



BRIE

BIOMASS RESOURCE USE, INNOVATION AND EFFICIENCY

Hydrogen production from agro-industries

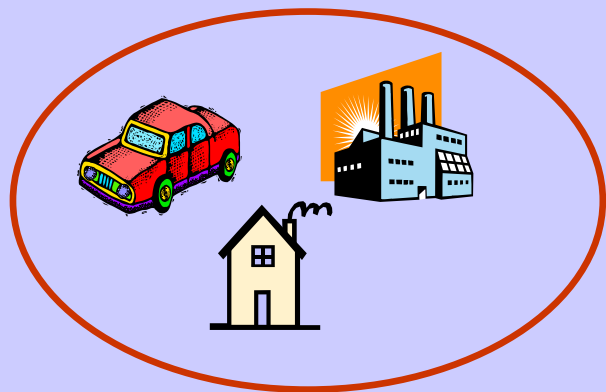
Final Transnational Conference

**Community Centre, Massa Martana
June 5, 2007**



Why Hydrogen?

➤ The environment, of course!



NO_x , SO_x , HC, CO, CH_4 , CO_2
Atmospheric pollution

Acid Rain



Land erosion



Greenhouse Effect

➤ Depletion of fossil fuels



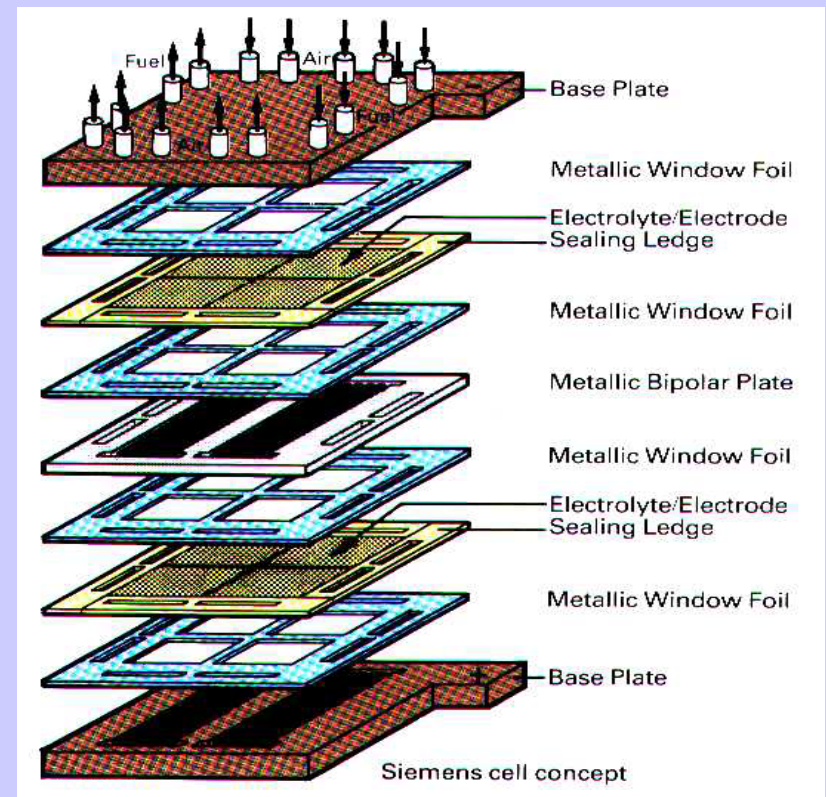
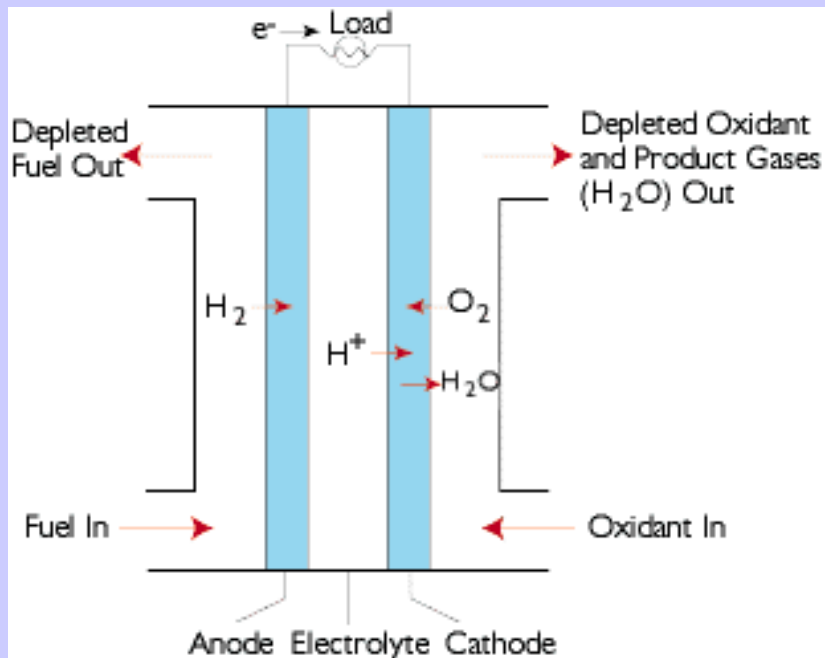
Utilization of hydrogen for energy production

