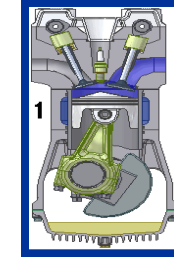


# Available Key Technologies/Resources

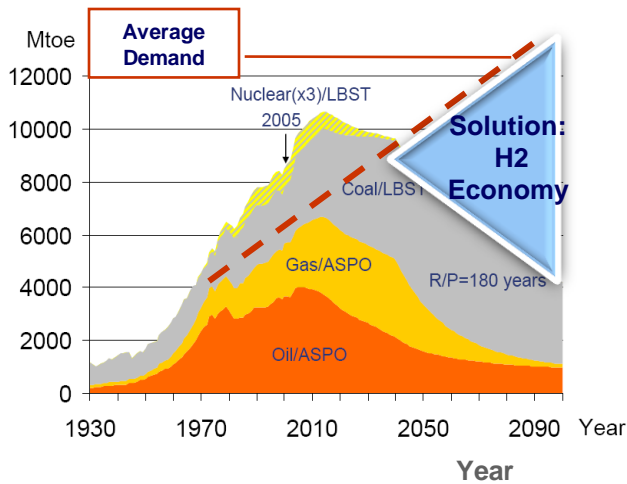


**Fuel Cells**



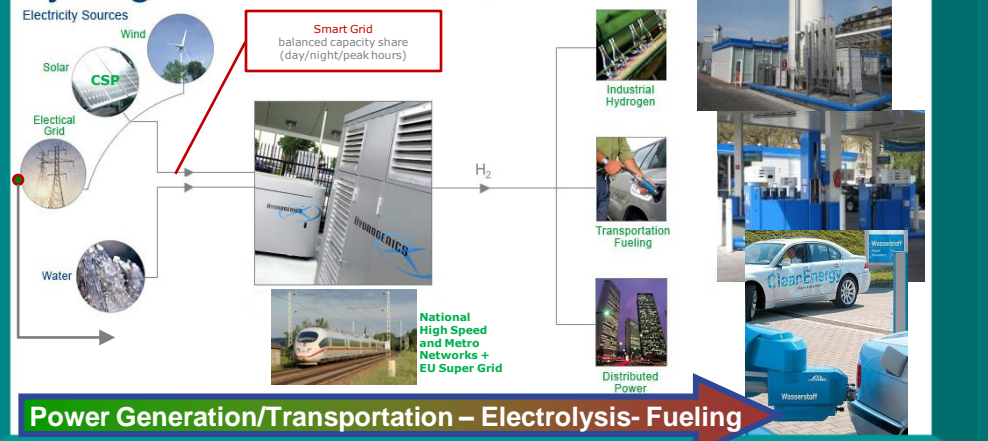
**Internal Combustion Engines**

## Concentrating Solar Thermal Power Plants (CSP)



Data source: Oil, Gas, Colin Campbell/ASPO 2005  
Coal-, Nuclear Scenario, LBST 2005

