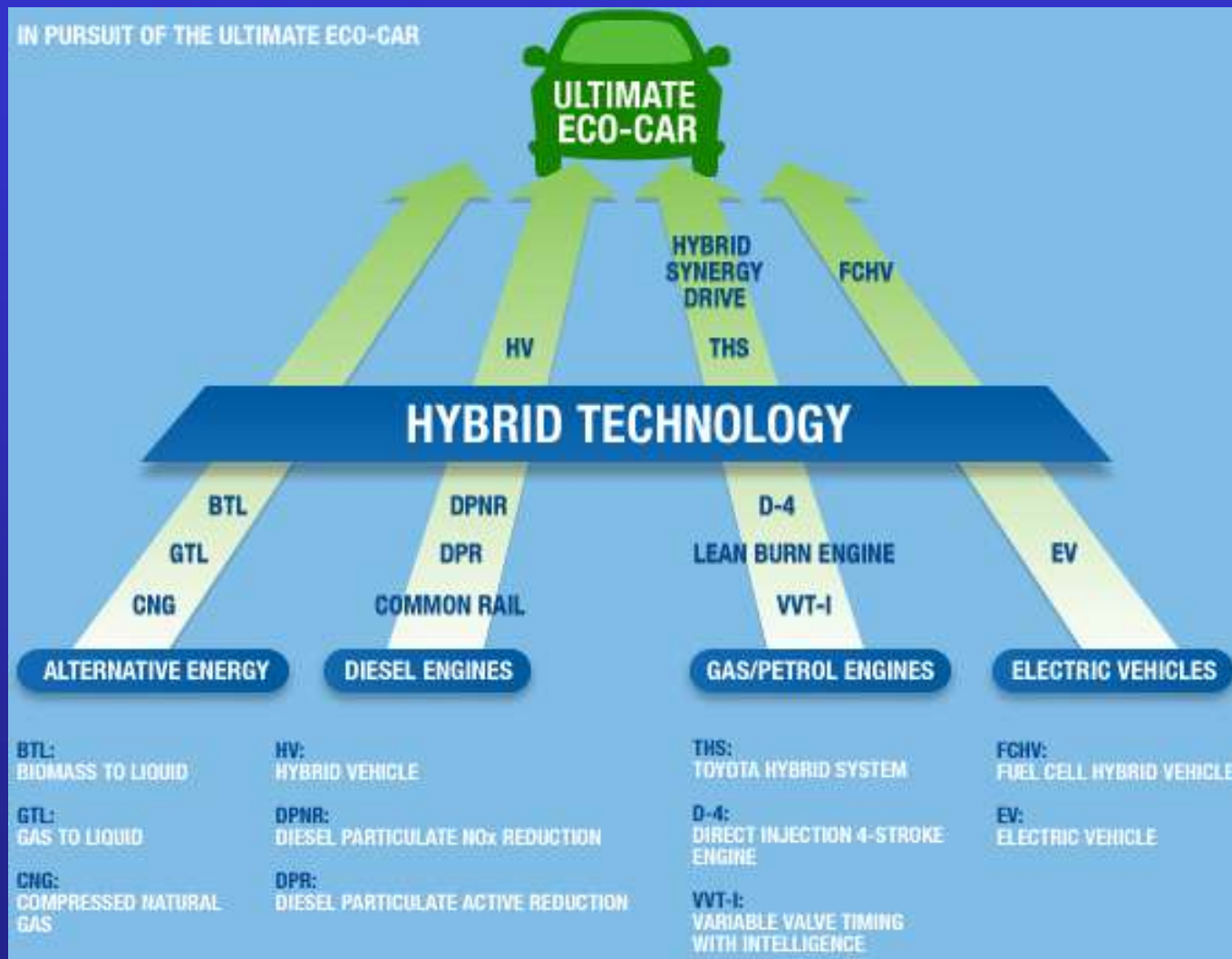
- Honda



- General Motors/Opel/Exxon



# Vehicles híbrids:





Islàndia, abril 2003



## Worldwide Hydrogen Refuelling Stations



Current number of database entries: **227**





Manhattan Scientifics, 2002



Honda, 2005

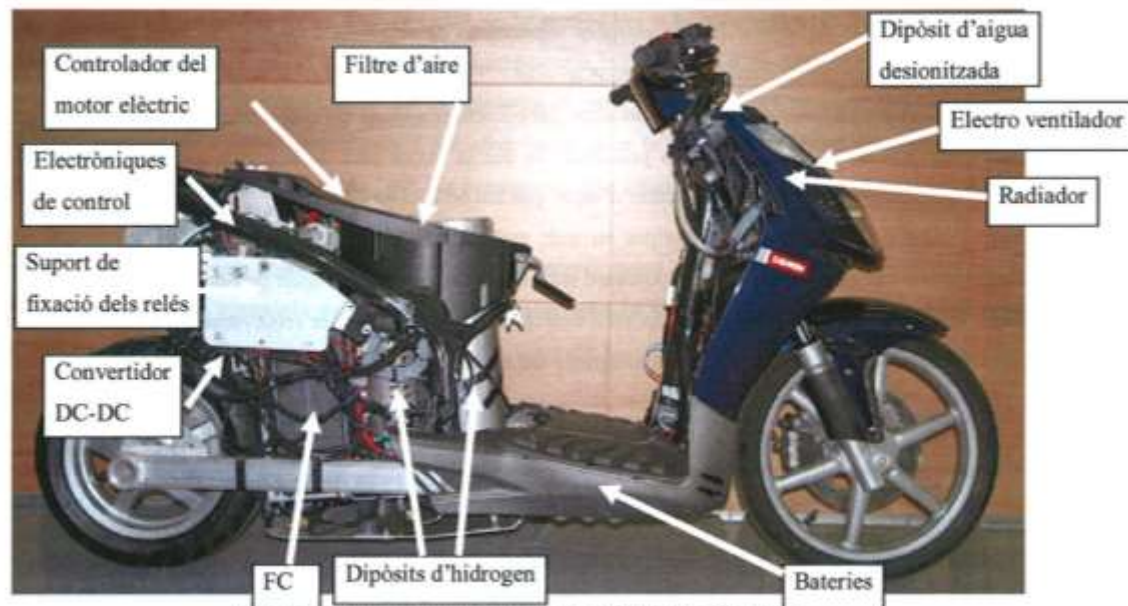


### 3.5.1 Lateral esquerra



Fotografia 13 Prototipus final. Sense carenat, vista esquerra

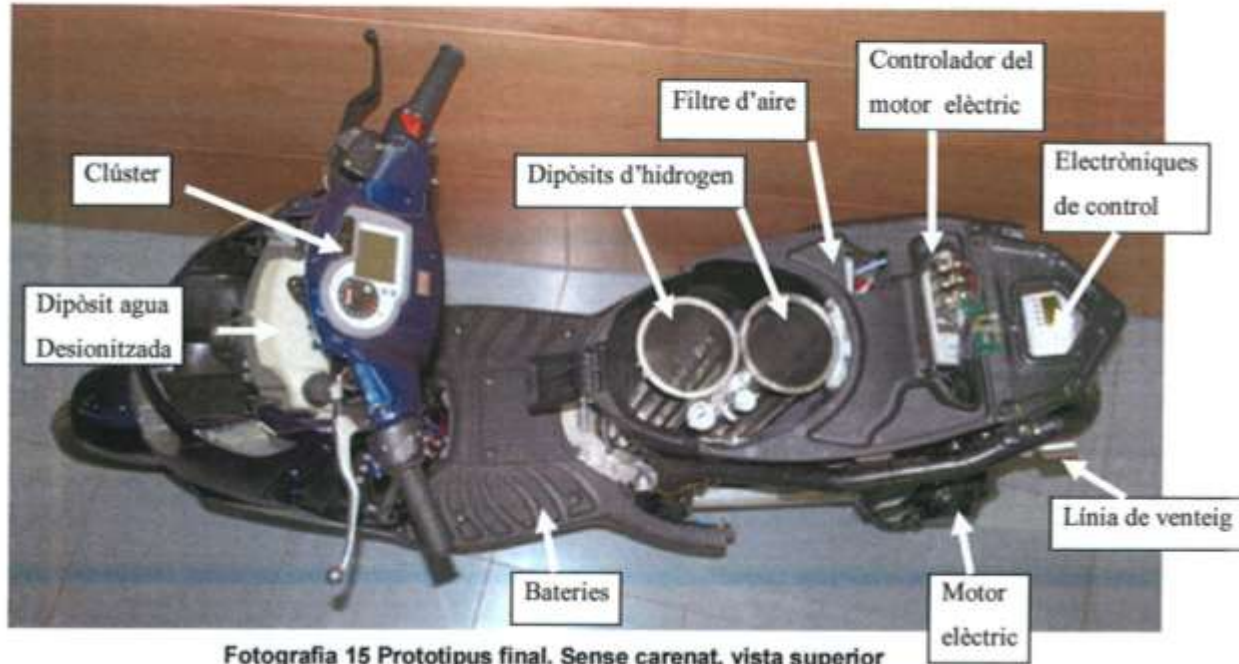
### 3.5.2 Lateral dret



Fotografia 14 Prototipus Final. Sense carenat, vista dreta



### 3.5.3 Vista superior



Fotografia 15 Prototipus final. Sense carenat, vista superior





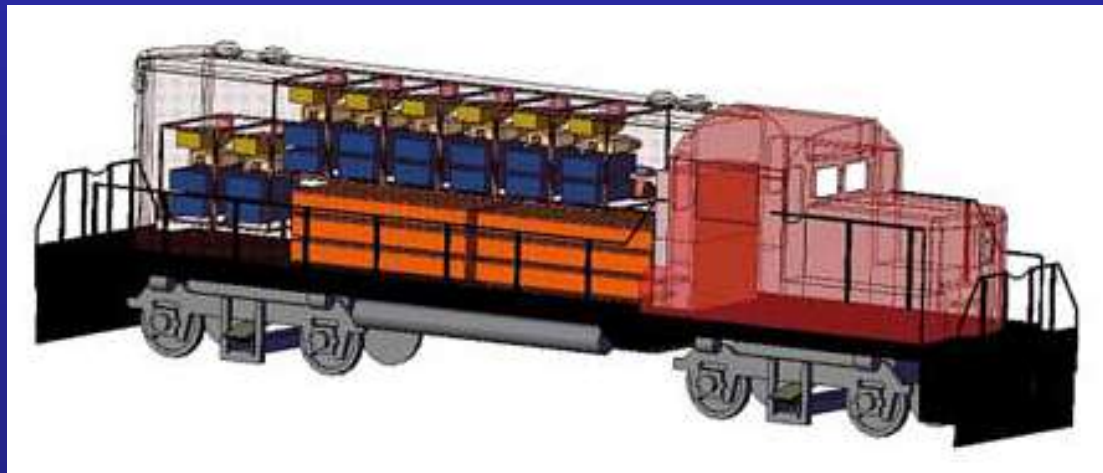
Aprilia, abril 2003  
45 km/h  
1,2 kW PEMFC