$H_2 \rightarrow \rightarrow \text{fuel cell} \rightarrow \rightarrow H_2O + \text{electricity} + \text{heat}$

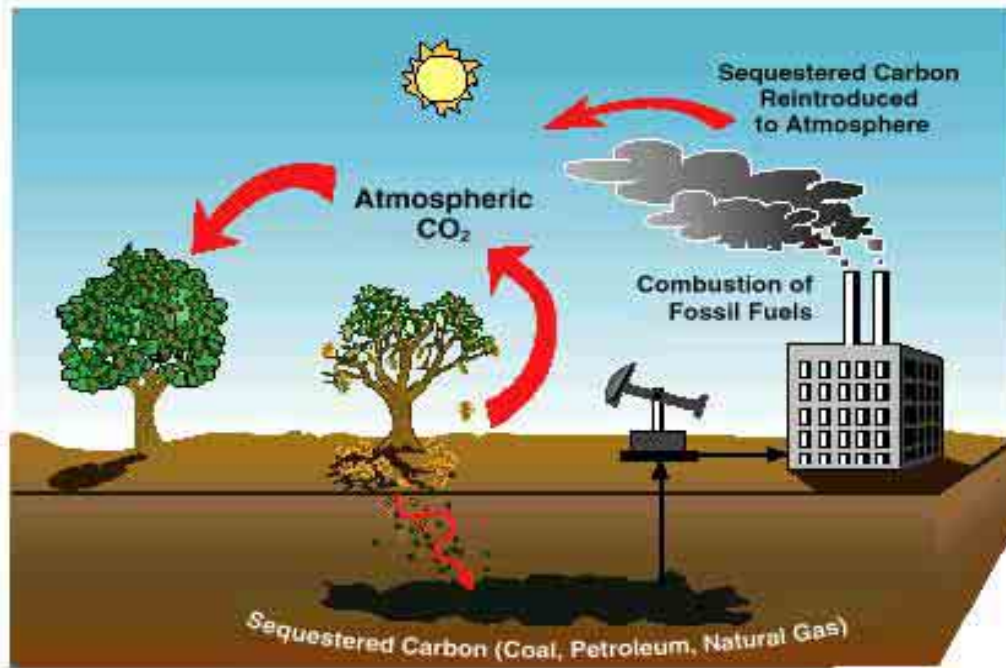
Characteristics:

