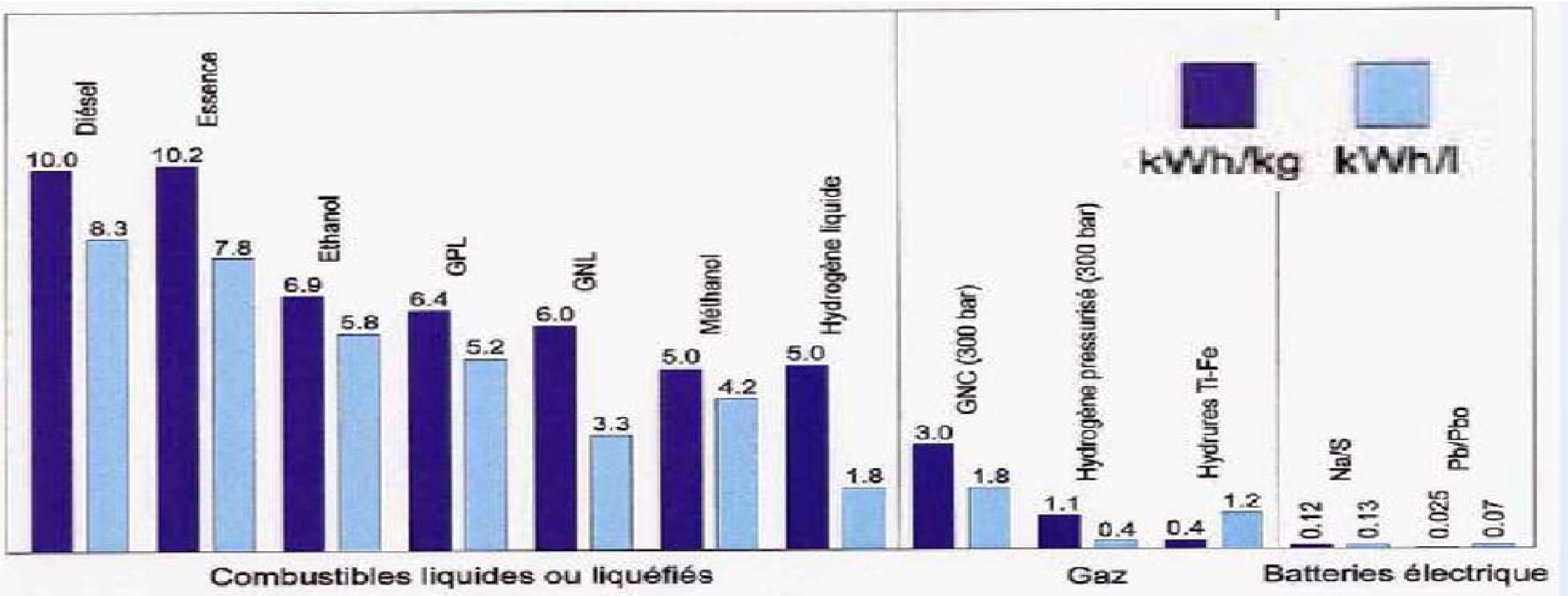
7°) energy storage from carbon dioxide

energy storage for liquid,gas or battery

Performances comparées de divers stockages d'énergie



Source : Daimler-Benz

EMRS FALL MEETING
Varsaw 13-15 sept 2010
Symposium A

Why Liquid Fuels?