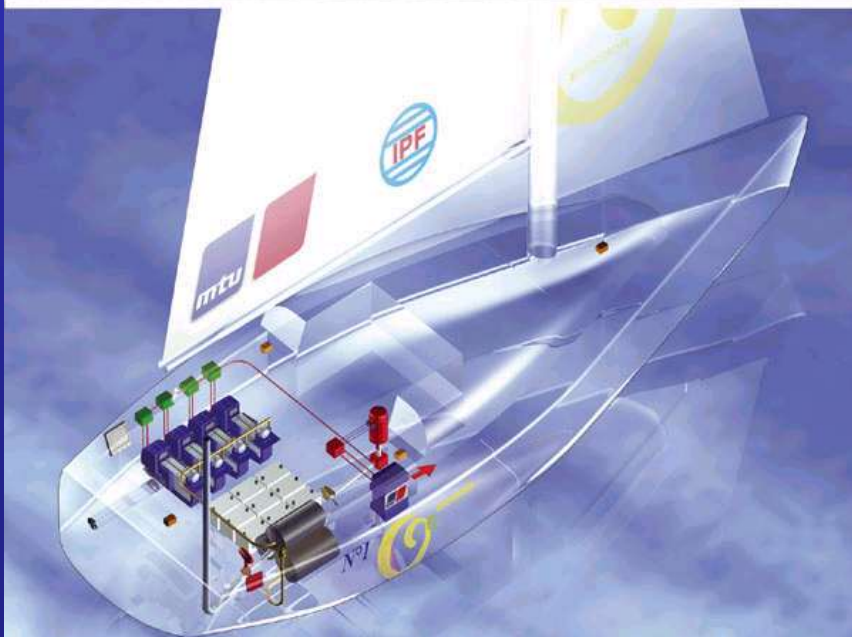
**FASTec, 2003**



DoD, 2004







MTU, 2003













**U31, Alemanya, 2003**

# Autobusos urbans a Los Angeles, Chicago, Munich, Vancouver, Tòquio...





AUTOBUSOS AMB FUTUR | UNA APOSTA FERMA

# NETS I MODERNS

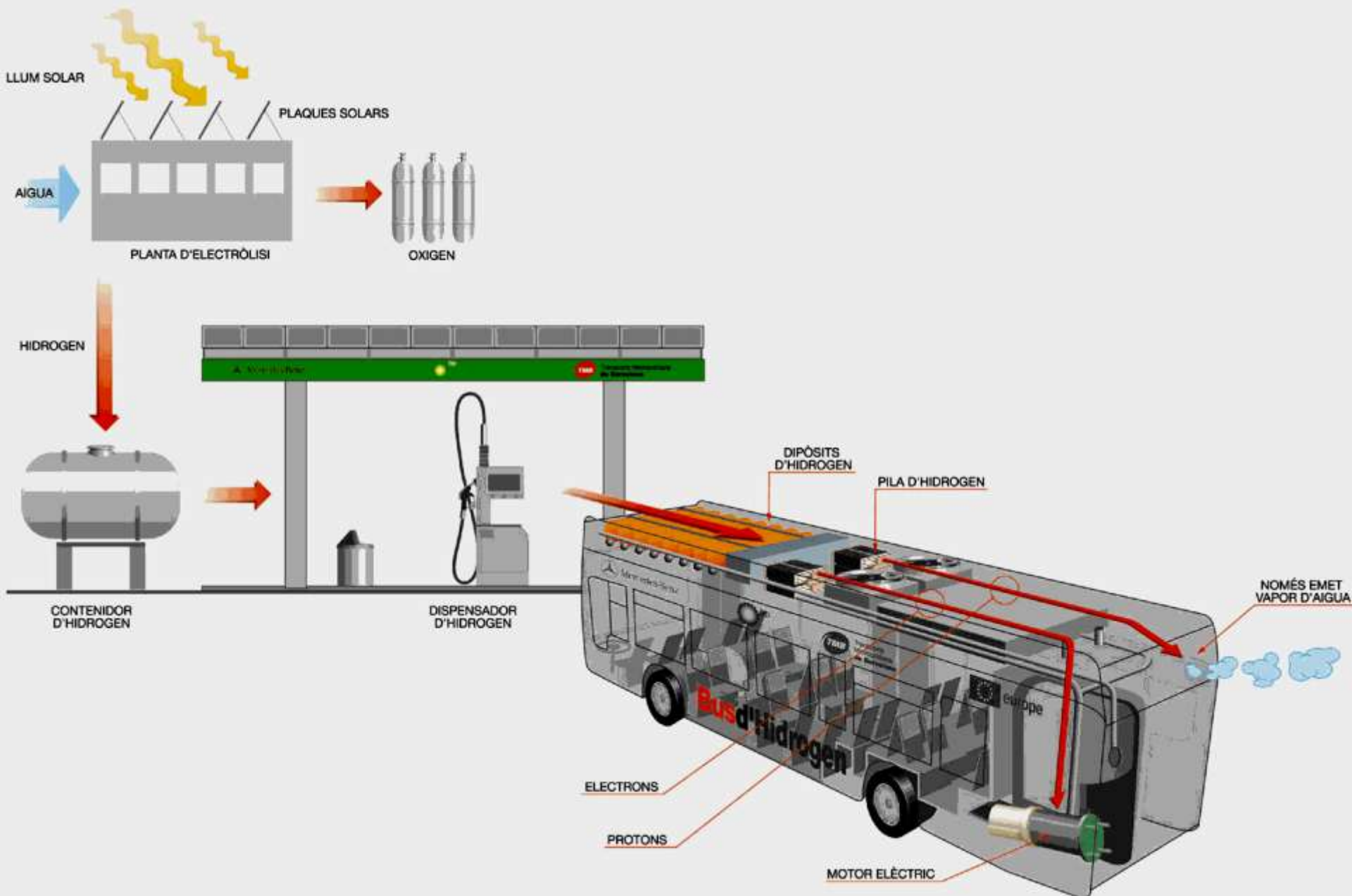
La recent entrada en servei de tres autobusos propulsats per hidrogen reflecteix la determinació de Transports Metropolitans de Barcelona per millorar i fer més ecològica la seva nombrosa flota.

FERHAN NADEU



■ **Ecològic** Un dels tres Mercedes Citaro de pila d'hidrogen de TMB, davant de l'estació de BP on reposten.