Zero emission of pollutants

High efficiency



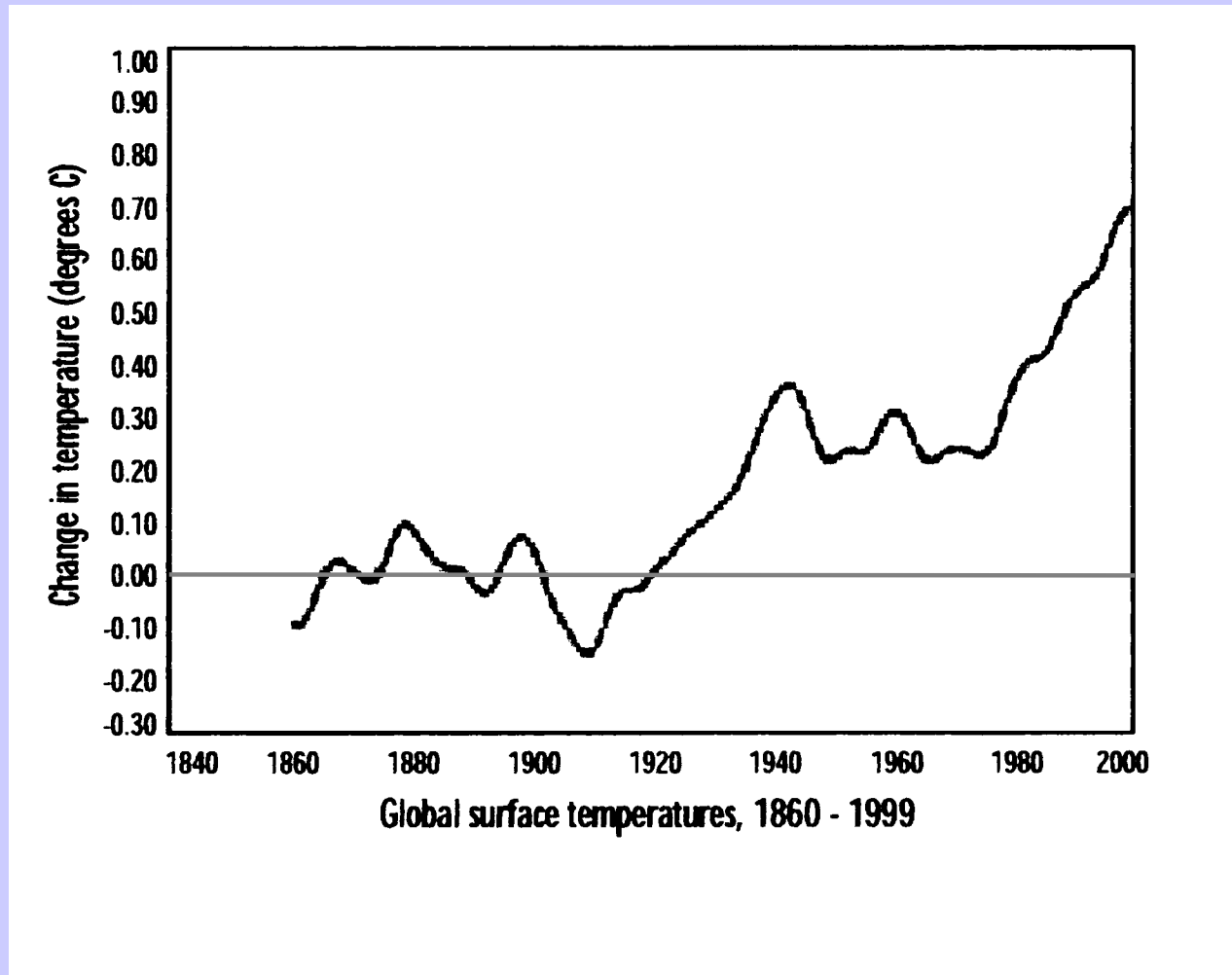
The Carbon Cycle



Simplified carbon cycle

Environmental consequences

- ❖ Changes of the mean global surface temperature in the last 150 years



Source: Hadley Centre for Climate Prediction & Research.

Hydrogen Production

➤ From **fossil fuels** (natural gas)

-CO₂ sequestration

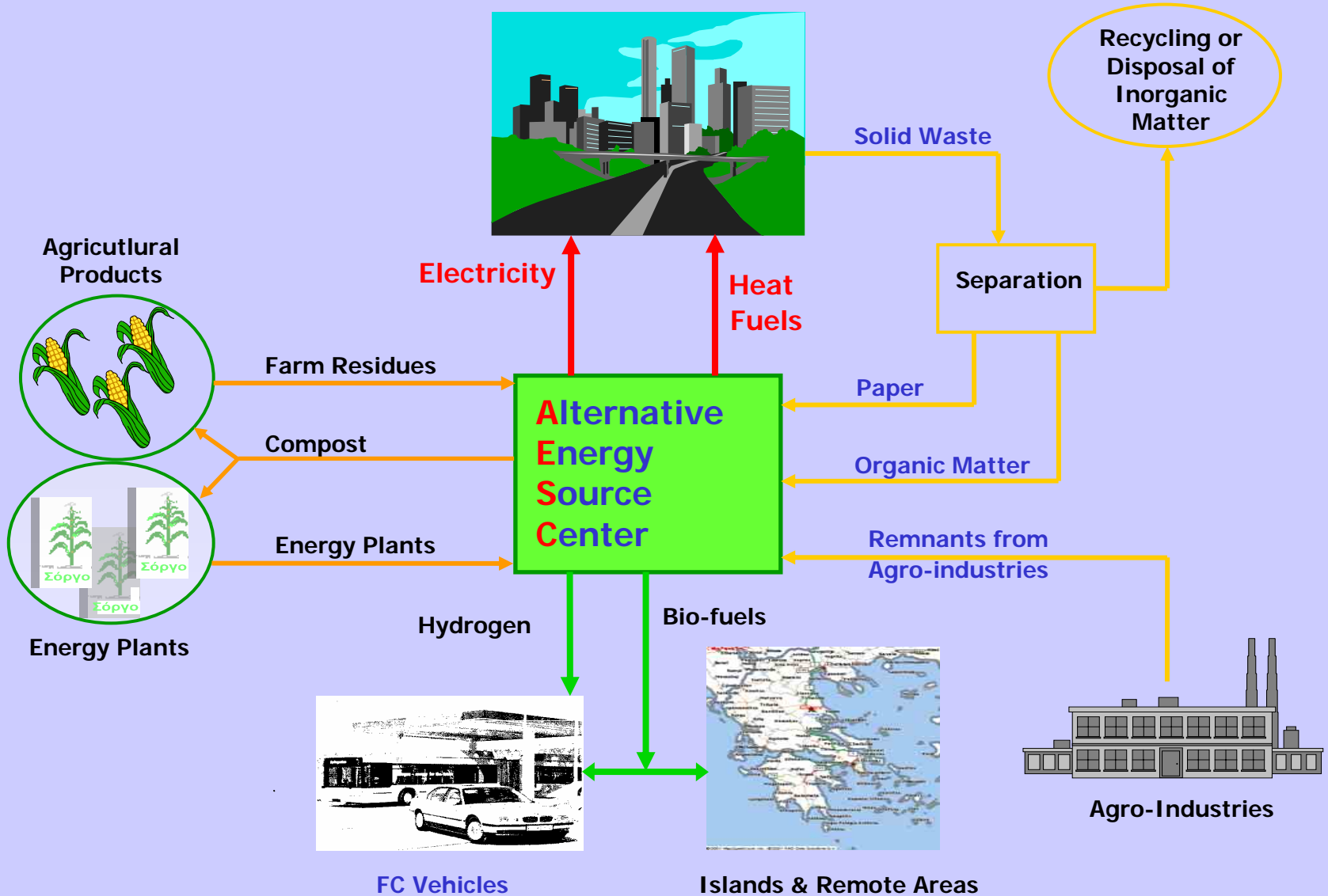
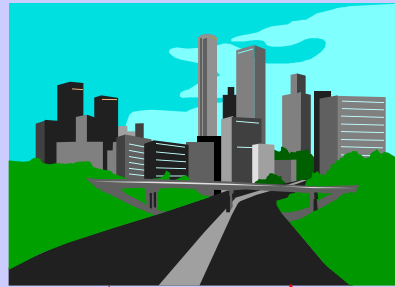
➤ From **renewable sources**