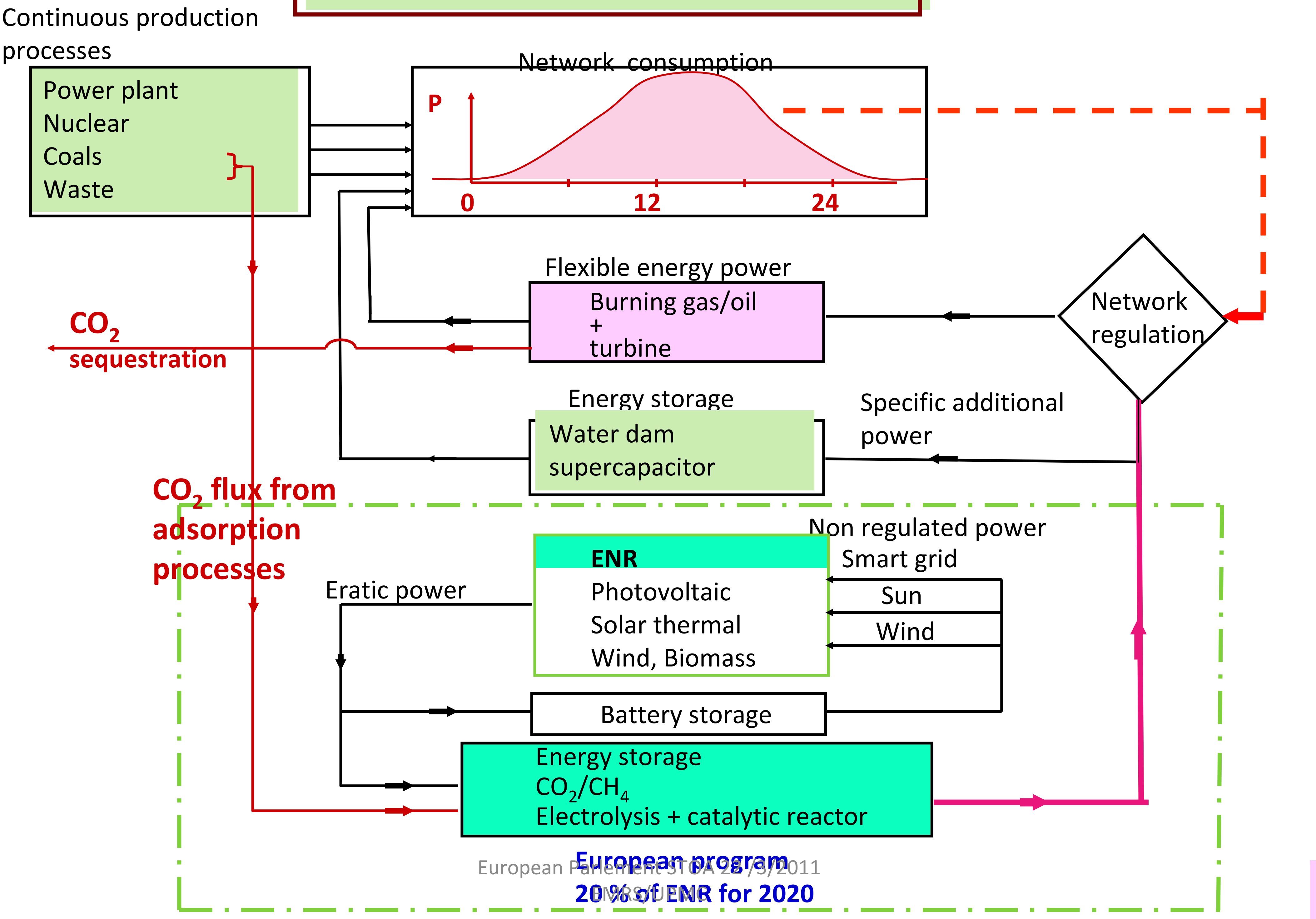
	Storage	Grav. Energy Density [kJ/kg]	Vol. Energy Density [kJ/l]	
Storage in Accumulators	Pb accumulator	126	252	
	NiCd accumulator	126	288	
	Ni hydrid accu.	180	576	
	Lithium ion accu.	432	936	
Chemical Storages [1]	DMC [2]	15 780	16 900	RON 105
	Methanol	22 700	18 100	RON 109
	DME	31 700	Pressure dependent	CN > 55
	Gasoline	43 500	32 000	RON 95
	Diesel	42 700	35 000	CN > 51
	Methane	50 000	Pressure dependent	
	Hydrogen	142 200	Pressure dependent	