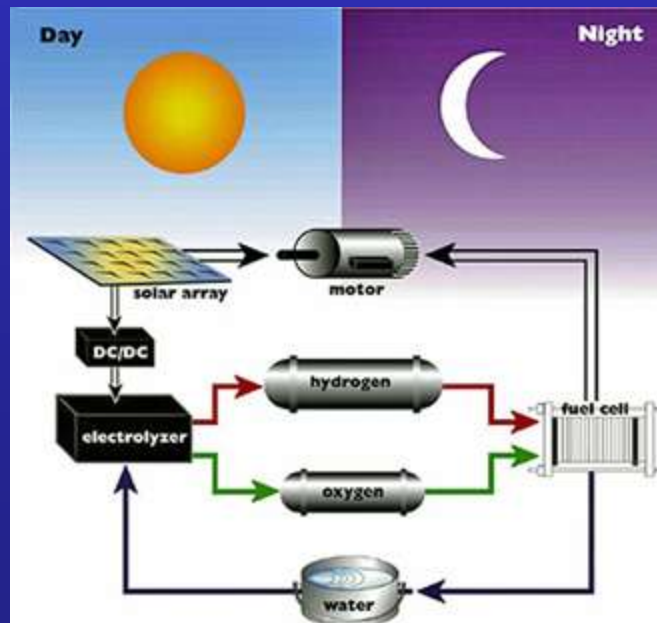
El Periódico, 7 de desembre de 2003



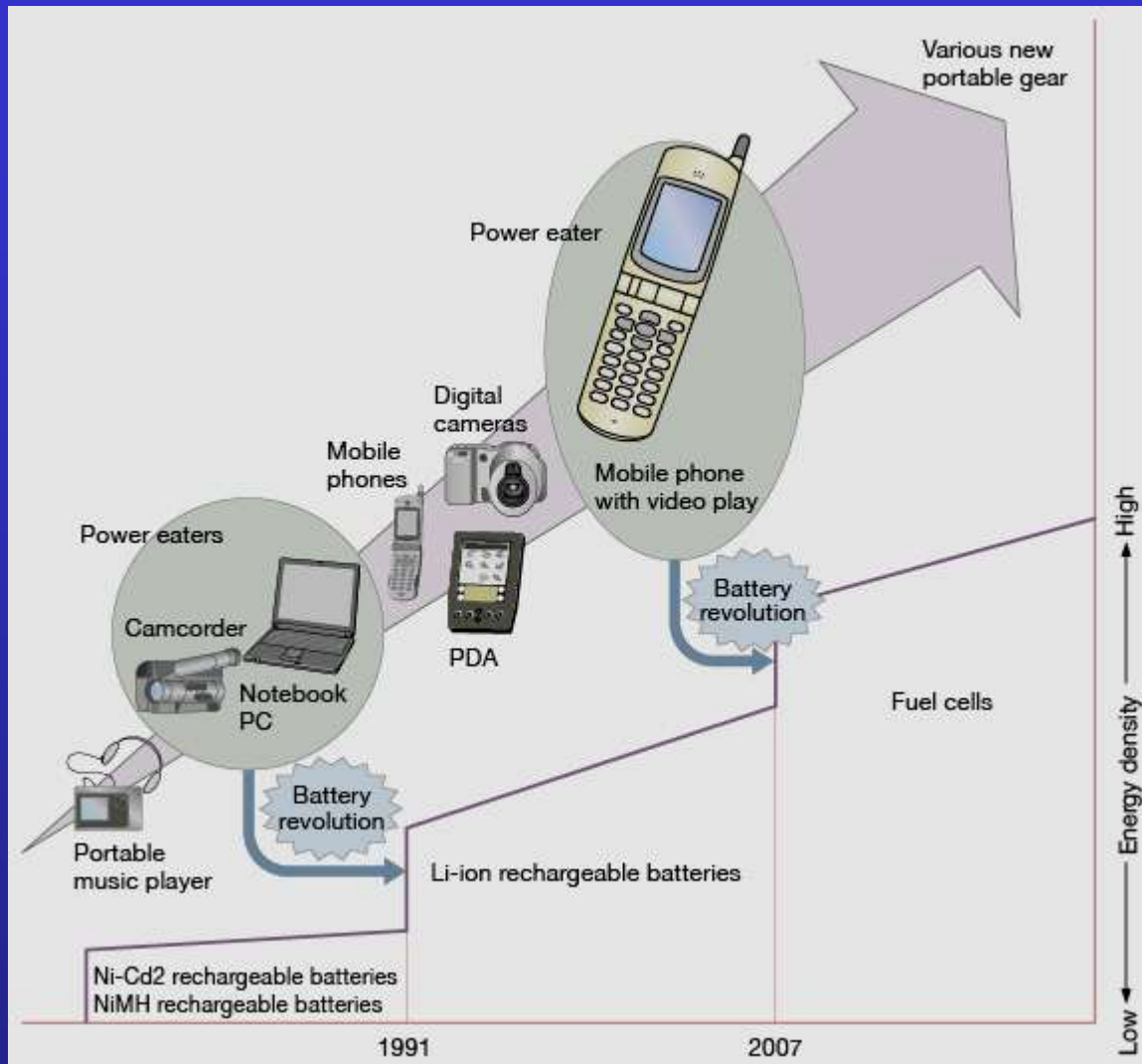


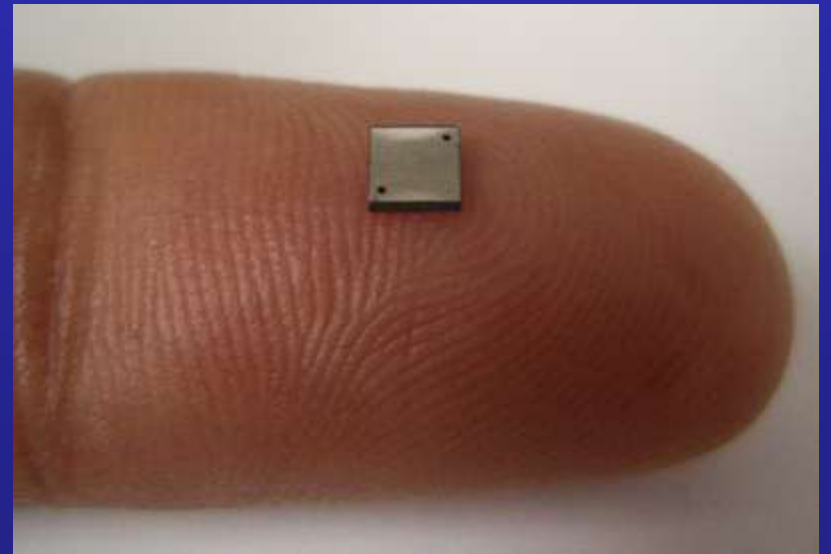
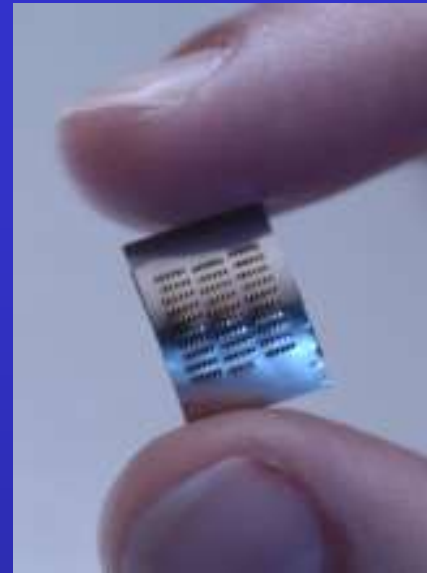
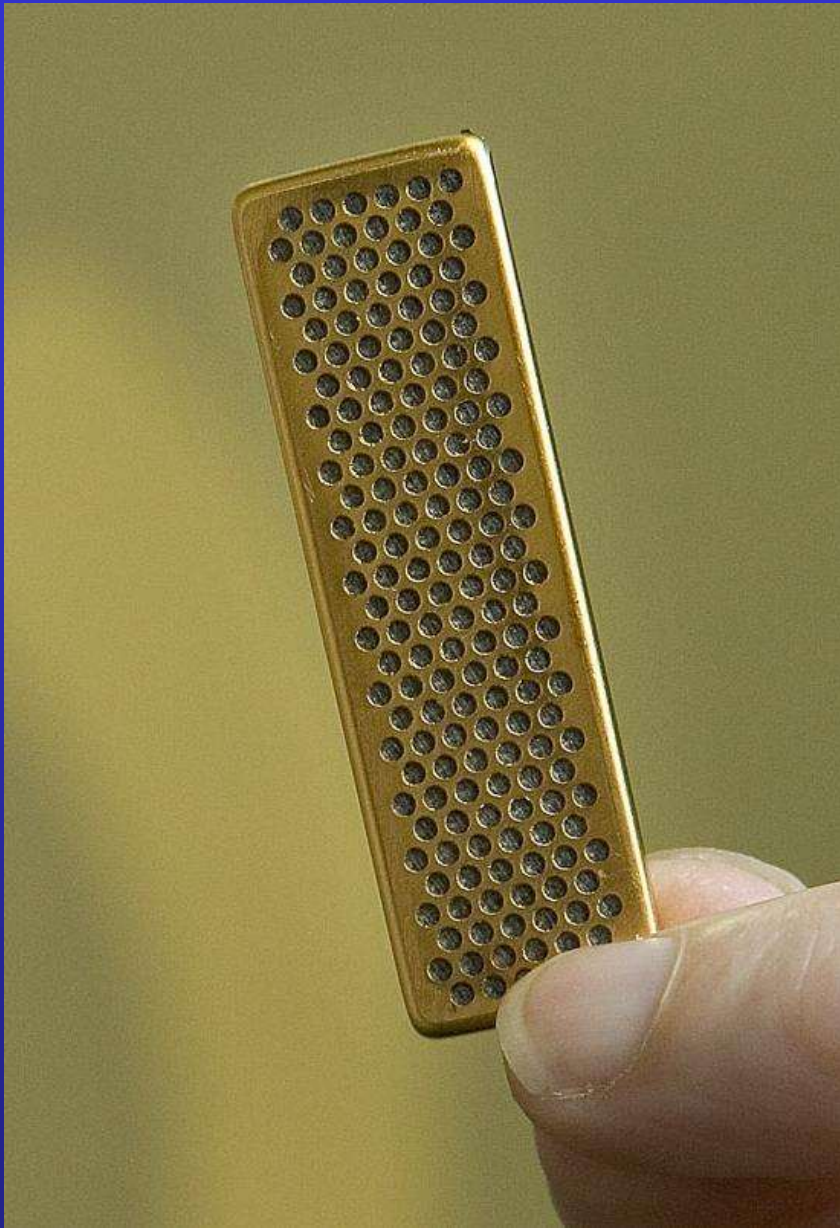


## Helios (NASA)



### III. Aplicacions portàtils:









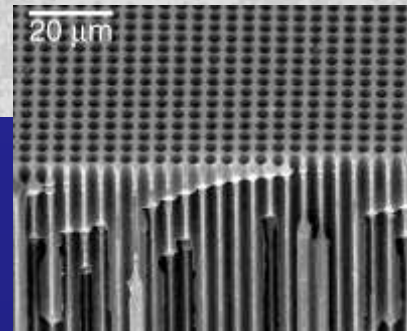
Casio (DMFC, 20h seguides)