- renewable electricity (wind, solar)
- biomass

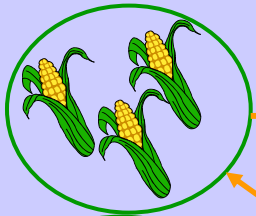


“GREEN“ ENERGY FROM BIOMASS

CITY



Agricultural Products



Farm Residues

Compost

Energy Plants

Electricity

Heat Fuels

Alternative Energy Source Center

Solid Waste

Separation

Paper

Organic Matter

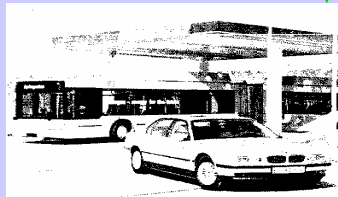
Remnants from Agro-industries

Recycling or Disposal of Inorganic Matter

Energy Plants

Hydrogen

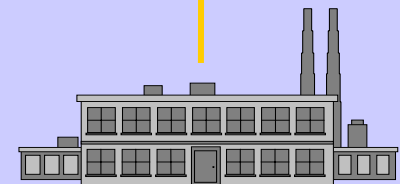
Bio-fuels



FC Vehicles

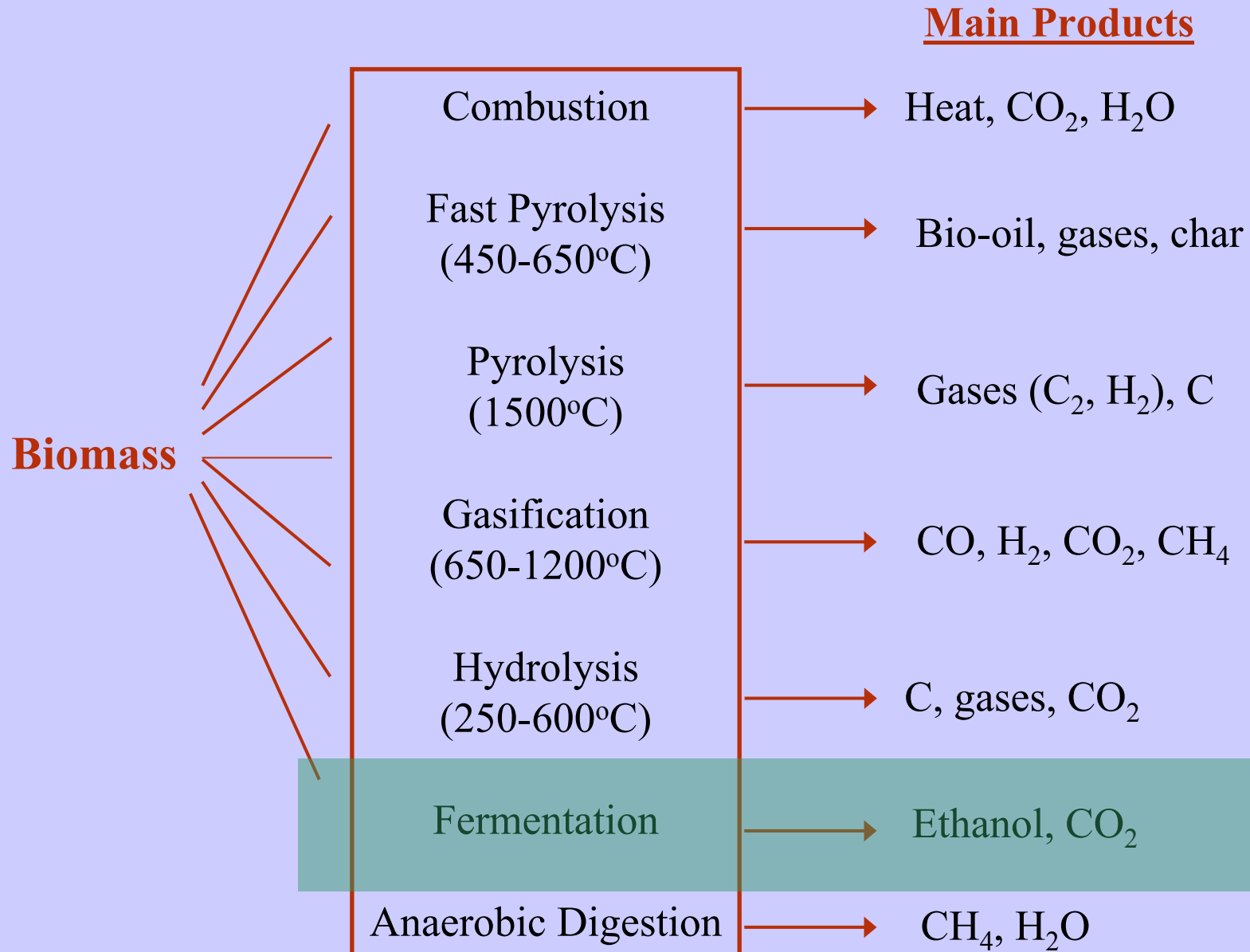