## Hydrogen Generation Station



# Propulsion Technologies

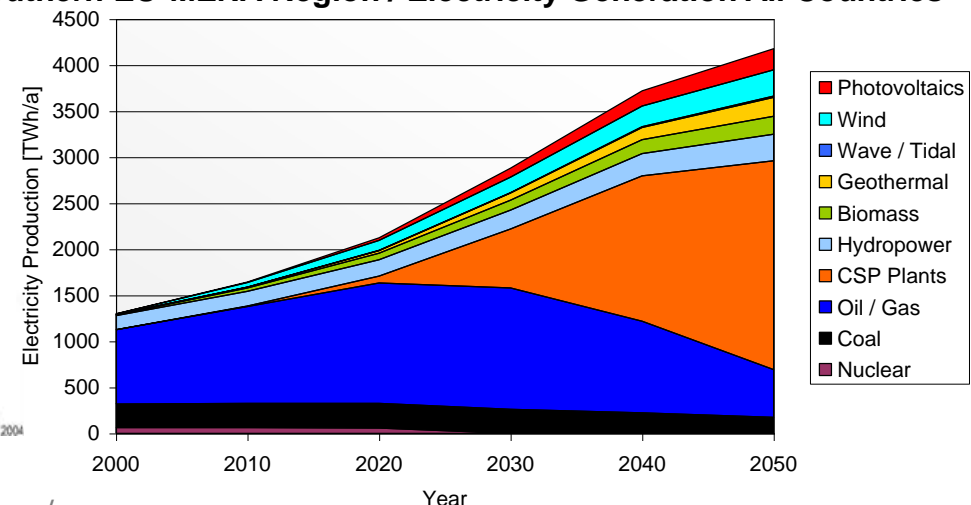
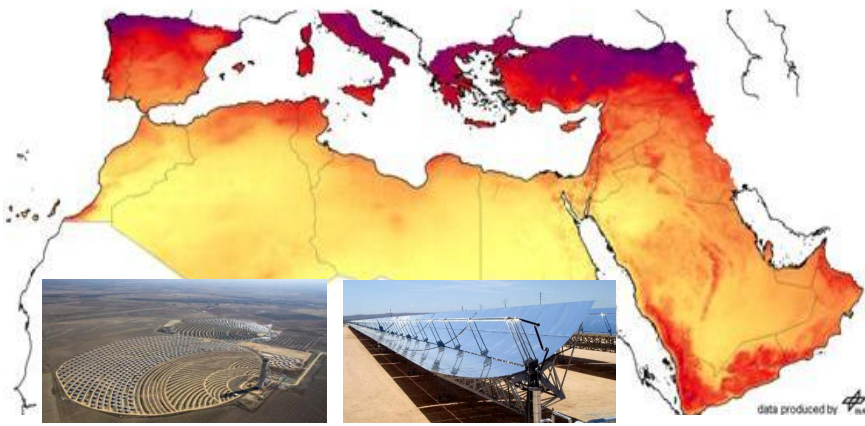
Propulsion Category	Internal Combustion Engine (ICE) Vehicle		Electric Vehicle (EV)	
Energy Storage	Gasoline/Diesel/ Natural Gas	H2	H2 via Fuel Cell (FC)	Battery
Vía Azul Relevance (vehicle usage)	0%	70% CGH2 only 100% CGH2+LH2	100% CGH2	0%
Energy Efficiency*	25-30%	30-35%	35-45%	20-25%
CO2 Emission vehicle	100%	0%	0%	0%
CO2 Emission Energy production/ distribution	Central Refineries/ Truck and Pipeline distribution: 100% (CH2 burning)	Local Electrolysis (CGH2): 0% and Local Liquefaction (CGH2->LH2) : 0%; Central Liquefaction (Distrib. incl.): 50%	Local Electrolysis (CGH2) via Smart Grid: 0%	Conventional Mixed Power: 60-70% (CH2 burning)
Fueling infrastructure	Fueling stations + Trucks	H2 Fueling stations + Smart Grid / H2 Trucks (LH2 central)	H2 Fueling stations + Smart Grid	Conventional Power Grid - Charging at home/office
Vehicle Cruising range/ Life cycle	500km / 150.000km	500km / 150.000km	500km / 3000H (150.000km)	250km / ?
Limited resource dependency	Fossil (CH2) Resources	None	Fuel Cells (Mat. i.e. Platinum)	Batteries (Mat. i.e. Silicon)
Vehicle security	High	High	High	High
Vehicle availability	Mature Series	Limited Series	Limited Series	Pilot Series
Industrial supply chain Production	ICE + mature manual/ automatic transmission	Improved ICE + mature manual/ automatic transmission	New Technologies: eMotors , High Voltage, FC, Transmission	New Technologies: eMotors , High Voltage, Batteries, Transmission
Industrial supply chain Recycling	Traditionally well established	Traditionally well established	To be developed	To be developed