LG



**KDDI (DMFC, 320h seguides!)**





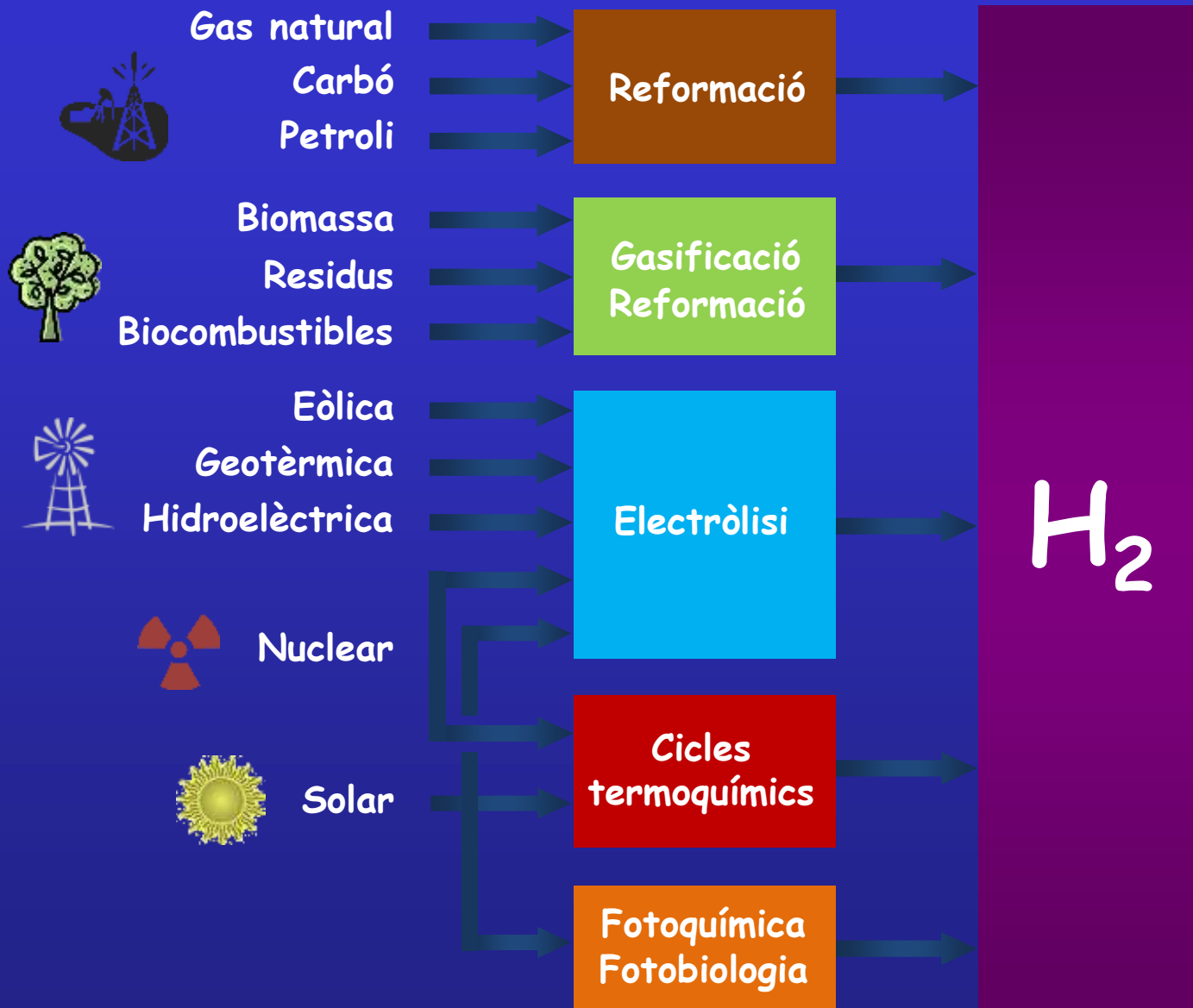
**Vector energètic**

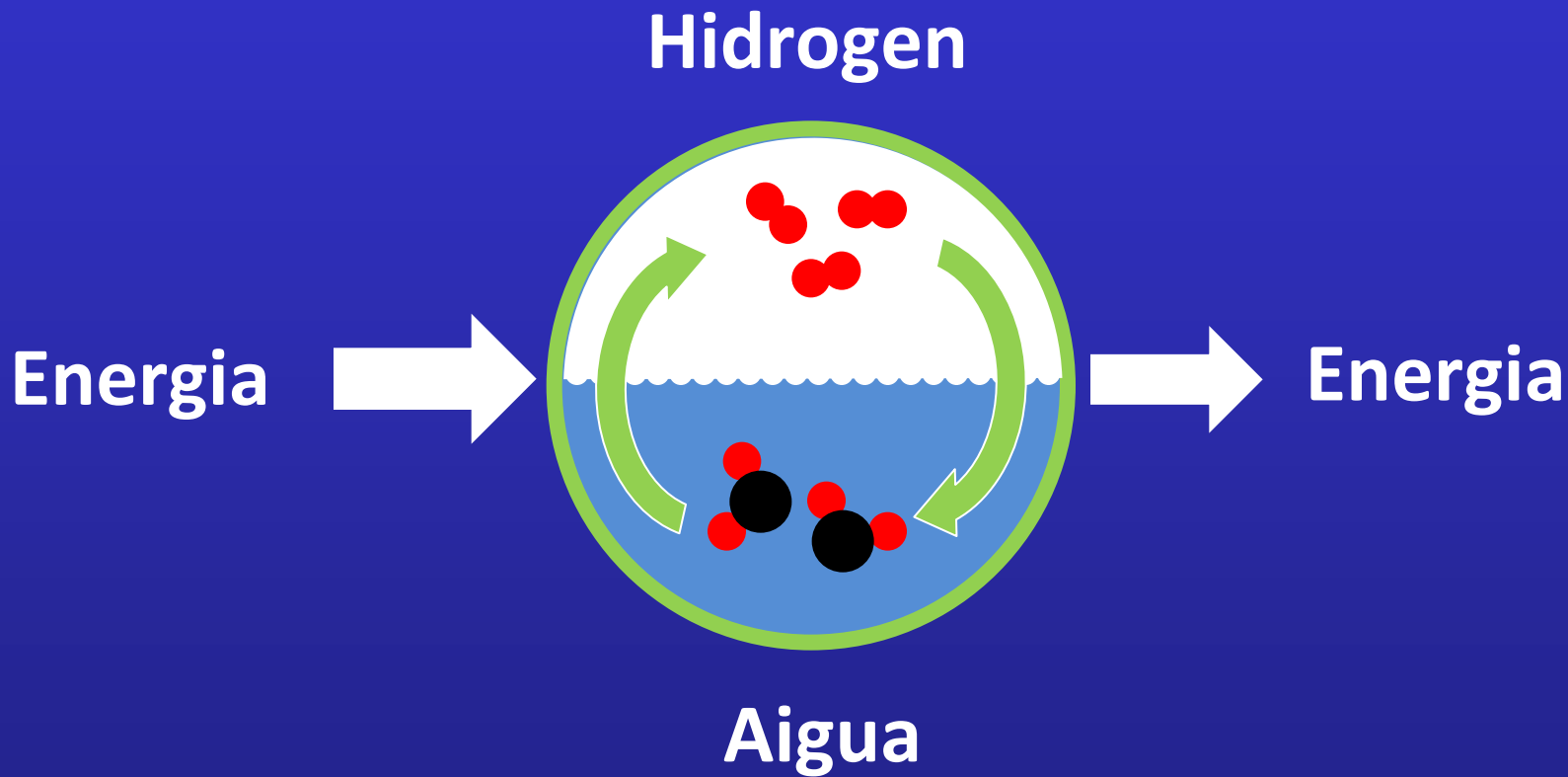
extracció física

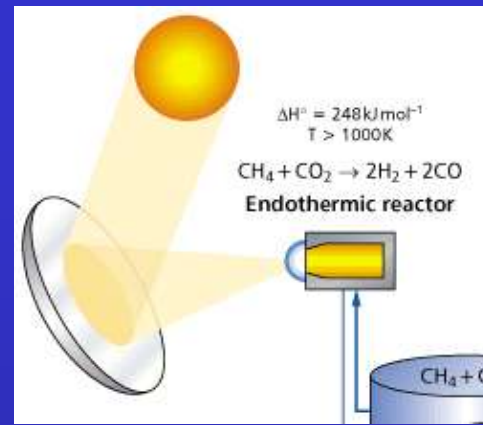
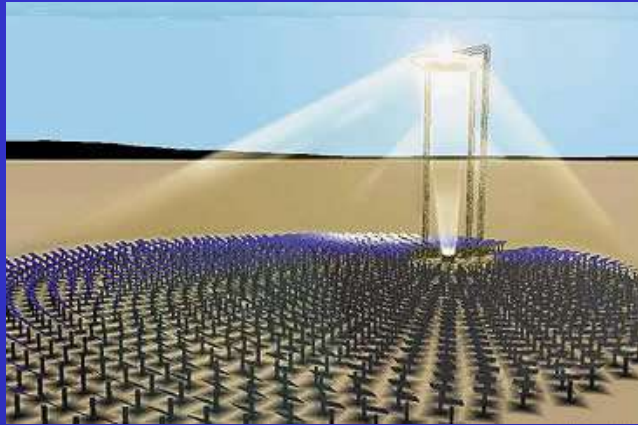
extracció química