Islands & Remote Areas

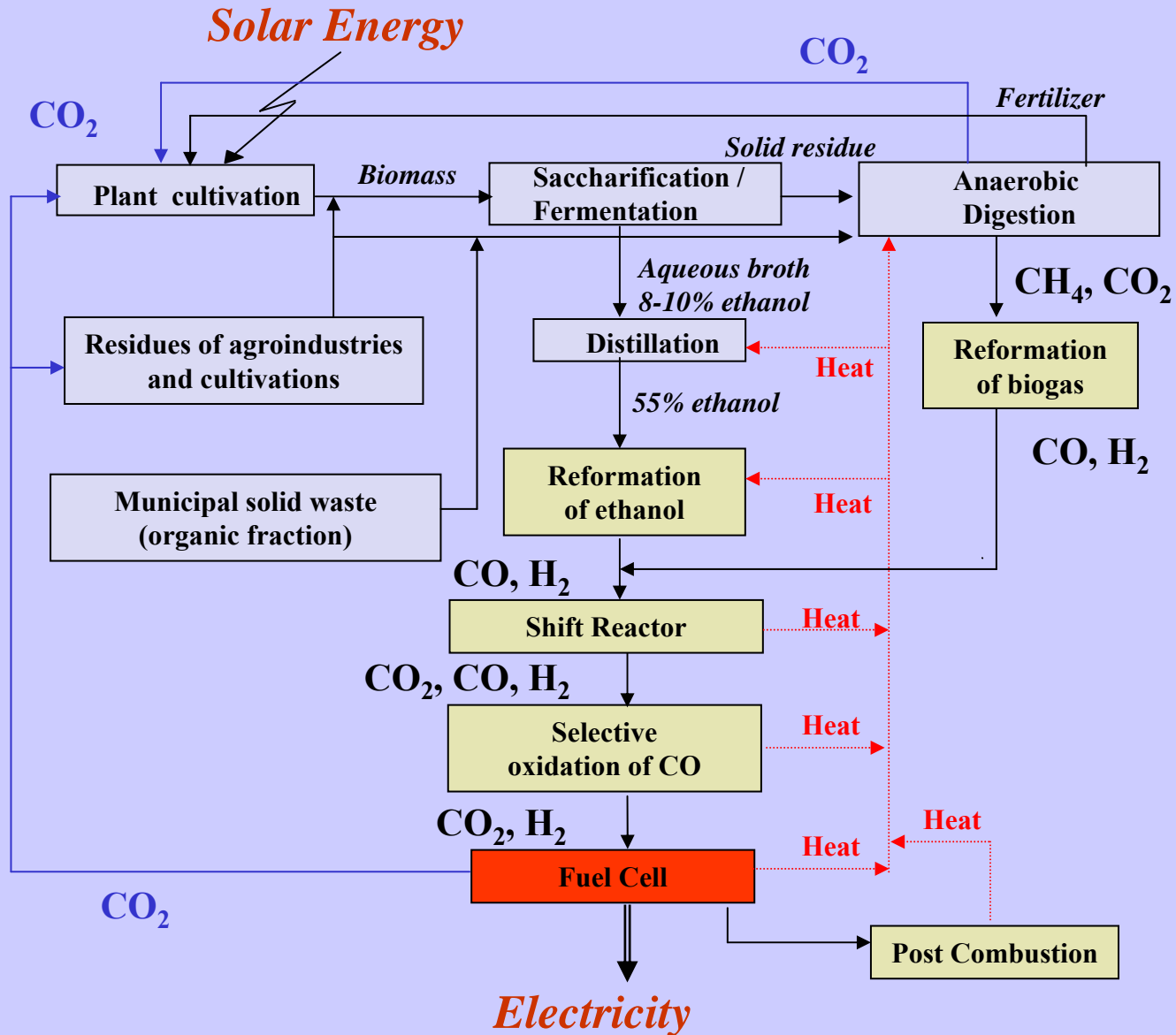


Agro-Industries

Biomass conversion processes



Production of H₂ and electricity from biomass



The process offers high energy yield

- Large fraction of biomass is utilized in production of ethanol and biogas.
- Water functions as fuel
- The efficiency of fuel cells is twice that of conventional thermal engines
- No need for pure (anhydrous) ethanol. Only 55-60% in water
- Part of the required heat for ethanol distillation can be obtained from other parts of the process