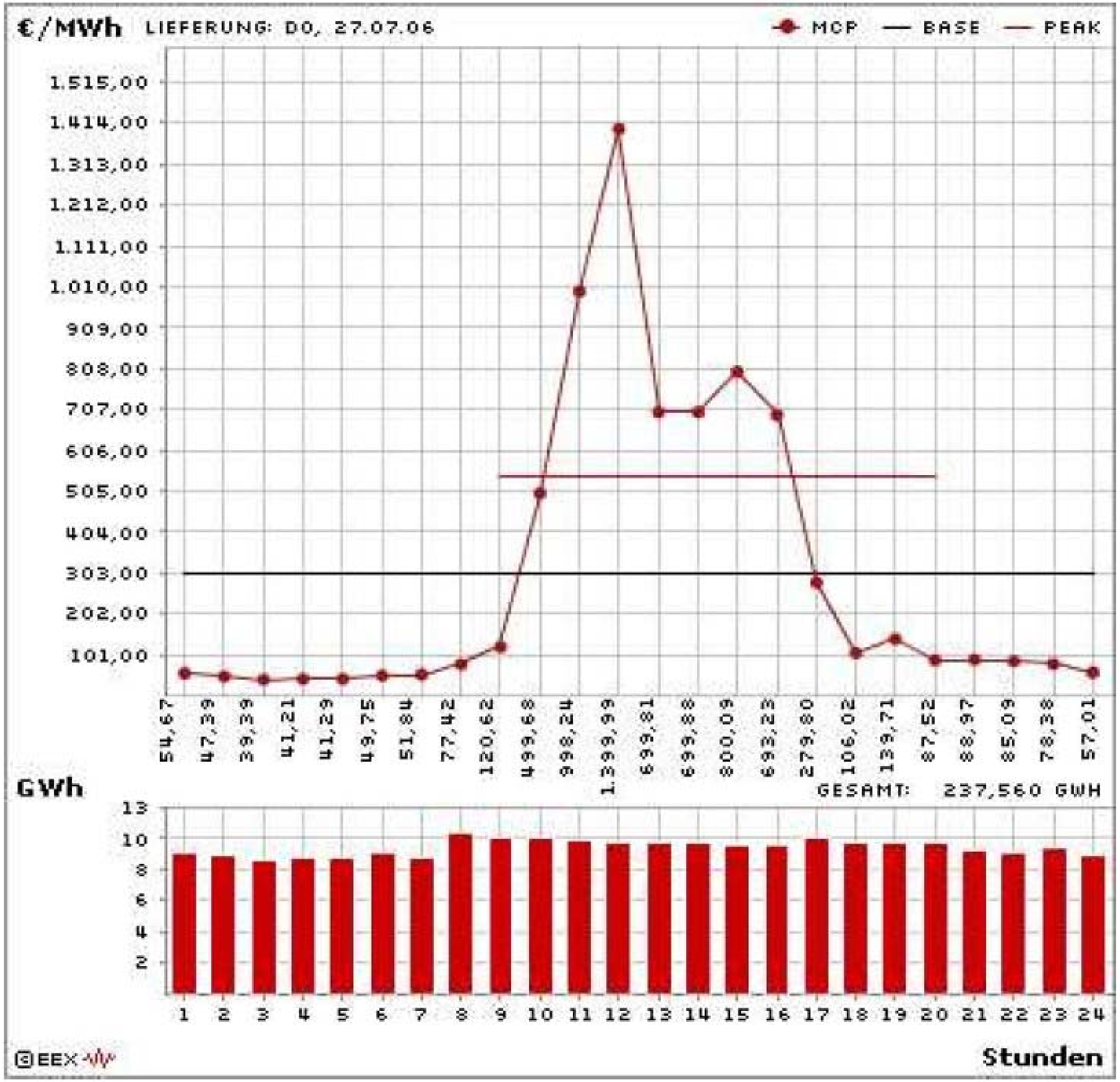
ratio :battery/gasoline= 1/100

CARBON DIOXIDE :A RAW MATERIAL FOR ENERGY STORAGE

***Electrical network regulation**
***Synfuel for transportation**

ELECTRICAL ENERGY PRODUCTION





High Electricity Spot Market Prices in Germany at Times with highest PV Output

SCHOTT solar

reducing carbon from coal: german projects C§EN 2010 sept 13 p 9

* **one project: CCS** BASF,Linde,RWE reduced by 20% the solvent related energy costs of CO_2 capturing at RWE's power station in Niederaussem