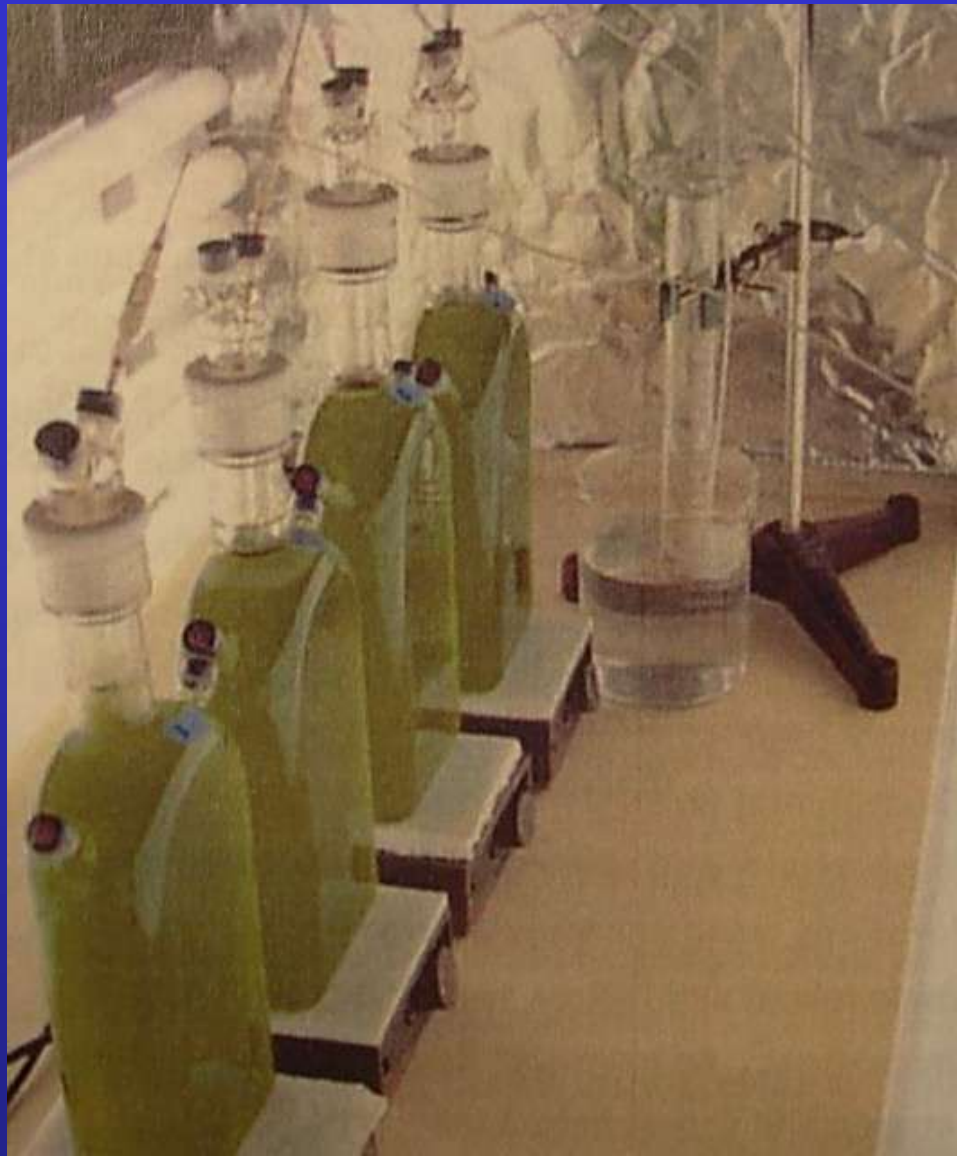
C/H:      9:1      1,5:1      1:2      1:4      0:1

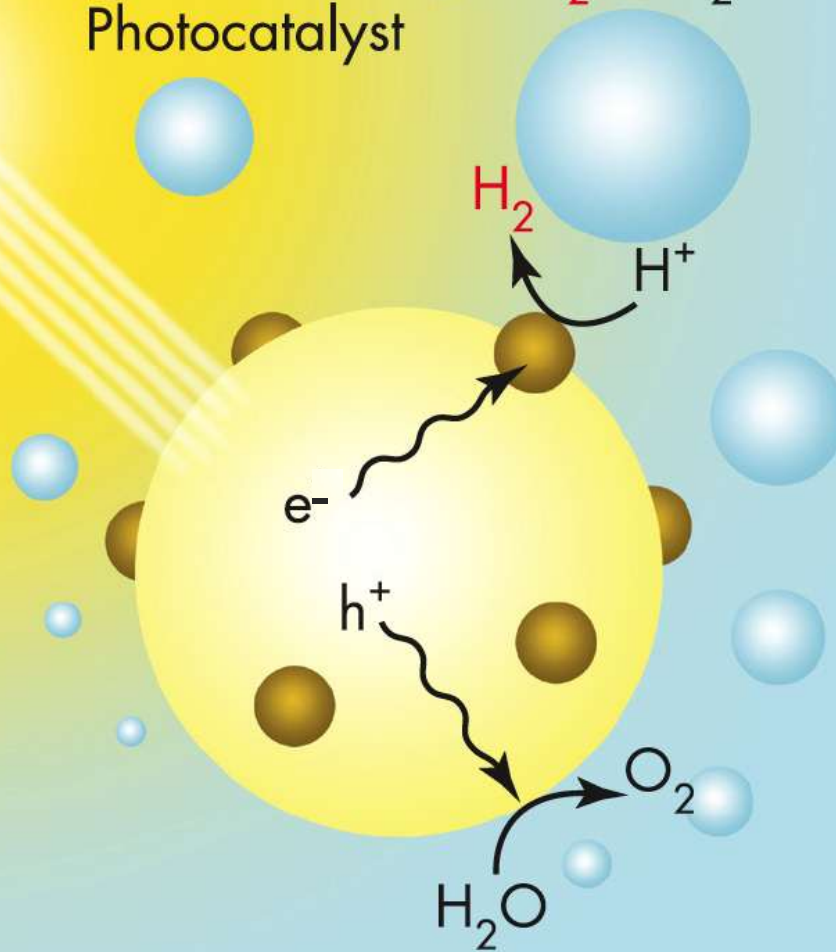
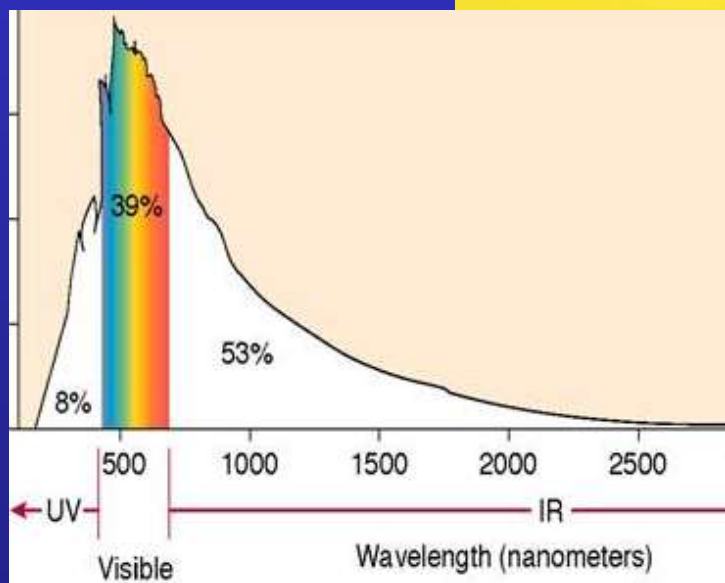






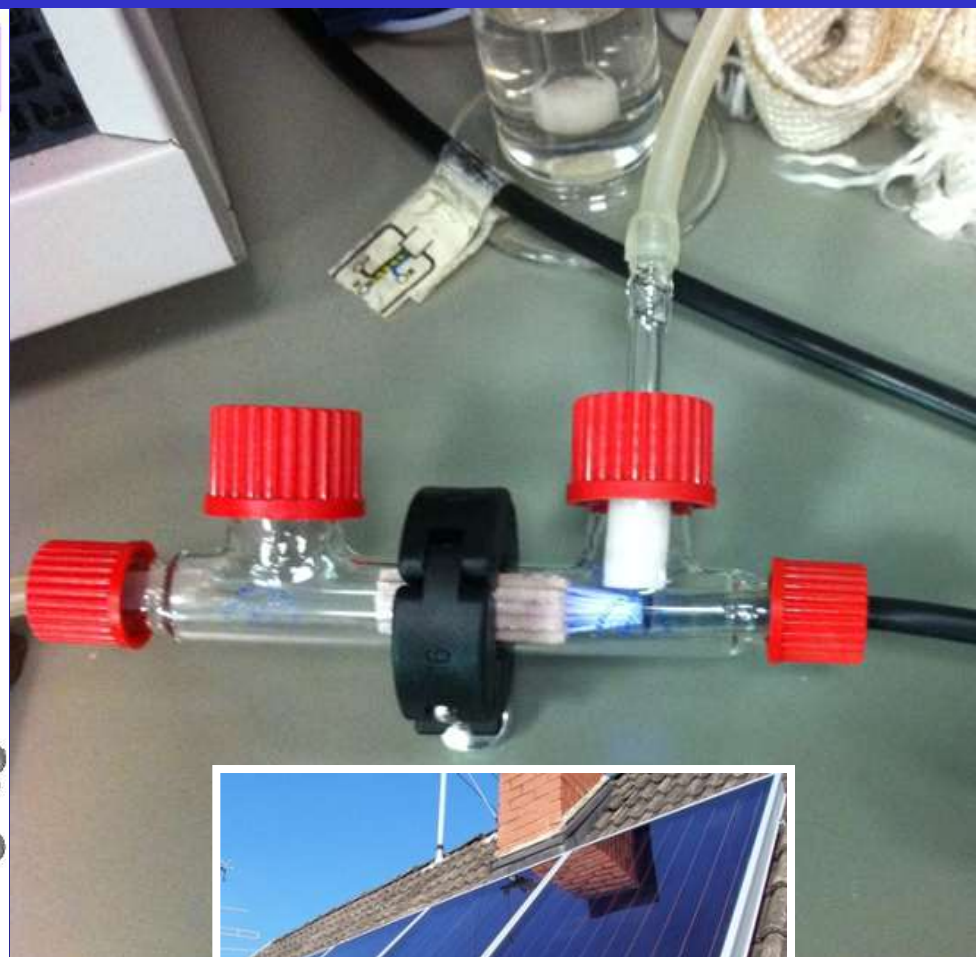
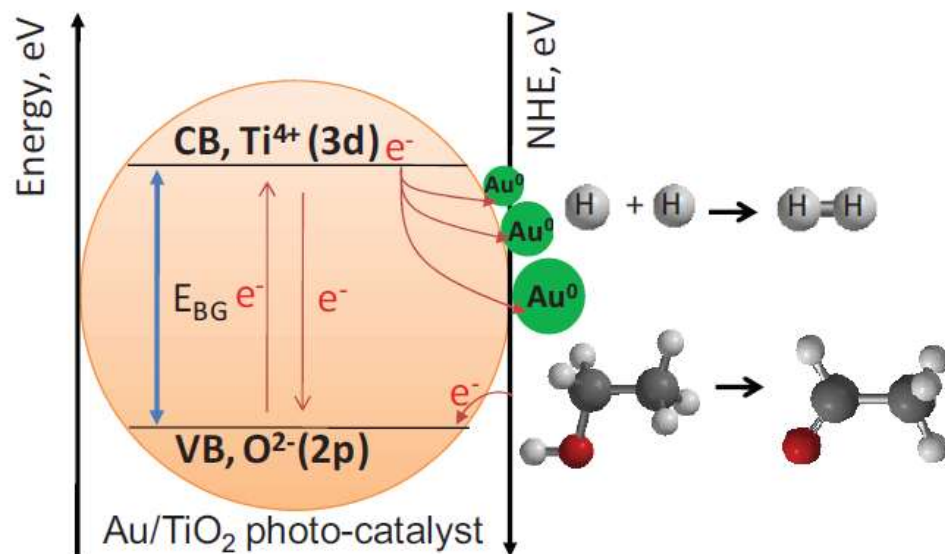