Advantages of the process

- Utilization of totally renewable energy source
- High energy efficiency
- Nearly closed carbon loop
- No production of atmospheric pollutants such as CO, NO_x, SO₂ or VOC's
- Efficiency independent of size of application
- Easy application in remote locations (off-grid), f.e. islands

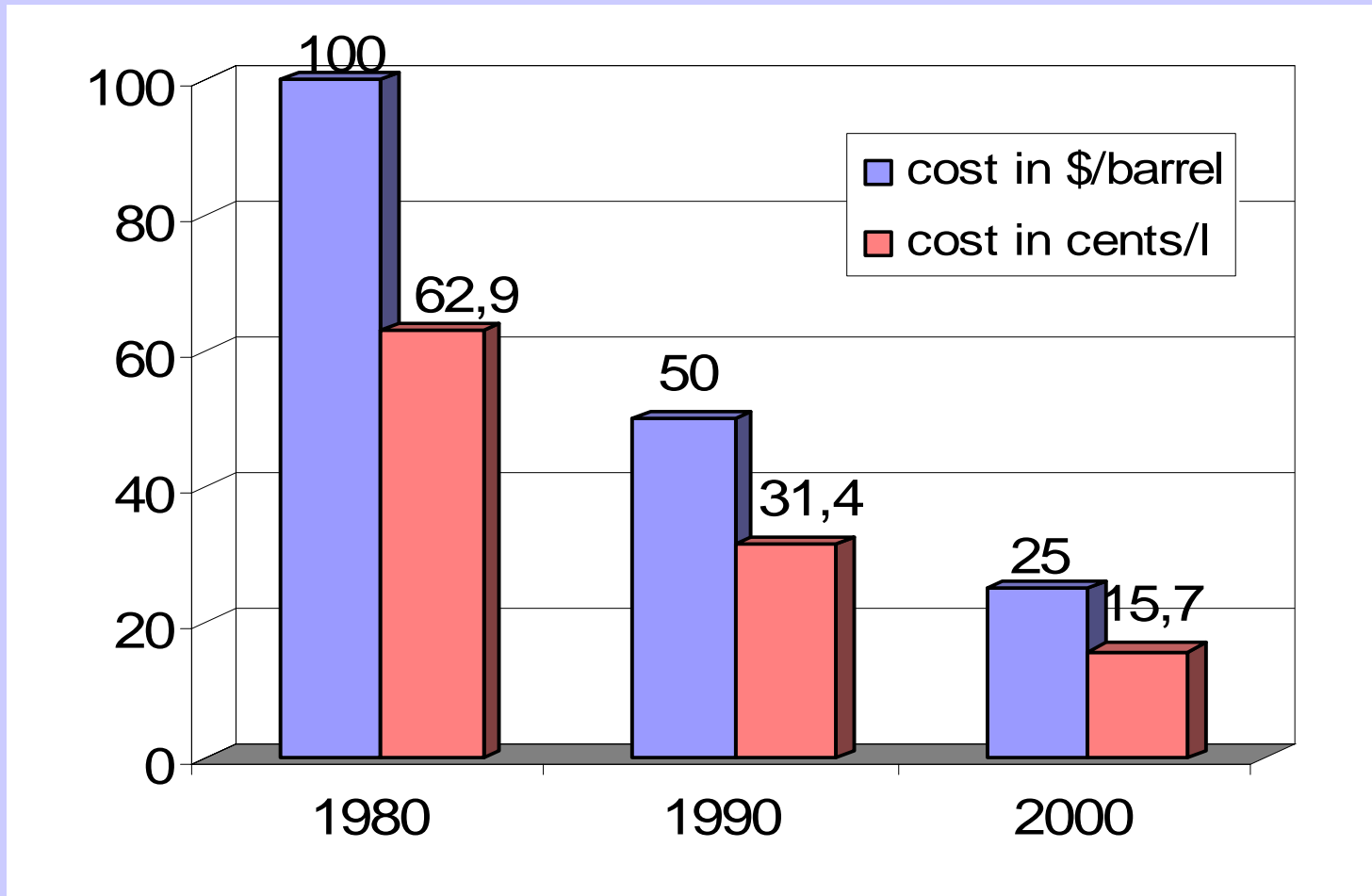
Motivation for ethanol as hydrogen source

- Ethanol can be produced from biomass, a renewable energy source (nearly closed carbon cycle).
- Easy to handle, store and transport.
- Aqueous rather than anhydrous ethanol \Rightarrow lower cost.
- Less toxic than methanol, gasoline, and hydrocarbons.
- Limited additional fuel infrastructure costs.
- Free from catalyst poisons, such as sulfur.
- *Economics?*