- 113 million pricetag tested CO_2 removal with BASF solvents for more than one year
- the partners plan to open demonstration plants by 2015 and commercialization installation by 2020

- **second project :Bayer,RWE,Siemens** and 10 german academic partners
- to use the CO_2 captured as a building block for chemical intermediate it is called ***CO2-Reaction using Regenerative Energies §Catalytic Technologies*** or CO2 RRECT **23 millions of budget**
- the partner envision a system in which surplus electricity from solar cells and wind turbines is stored as hydrogen that is generated via water electrolysis technology supplied by Siemens.
- the hydrogen can then be reacted with CO_2 to form building block for plastics and other chemicals

Carbon dioxide
a good candidate for energy storage

- **How to do that ?**.
- transformation of **CO2 to synfuel** means
- **large industrial chemical plants**
- **Principle** :
- CO2 + **H2** → CH4 or CH3OH or
- syndiesel

Catalytic material for CO_2 process

a key step

- Catalyst for CH_4 synthesis
- Catalyst for CH_3OH synthesis
- Catalyst for Syngas synthesis
- Catalyst for Fisher Tropsch synthesis
- Many kinds of catalyst for polymers,and chemical synthesis

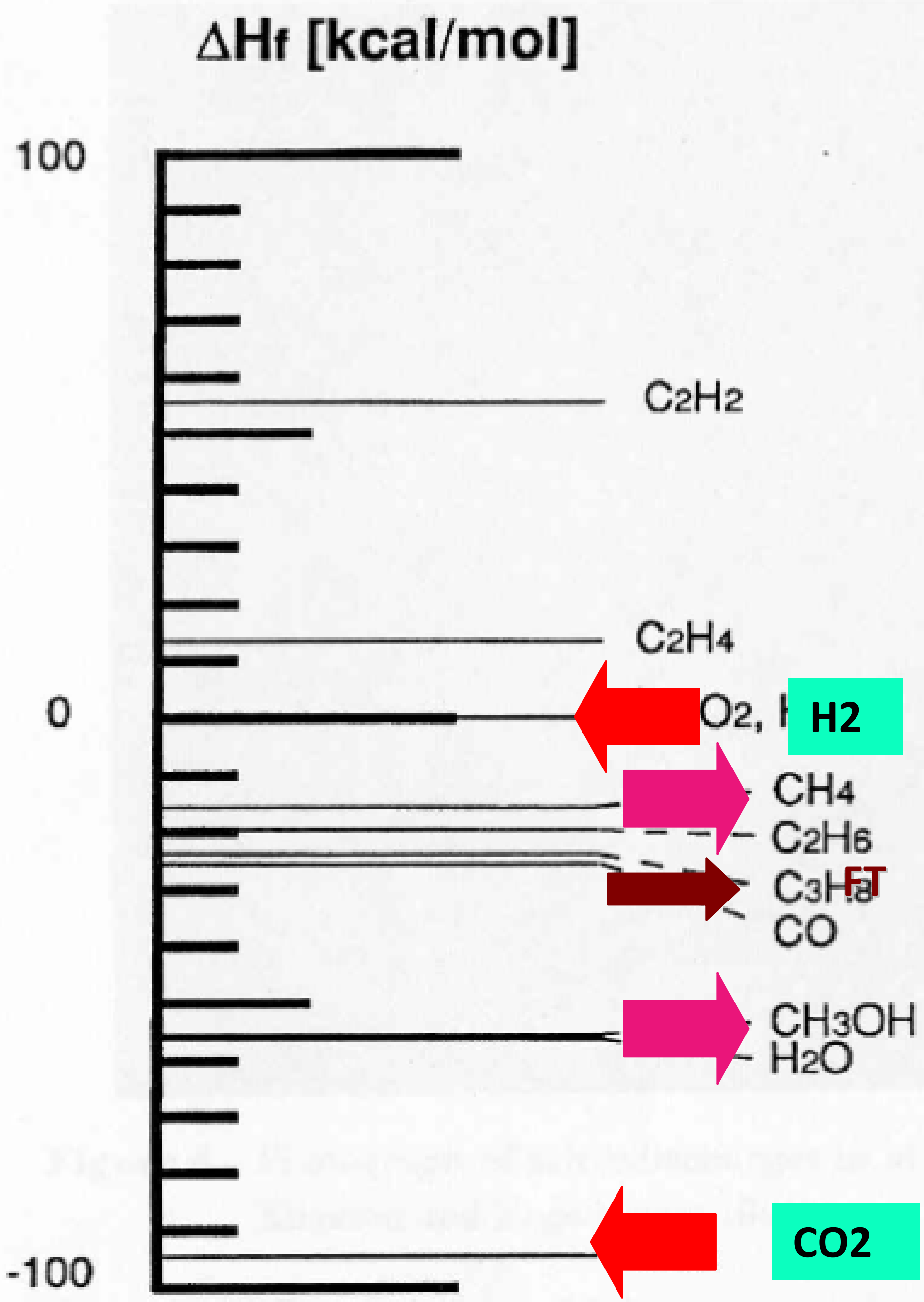
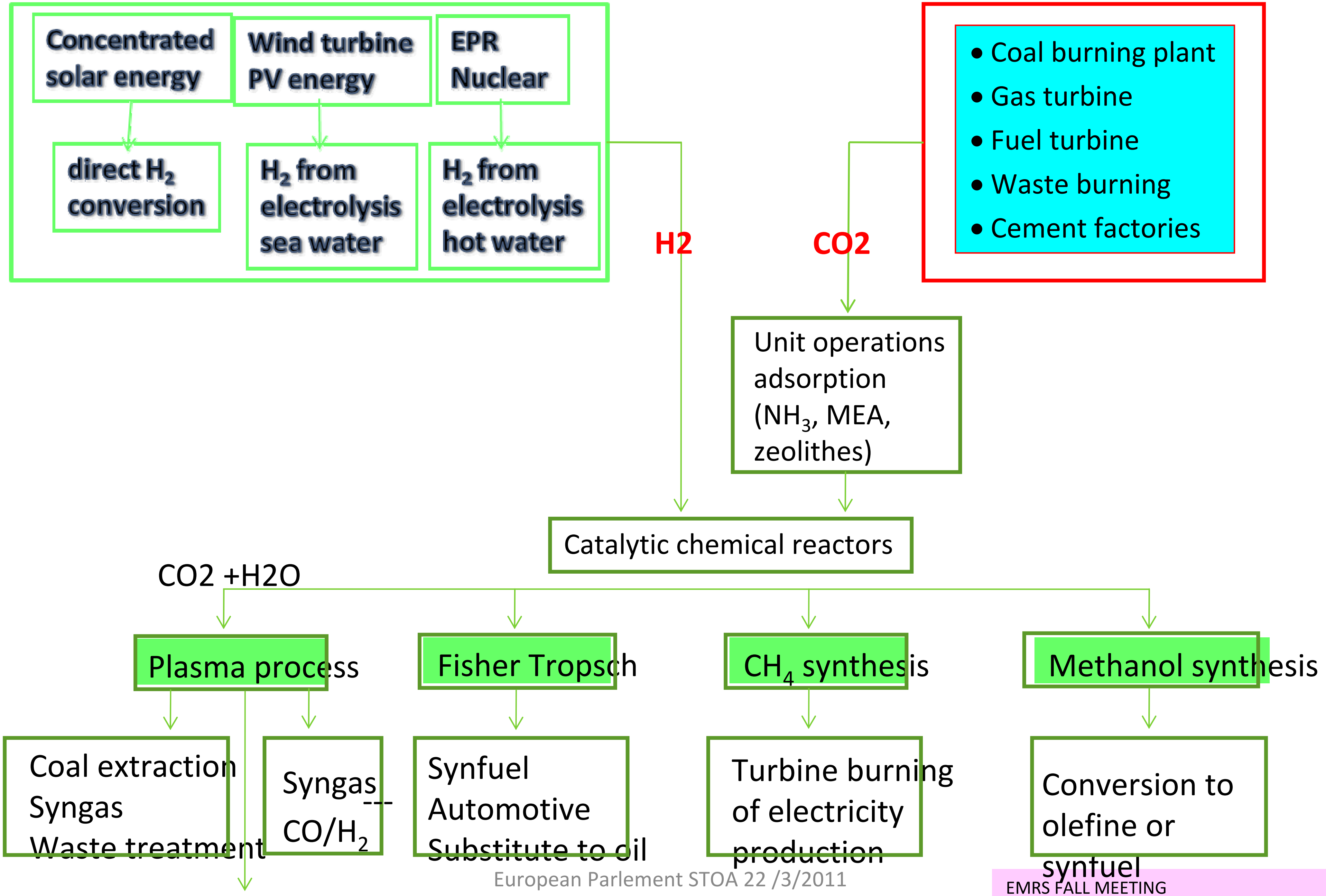


