Environmental management reform for sustainable farming, fisheries and aquaculture

Second workshop on “Realising the ETAP in the management of waste from farms”

19 JUNE, 2009: 9:00-15:00
Vienna, AUSTRIA

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Lignocellulose and Second Generation Biofuels: an Overview

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World demand for energy is huge and will continue to be so in the future

Compared to 2004 by 2020-2030

Total Energy Increase by ca. 50%

(Fossil fuels alone by ca. 40%)

CO_2 up by 55 %

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World Energy supply (IEA 2002)

1971 ≈	6	Gtoe
1990 ≈	8.5	Gtoe
2000 ≈	10	Gtoe
2010 ≈	12	Gtoe
2020 ≈	14.8	Gtoe
2030 ≈	15.2	Gtoe

Main source of energy

Fossil fuels (75-85%)

Coal (2180-2214)

Oil (2080)

•Natural gas (2047-2084)

Oil shale & tar sands

•For electricity → cleaner, cheaper, more energy on combustion than coal

•Less abundant and not evenly distributed

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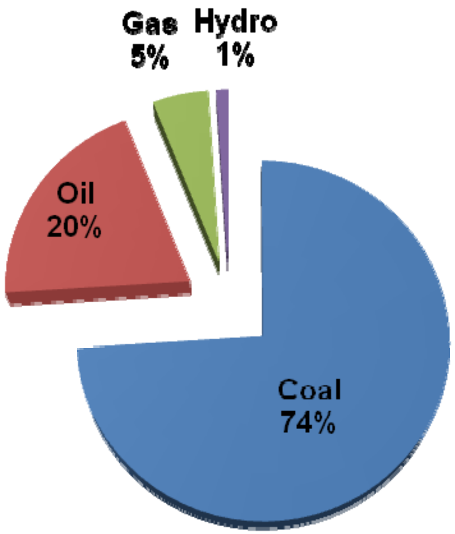
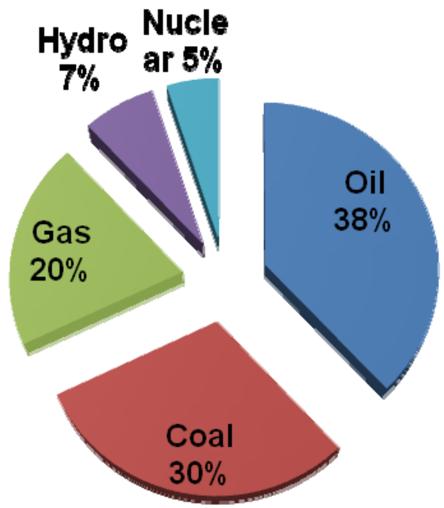
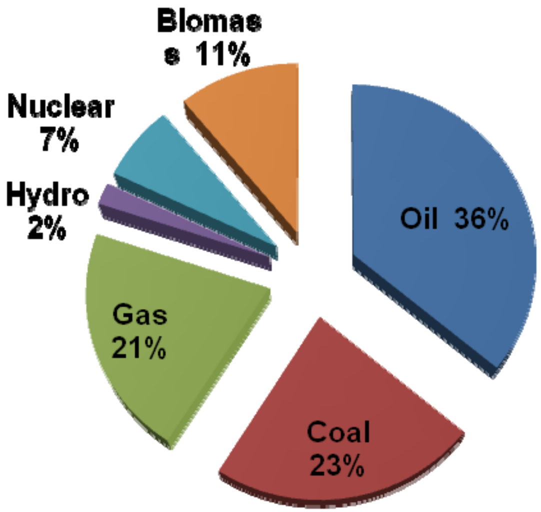