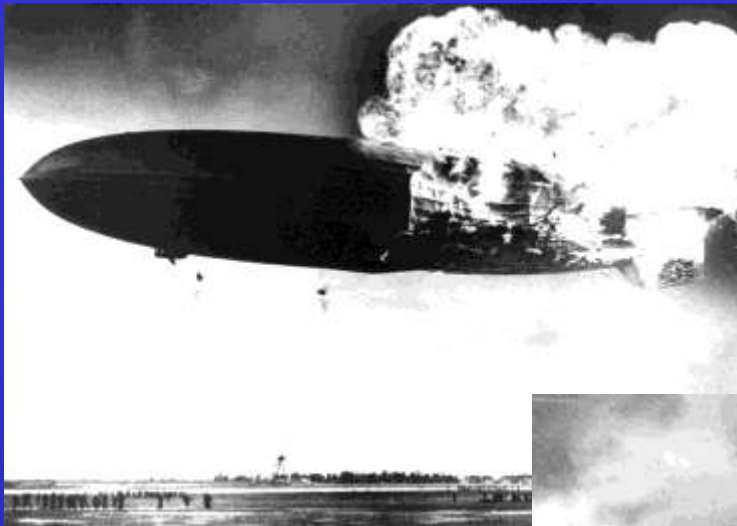


# The effect of gold loading and particle size on photocatalytic hydrogen production from ethanol over Au/TiO<sub>2</sub> nanoparticles

M. Murdoch<sup>1,2</sup>, G. I. N. Waterhouse<sup>3</sup>, M. A. Nadeem<sup>1,2,3</sup>, J. B. Metson<sup>3</sup>, M. A. Keane<sup>4</sup>, R. F. Howe<sup>5</sup>, J. Llorca<sup>3</sup> and H. Idriss<sup>1,2,\*</sup>



És perillós l'hidrogen?



Hindenburg, 1937





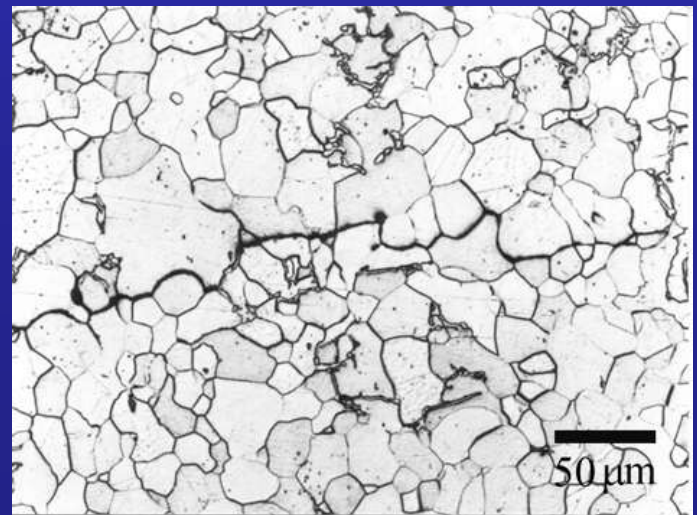
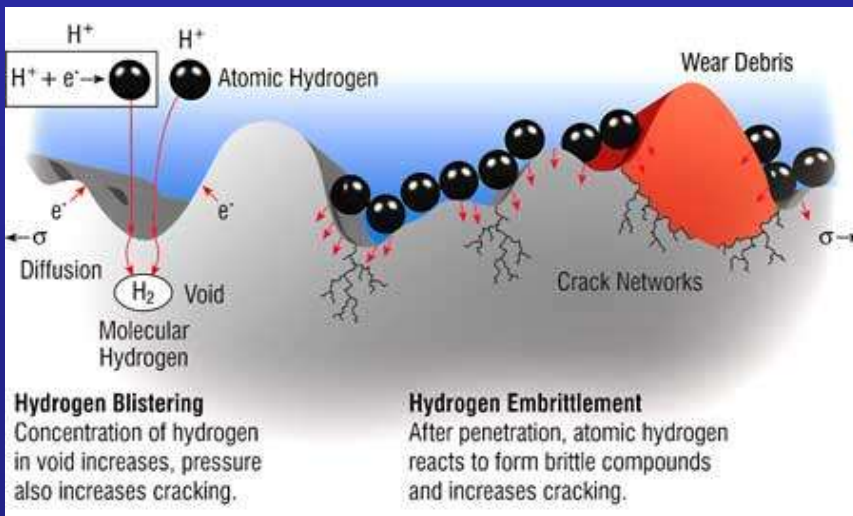
Mescles en aire	inflamable	explosiu
hidrogen	4 %	13 %
benzina	1 %	1,1 %
metà	5,3 %	6,3 %

índex de perillositat:

propà > benzina > hidrogen = gas natural

# Exercici 15. Quina de les dues situacions d'incendi és més perillosa?











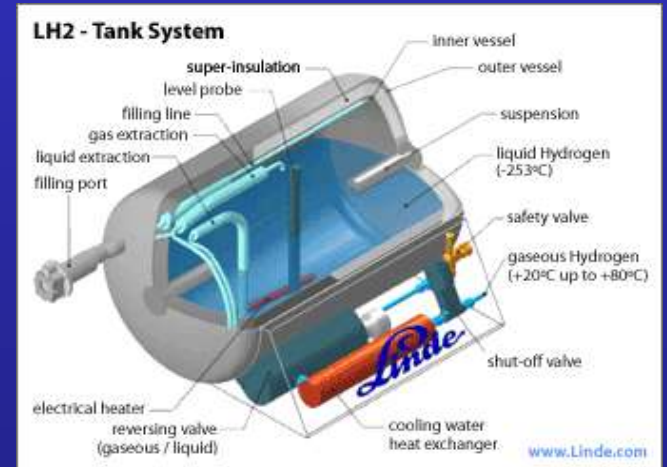
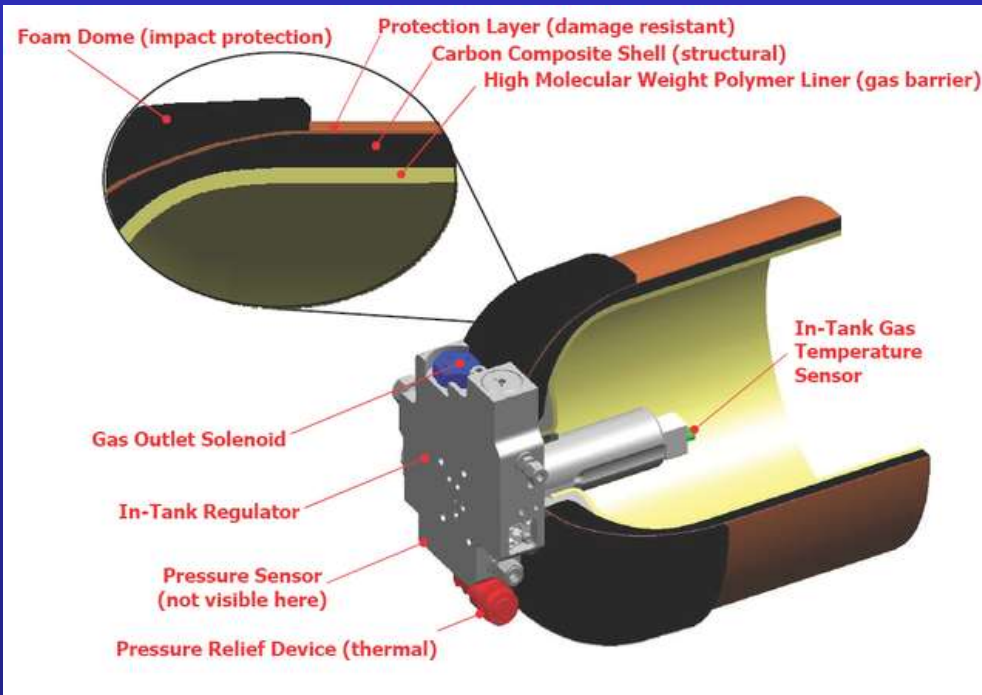
H<sub>2</sub> comprimit