\*Further  
research  
needed

# Synergies of Joint Initiatives



## MED-CSP Study: Annual Direct Solar Irradiance in the southern EU-MENA Region / Electricity Generation All Countries



# Trans-Mediterranean Inter-connection for CSPs

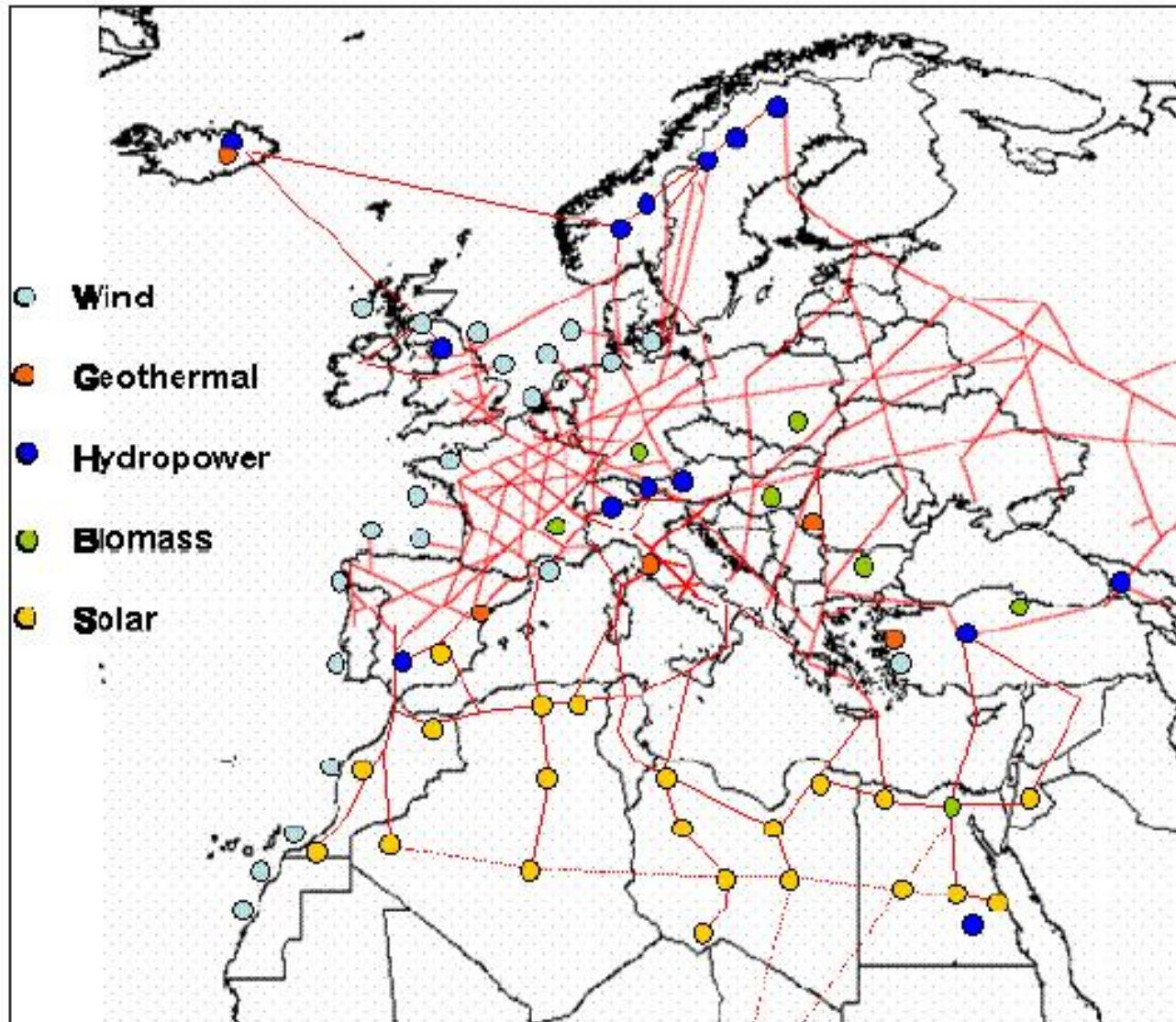


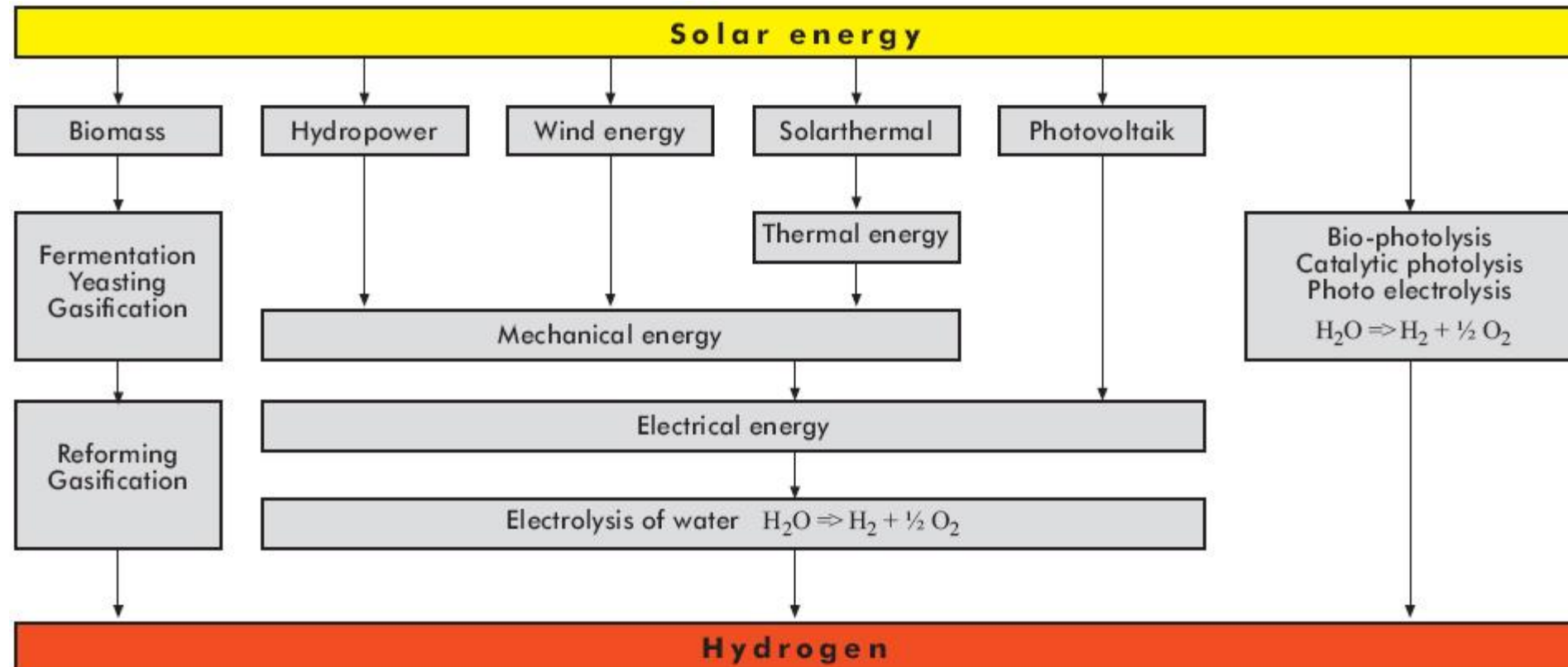
Figure 2: Vision of an EUMENA backbone grid using HVDC power transmission technology as “Electricity Highways” to complement the conventional AC electricity grid.

# Hydrogen Production from fossil fuels and Water

Process	Steam reforming	Plasma reformin	Partial oxidation	Coal gasification	Carbon monoxide conversion
Examples	different	Huels process	Shell process, Texaco process	Winkler-, Lurgi-Koppers-Trotzek-, Texaco-process among others	HT-conversion TT-conversion
Raw material	gaseous, liquid hydrocarbons	gaseous hydrocarbons	gaseous, liquid solid hydrocarbons	Coal	carbon monoxide
Temperature °C	> 850	> 1300	1200 - 1400	800 - 2000	350 - 500 (HT*) 200 - 250 (TT*)
Pressure bar	25	3	10 - 100	1 - 40	-
Reaction agent	H <sub>2</sub> O	H <sub>2</sub> O	H <sub>2</sub> O, O <sub>2</sub>	H <sub>2</sub> O, O <sub>2</sub>	H <sub>2</sub> O
Catalyst	Nickel oxide				Fe <sub>2</sub> O <sub>3</sub> /Cr <sub>2</sub> O <sub>3</sub>
Process energy	fossil	electrical	fossil	fossil	fossil
Gaseous componenets	H <sub>2</sub> CO	H <sub>2</sub> CO	H <sub>2</sub> CO	H <sub>2</sub> CO	H <sub>2</sub> CO <sub>2</sub> O
Volume-%	52 11	75 25	50 50	25-40 65-15	70-90 30-10
* HT = High temperature, TT = low temperature					

Characteristic process yielding hydrogen as end product  
Table courtesy: DLR

# Non-fossil production of Hydrogen



Energy conversion steps of the non-fossil hydrogen production  
Graph courtesy: DLR