Figure 2. Standard enthalpy of formation for some important compounds in hydrocarbon chemistry.

A strategy for energy storage



CATALYSISTS and CHEMICAL REACTORS

- development of catalysist reactors with strong exothermic reactions need to control temperature and secondary reactions such as cokefaction, catalysist aggeing (active surface decreasing, poison on specific sites , heat transfert from the bulk of the reactor to the exhange wall etc..)
- fluidized bed or spouted bed or much more efficient than fixed catalytic bed for working parameters control

Materials for $CO_2 \rightarrow CH_4$ process (Japon) – Prof.K. Hashimoto

1. Electrocatalysis of sea water anode type electrode with Ti/Mn-Mo-SnO_x

   cathode for electrocatalysis

   Type Ni-Fe-C or $Ca_{18}Ni_{13.5}Fe_{3\text{-}4}e$

   Modification of the hydrogen surtension voltage

2. Catalysis for CO_2 reduction in fixed bed reactor

   zircone stabilized by Sm (tetragonal structure) + Ni sites for redox

   phenomena (amorphous deposit of few nm)

Material for $CO_2 \rightarrow CH_4$ process (Fisher-Tropsch)

Nickel is the main material for hydrogenation and Fisher-Tropsch processes.

Ni on Al_2O_3 which is due to spinel shells $NiAlO_4$

Ni on ZrO_2 stabilized by Ce or Pr (tetragonal)

However for CH_3OH or DME

ZrO_2 monoclinic + Ce as a catalyst in cubic structure

Ni/ZrO_2 doped with Ce

Co-Fe spinel mixed oxides as Fisher-Tropsch catalyst very active for CO/H_2 or CO_2/H_2 reactions

$CO_2 \rightarrow CH_3OH$ process

BASF Process (320-380°C) – 240-340 bars

Catalyst ZnO and Cr_2O_3 (70/30)

ICI Process (230-270°C) – 55-100 bars

CuO-ZnO-Al_2O_3

Cu, Ag, P, Pb are able to be use for CO or CO_2 adsorption without breaking bond for
CH_3OH synthesis

Cu is the most appropriate for industrial process

ZnO (stabilization of copper species such as Cu^+ or Cu^o) and control the Redoxcycle between Cu^+ and Cu^o

γAl_2O_3 methanol catalyst from Syngas with high specific area and ZnO particles

CuO-ZnO-Al_2O_3 is used for CO_2 hydrogenation to produce CH_3OH (Cr_2O_3-Ga_2O_3 increase the specific activity of Cu/ZnO catalysis)

Material for Syngas production (Russia – Westinghouse – Tektronic)

Copper electrodes for high voltage and high power (up to 1000 KW) are qualified for
plasma arc production from mixtures such as CO_2-H_2. On air-H_2O with on line treatment of coal

These cold fingers of copper electrodes are specific for this treatment and point out that copper oxide Cu_2O which is a semiconductor plays a key role in the energy transfer and the time life of these electrode
Scale up 2009 (500.000 T/year)