Quantum, 350 bar



GM, 700 bar

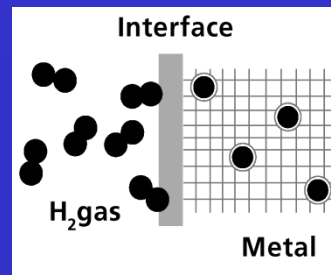


Linde

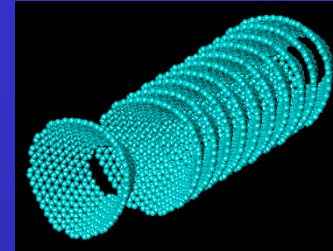
Quantum



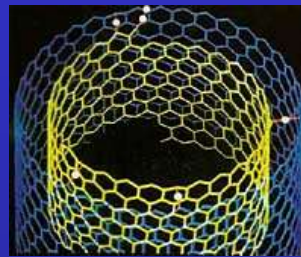
- aliatges metàl·lics



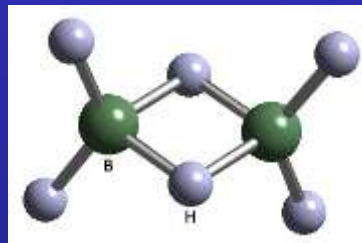
- materials amorfs (C, BAMs)



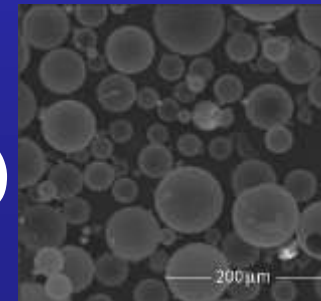
- nanotubs (C, BN)



- hidrurs



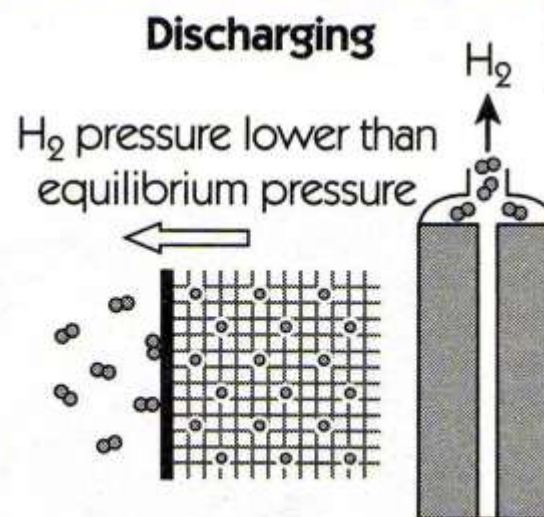
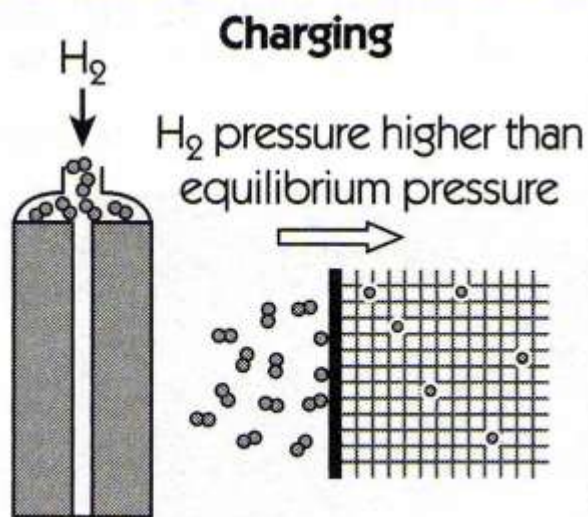
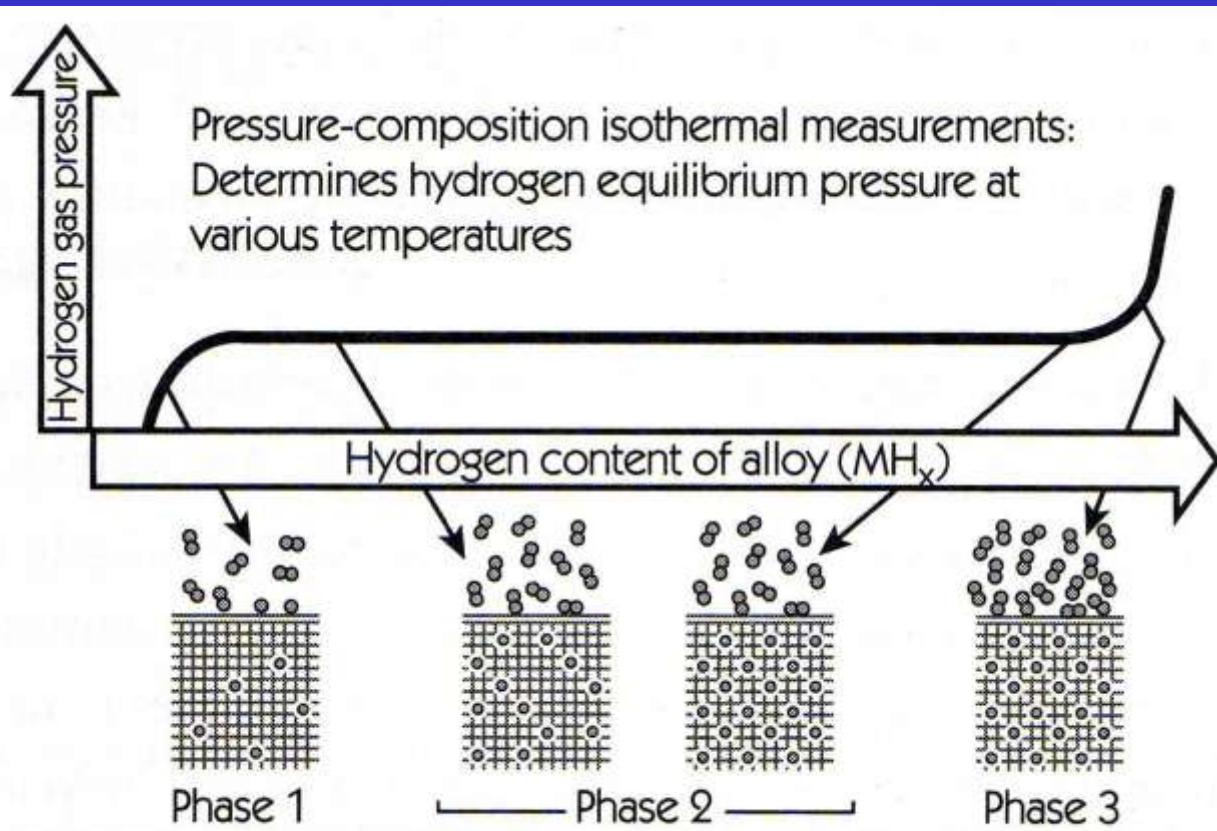
- microesferes (vidre, polímers)



- híbrids orgànics-inorgànics (MOFs)