Energy Resource / Production	Input	H2 Production	Output Volume %	Transformation into CGH2+LH2	Transportation to POS	European Hydrogen Infrastructure Transportation – Solution Candidates Pros (+) / Facts (*) / Contras (-)
Fossil Fuels / Central	H2O + Thermo Energy 800-2000°C (from Electricity/ Production Processes)	Steam Reforming; Plasma Reforming; Partial Oxidation; Coal Gasification; Endothermic CO conversion	GH2: 25-75 (1-100 bar) CO: 11-65 (CO-CO2 conversion GH2:70-90 CO2:10-30)	Central Compression + Liquefaction	CGH2/LH2 in Trucks + Pipeline (Central Electricity capacity)	<ul style="list-style-type: none"> <li>+ : Partial use of existing central capacities: 4 Mio m<sup>3</sup>(H2)/d</li> <li>*:Substantial extension of central capacity required</li> <li>-: NO reduction of fossil fuel dependency;</li> <li>-: NO reduction of CO2 emission</li> <li>-: H2 Truck/Pipeline transp. involved</li> </ul>
Fossil Fuels Steam Reforming / Decentral	H2O + Thermo Energy >850°C (from Electricity)	Steam Reforming;	GH2: 52 (25 bar) CO: 11 (CO-CO2 conversion required)	Decentral Compression + Liquefaction	Fossil Fuel in Trucks + Pipeline Decentral Electricity capacity	<ul style="list-style-type: none"> <li>+ : Partial use of central existing capacities</li> <li>*:Substantial extension of centr. capac. req.</li> <li>*:Establish decentral capacities</li> <li>-: NO reduction of fossil fuel dependency;</li> <li>-: NO reduction of CO2 emission</li> <li>-: H2 Truck/Pipeline transp. involved</li> </ul>
Biomass / Central or decentral (Steam reforming)	Solar/Bio Energy; Fermentation; Yeasting; Gasification	Reforming; Gasification	CH4 (Methane) to GH2: 75 (25 bar) CO: 25 (CO-CO2 conversion required)	Central or decentral Compression + Liquefaction	CGH2/LH2 or Bio Gas in Trucks + Pipeline (Central or) Decentral Electricity capacity	<ul style="list-style-type: none"> <li>+ : Reduction of fossil fuel dependency</li> <li>+ : Substantial value add to solve urban areas waste problems</li> <li>+ : Energy resource available 24/7</li> <li>+ : Waste: Supports introduction of Green Energy Card (Communities of Sustainable Energies)</li> <li>*:Substantial extension of centr. capac. req.</li> <li>*:Establish decentral capacities</li> <li>-: Bio-Gas + CO2 emissions</li> <li>-: H2/Bio Fuel Truck/Pipeline transp. involved</li> </ul>
Wind, Hydro, Photovoltaic / Decentral	H2O + Solar Energy via Mechanical Energy (PV: n/a) to Electricity	Atmospheric Electrolyser Single-Module 4,0 x 13,5 m; 485 m <sup>3</sup> (H2)/h at 2,1 MWh	GH2: 67 (<1 bar) O2: 33	Decentral Compression + Liquefaction	Decentral Electricity capacity, via HVDC	<ul style="list-style-type: none"> <li>+ : Reduction of fossil fuel dependency</li> <li>+ : 0 emissions</li> <li>+ : NO Truck/Pipeline transp. involved</li> <li>+ : PV/Wind: Support introduction of Green Energy Card (Communities of Sustainable Energies)</li> <li>*: Energy resource available 12-24/7 (subject to natural fluctuations)</li> </ul>
Solar Thermal / Decentral	H2O + Solar Energy via Mechanical Energy to Electricity	Atmospheric Electrolyser Modules	GH2: 67 (<1 bar) O2: 33	Decentral Compression + Liquefaction	Decentral Electricity capacity, via HVDC/MED-CSP	<ul style="list-style-type: none"> <li>+ : Reduction of fossil fuel dependency</li> <li>+ : 0 emissions</li> <li>+ : NO Truck/Pipeline transp. involved</li> <li>*: Energy resource available 20-24/7 (heat storage in salt tanks)</li> </ul>