Estimated costs for Bio-Ethanol Production

Estimated cost of bio-ethanol produced from different crops			
Crop	Sugar yield (tons/ha)	Price of bio-ethanol (\$/m ³)	Energy ratio (out/input)
Sugar beet	6-8	300-400	1.76
Sugar cane	8-12	260	2.42
Sweet sorghum	7-12	200-300	2.23
Potatoes	2-5	990	1.7
Corn	5-8	300-420	1.3
Wheat	2.5-4.5	770	
Cassava		790	1.73
Synthetic ethanol		540	0.75

Ethanol cost reduction potential: the Brazilian example



*Source: Jose Goldberg in "Tagungsband zur Veranstaltung Biotreibstoffe",
22 Juni 1999, Rüslikon, Switzerland*

Fermentation - Bioethanol

Illinois, USA
(Pekin Energy Company's).
1 million lit bioethanol/day

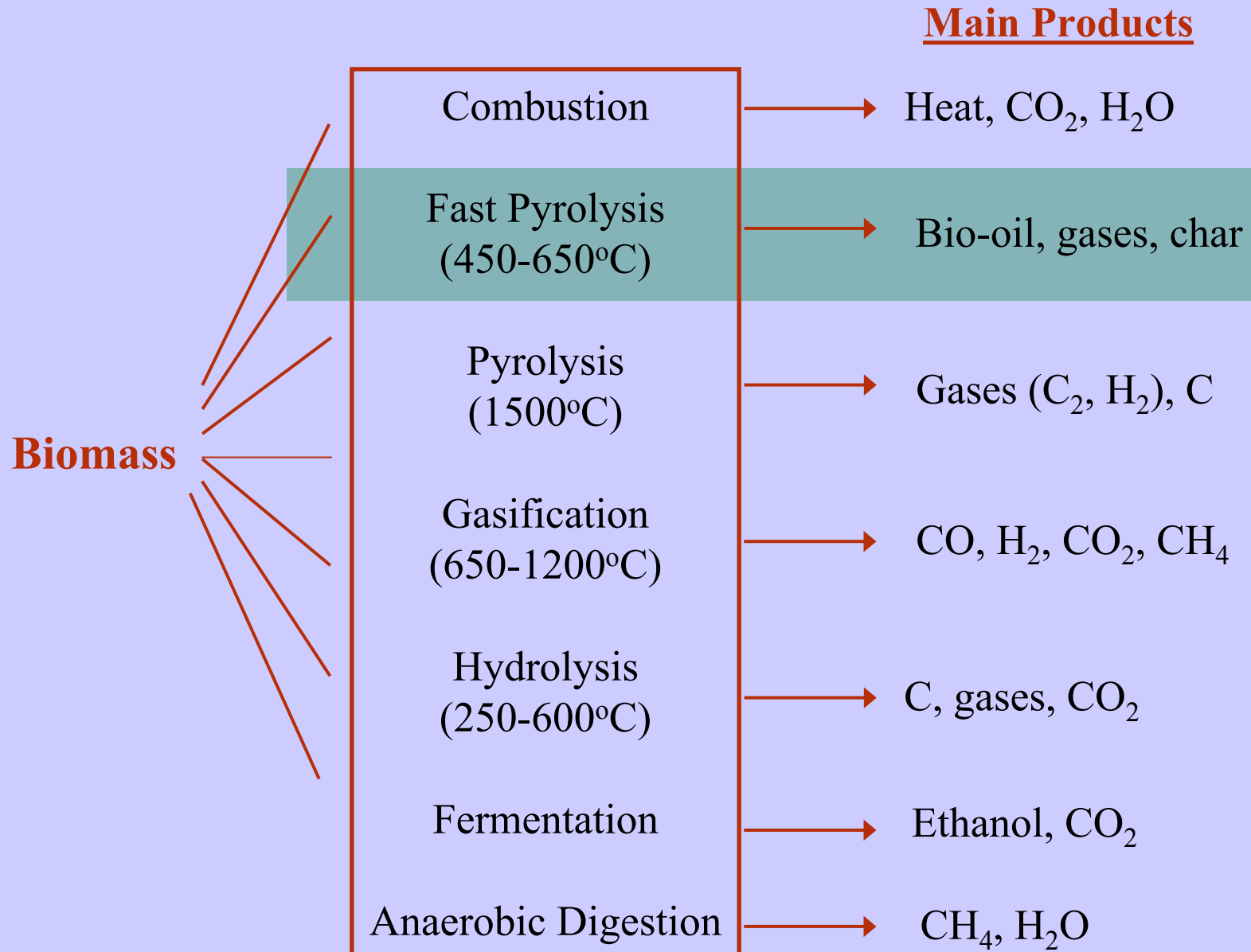


Hastings, Nebraska, USA
(Chief Ethanol Fuels Inc.)
325,000 lit bioethanol/day .

Nebraska, USA.
(Minnesota Corn Producers).
925,000 lit bioethanol/day.