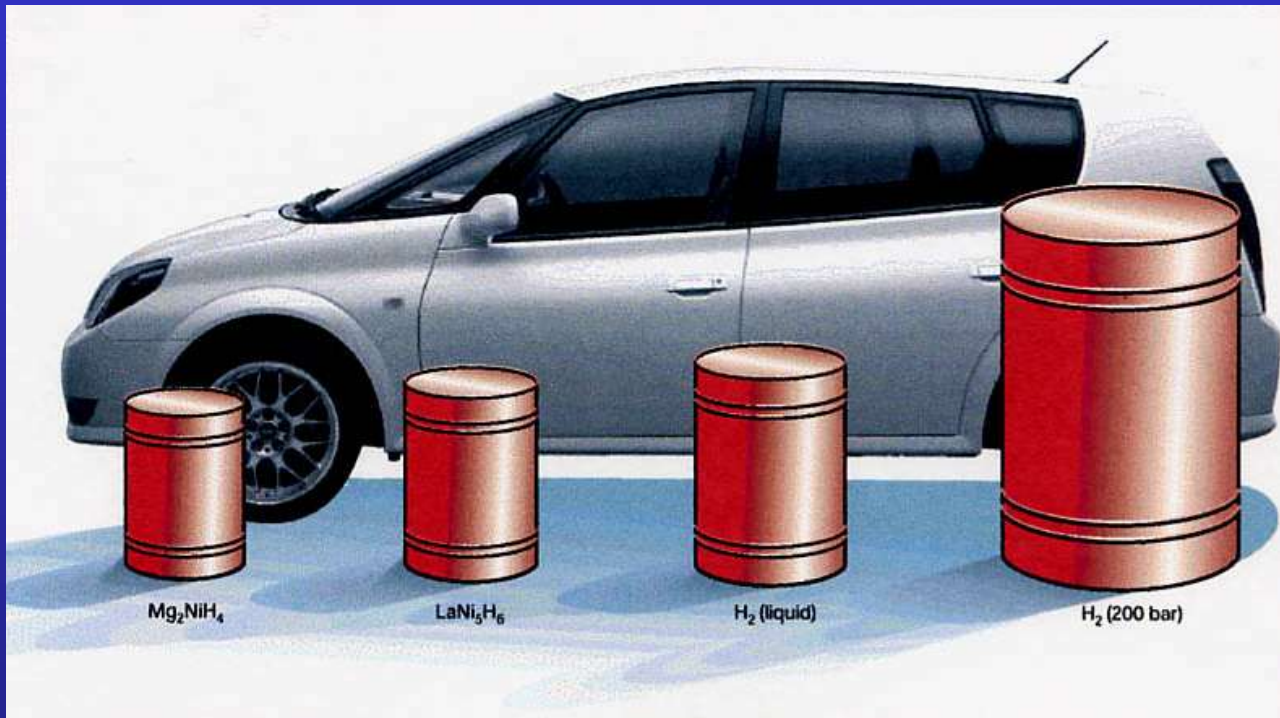








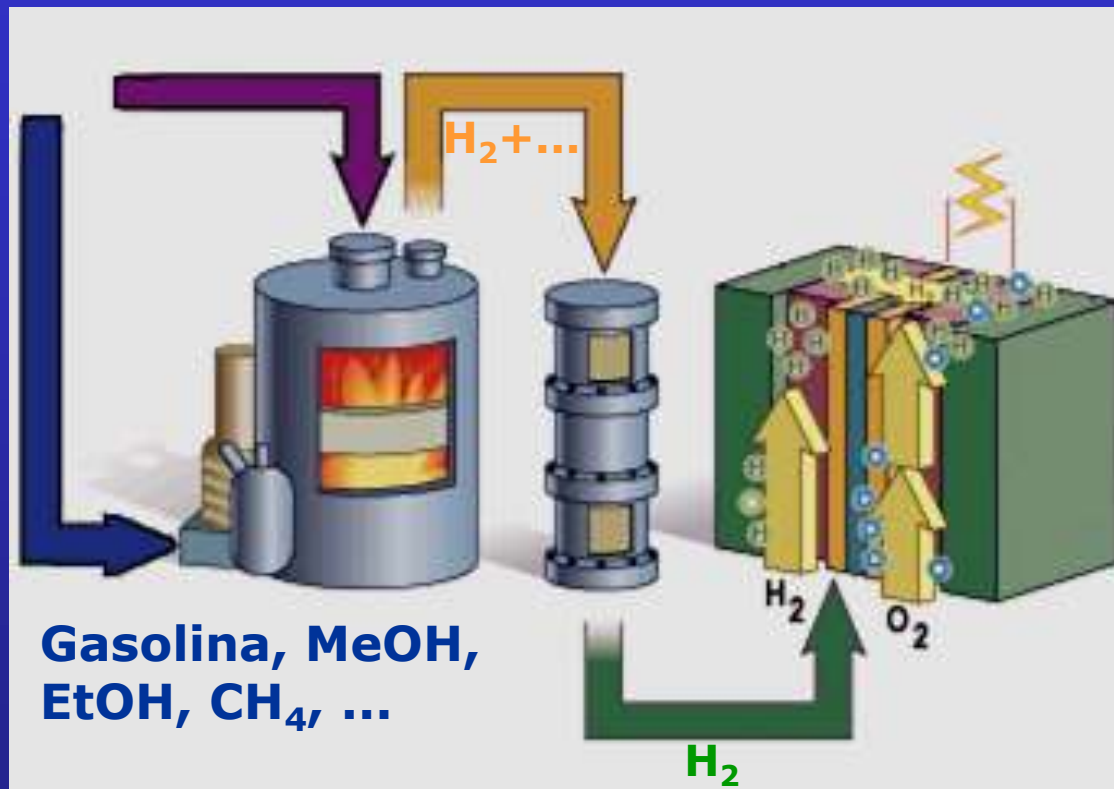
Dipòsit necessari per a emmagatzemar 4 kg d'H<sub>2</sub>:  
(~350 km amb un cotxe amb pila de combustible)



Producció d'H<sub>2</sub> *in situ*: No cal emmagatzematge!

Producció d'hidrogen

Pila de combustible





# Amb gas natural o biogàs:

## 1. Fuel Processor (Reformer)

The Fuel Processor reforms the fuel (natural gas or anaerobic digester gas) to a hydrogen rich gas to feed the fuel cell stack.

## 2. Fuel Cell Stack

Hydrogen rich gas and oxygen from the air are combined in an electro-chemical process that produces Direct Current (DC) power, pure water and heat. The byproduct water is utilized in the operation of the power plant. The waste heat is available through an integral hot water heat exchanger for use in meeting other facility thermal energy requirements.

## 3. Power Conditioner

The DC power provided by the Fuel Cell Stack is conditioned to provide high quality Alternating Current (AC) output power.

## 4. Electronics and Controls

Each PureCell™ system can be remotely controlled and monitored.

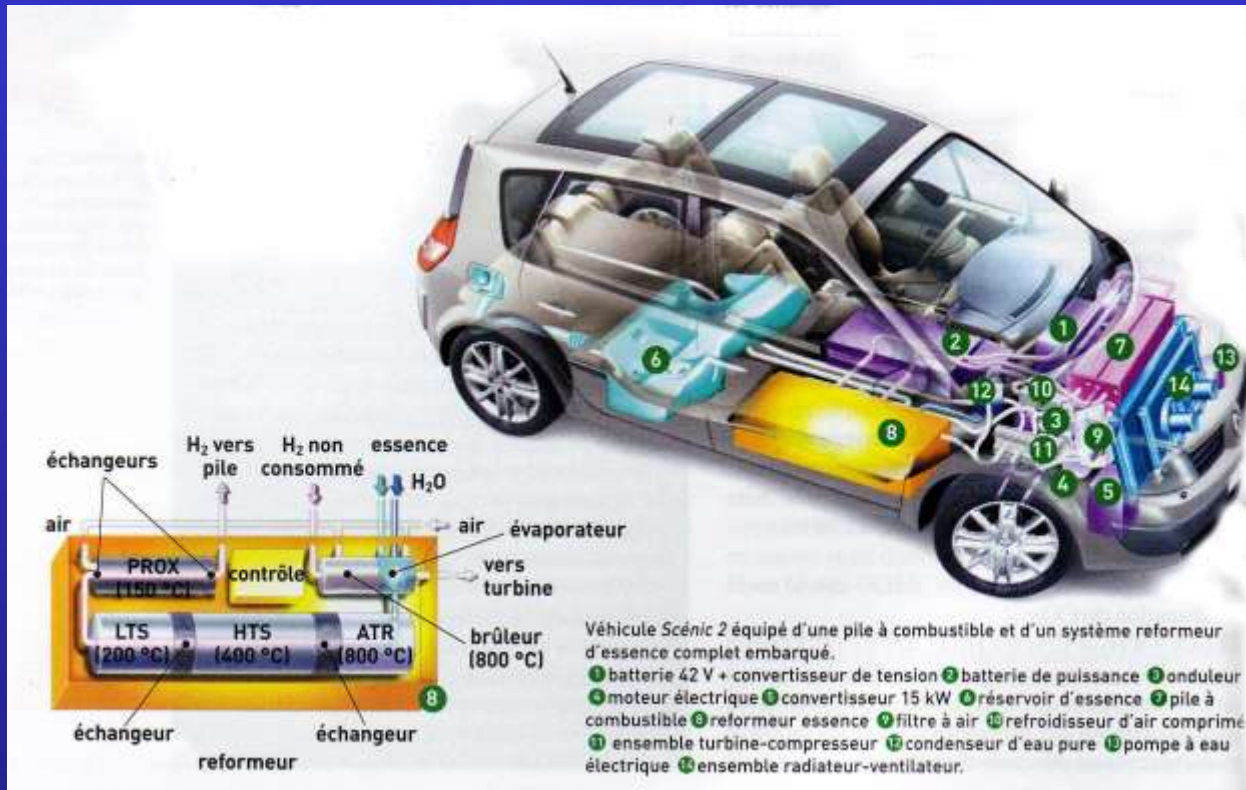


UTC 200 kW

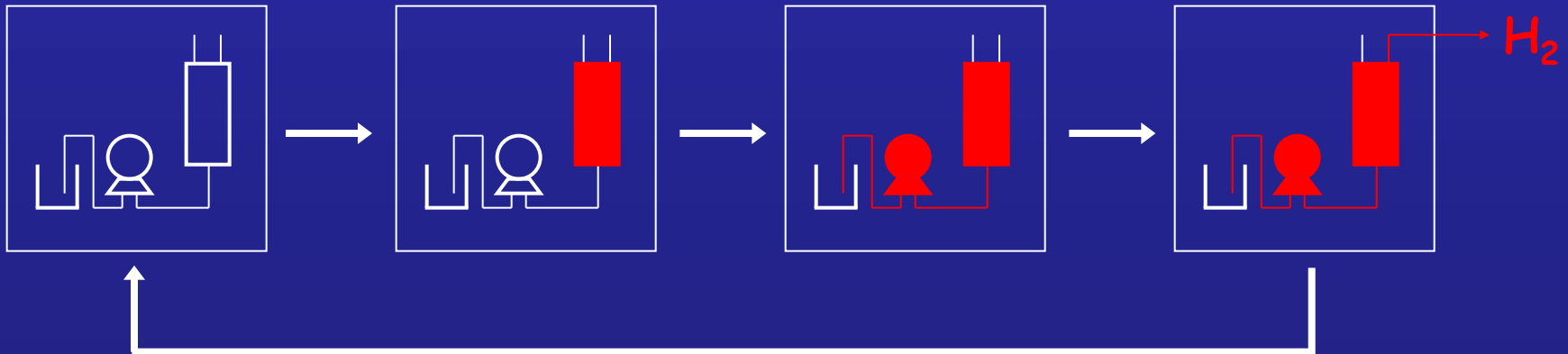


**Ballard 250 kW**

# Amb combustibles líquids (hidrocarburs, alcohols,...):



## Reformador





# Thank you!

jordi.llorca@upc.edu



Technical University of Catalonia  
BarcelonaTECH