# “Vía Azul (M)”

## CSPs and Highway Power Grid for local H<sub>2</sub> production (AE)

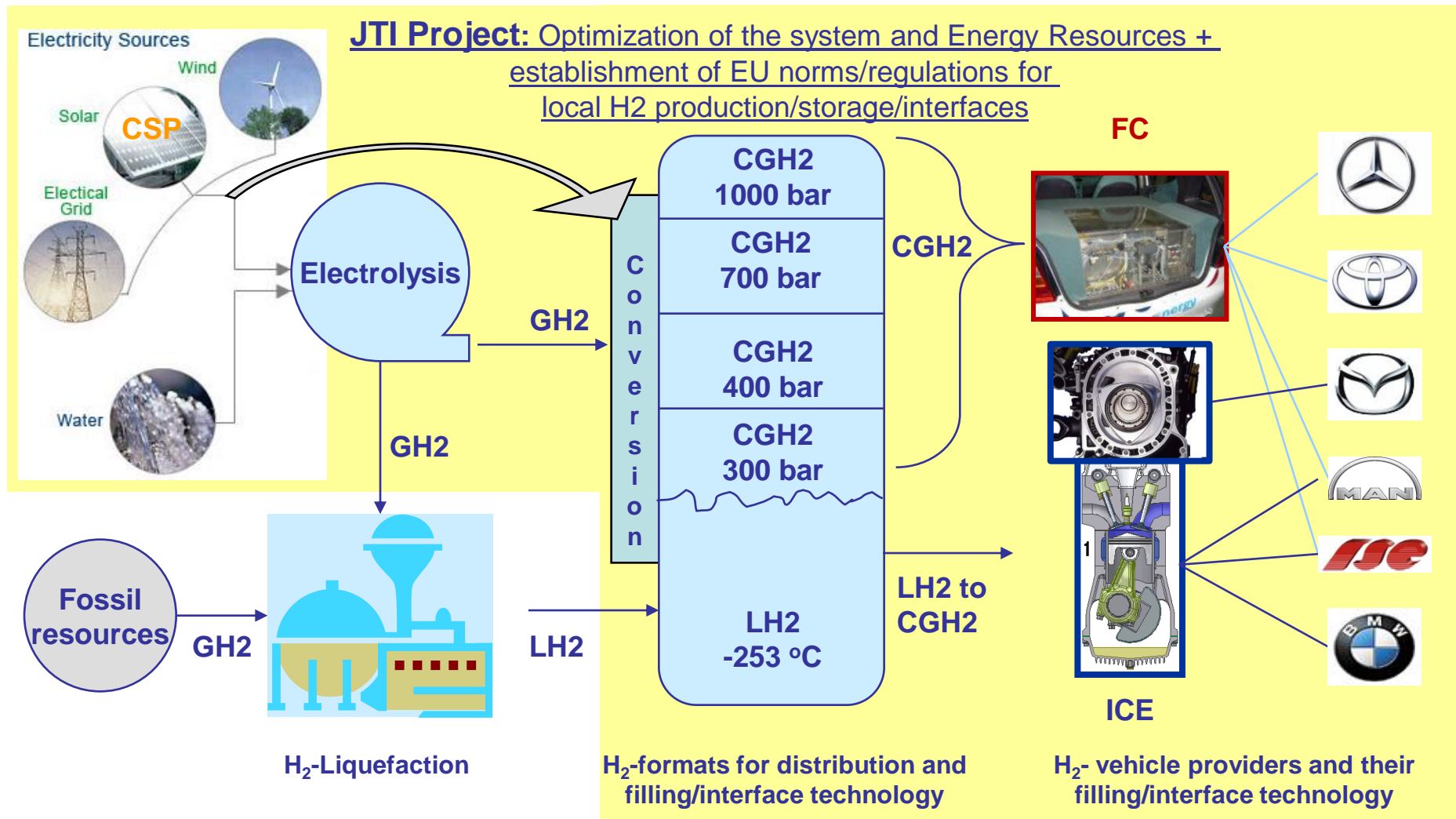


Local Sustainable energy production about to pass capacity of 1 nuclear plant (800 MW)

AE: Atmospheric Electrolyser: 485 m<sup>3</sup>(H<sub>2</sub>)/h at 2,1 MWh

CSP: Concentrating Solar Thermal Power Plants

# CTH: EU Normalization y Regulations



# Summary

## Value Add to EU and local regions

### 1. Technology and Standards

- Integration Synergies and Standards: CSP, Smart Grid (HVDC), H2 infrastructure/vehicles
- H2 production, storage and unified H2 vehicle interfaces