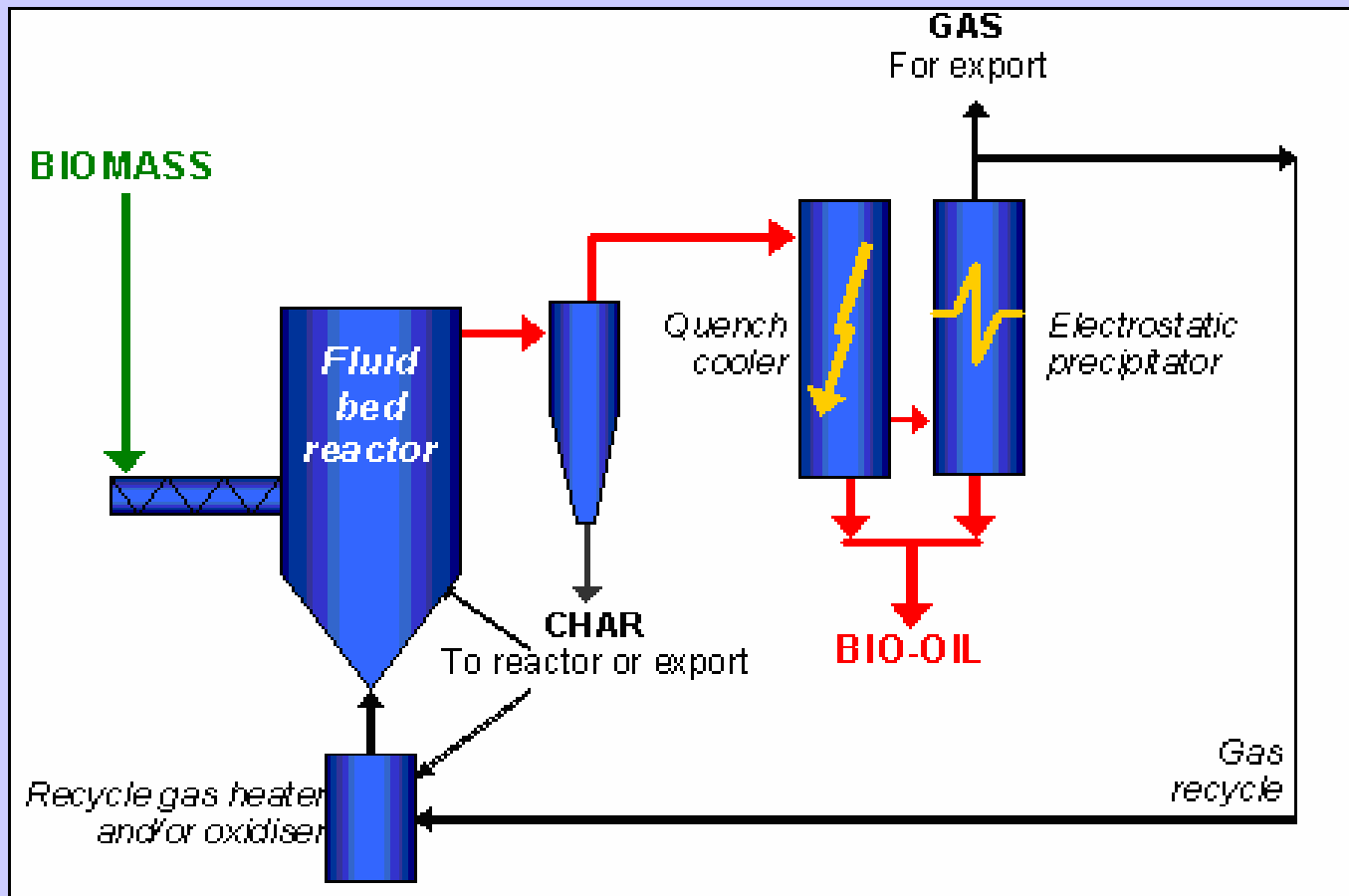


Biomass to hydrogen processes



Fast Pyrolysis of Biomass

- ❖ Fluidized-bed reactors
- ❖ Small residence times
- ❖ Temperature range: 450-650 °C
- ❖ Efficiency ~ 75 wt% (dry biomass)



Bio-oil

- Mixture of organic oxygenates
- High density: 1.2 kg/l
- High viscosity: 20-100 cP



Typical Composition

■ Organic Acids	5-15	(weight%)
■ Alcohols and Sugars	2-10	
■ Aldehydes and Ketones	10-15	
■ Ethers	1-5	
■ Phenols	15-30	
■ Water	25-35	

Conclusions

- Biomass can be converted to various fuels via established technologies, offering an important renewable energy source.
- Hydrogen can be produced from various biomass – derived components in an efficient and environmentally friendly manner. Hydrogen, in combination with fuel cells offers high electrical energy efficiency and zero emission operations.
- Biomass-derived ethanol, as hydrogen carrier for fuel cell applications, offers important environmental and operational advantages.
- Bio-oil, derived from biomass via fast pyrolysis of wood, can be used as hydrogen carrier for certain applications.