### 2. Organization

- Public private partnership
- Advisory Board drives establishment of Via Azul Consortium

### 3. Realization and Financing

- 7 years, 5 phases, Special financing models => ROI enabling

### 4. Benefit local (Andalucía/Spain)

- Energy provider (MED/TRANS-CSP Pilot Region) => Balance economic/industrial deficits
- Technology leadership => Energy Efficiency (H2/CSP/HVDC), Fueling/Vehicle Techn./Service
- Reduction CO2 emissions => Reduction Kyoto penalties for Spain
- Local production of selected Modules => Extended Labor (engineering, construction, etc.)
- International Show Window H2 Technologies => More Commercial Visitors and Tourists

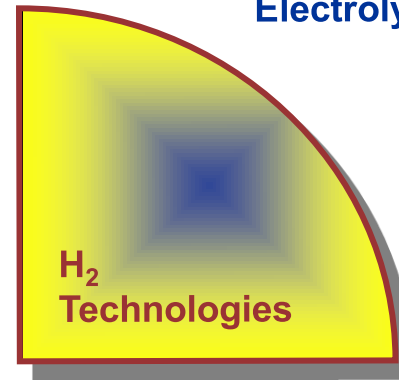
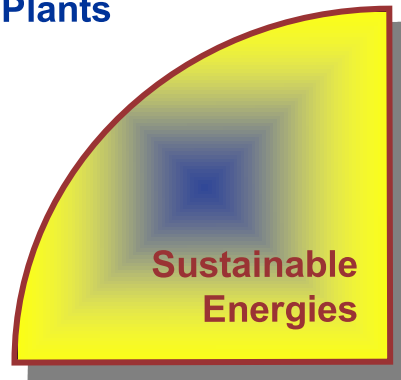
### 5. Benefit EU (global)

- Reduction dependency from fossil resources and hidden costs for external supply chains
- Meet SET<sup>1</sup> 20:20:20 targets by 2020
- Global Technology leadership/export: CSP<sup>2</sup>, HVDC and H2 infrastructure technologies/vehicles
- ROI in less than 10 years
- TAX, Re-vitalization and EBIT for involved industries, Improved export balances

# How to proceed? Establish the Critical Mass!

Concentrating Solar Thermal  
Power Plants

H<sub>2</sub> Power  
Electrolysers



Wind + Biomass

H<sub>2</sub> Storage + Fueling

✓ European Strategic  
Energy Technology  
'20-20-20' in 2020

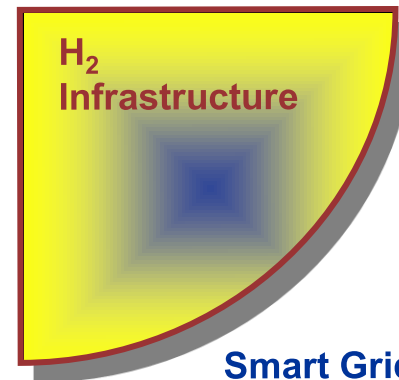
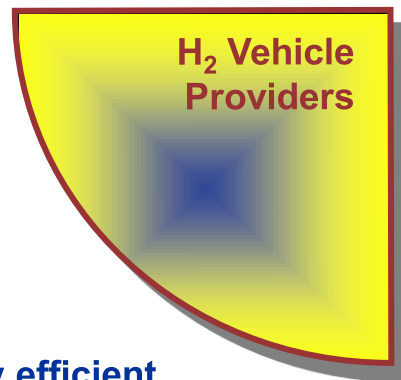
CTH + Vía Azul Eurpe 10

- European Initiatives:**
- ✓ HFPeurope (FCH-JTI)
  - ✓ EHA/HyRaMP
  - ✓ MED-CSP<sup>1</sup>
  - ✓ Smart Grids

- Local Drivers:**
- ✓ Public Authorities
  - ✓ Financial Entities
  - ✓ Investors
  - ✓ Technology companies

H<sub>2</sub> Vehicle Fleets

Vía Azul Europe 10



Energy efficient  
driving

Smart Grid for  
local H<sub>2</sub> production

# Experts welcome to join the Vía Azul Advisory Board!

- Members to be engaged