Energy source 1937



Energy source 1988



Energy source 2002

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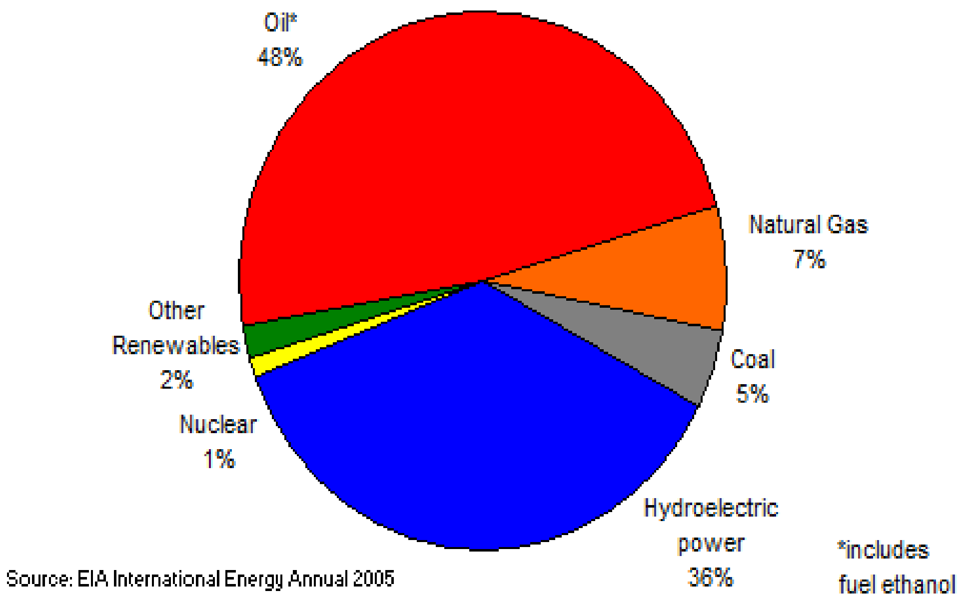
Total Energy Consumption in Brazil, by Type (2005)



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Concerns/Positives

- *Fossil fuels are finite*
- Cause environmental pollution
- Not evenly distributed
- Found in hostile and harsh environment
- On combustion →GHG, acid rain & other air pollution

✓ Relatively cheap
✓ With advanced technology for manufacturing and control —> less pollution emission than conventional ways
✓ Easy to transport (oil)

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Immediate danger is not the finite issue, but the supply and demand one

When demand out strips supply

↓

adversely impact improvement of living conditions measured by life expectancy and infant mortality

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Meet projected demand and minimize the adverse impacts

⇅

Sustainable, renewable, and clean (low emissions) energy resources

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Alternative non-fossil fuel energy sources

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1- Hydroelectric power (responsible for ca 17% of the electricity supply in developed countries and 31% in developing countries)

2-Geothermal power 3- Solar power 4- Wind power

5- Tidal power 6- wave power (also Nuclear Power)

- ✓ All are limited geographically and/or sustainability (except perhaps No. 2)
- ✓ Some are at experimental stage
- ✓ Some with environmental effects
- ✓ Some are clean (e.g., 6, but limited to 10% of hydropower)

Biological power --- Biomass

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Rough Estimates of Biomass Wastes Production and Oil Consumption

	World		EU
	Billion tons/year in the world	Million tons/year	Million tons/year
Biomass Waste (BW) Production	5-10		2500
Oil Equivalent to BW	0.75-4.5		
Total Oil Consumption	3.3-4		
Oil Consumption for Energy Needs	~3.1		

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Potential monetary value of OFMSW as fuel

Fuel	Caloric value	4500 kcal/kg
	Equivalent weight of oil	0.450 kg/kg oil/MSW organics
	Monetary value based on 50 $/barrel of oil and 1.3 $/€ exchange rate	0.12 €/kg MSW organics

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Based on the above,

Biomass wastes could in principle cover a large part of the total oil demand, but some problems needs to be addressed such as

→ **Collection**
Transportation
pre-treatment costs
their complex chemical nature

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Biomass

- Biomass supplies 13.5 - 15 % of world energy
  → Equivalent to > 25 M barrels of oil/d
  → Predicted to decline (12.5 %) by 2030 (not considering new technologies)

- Currently, global biofuels market is ca. 85% bioethanol and 15% biodiesel

- Bioethanol is produced and consumed mainly in Brazil and North America

- Biodiesel is produced mainly in Europe → ca. 3/4 of the European biofuels market

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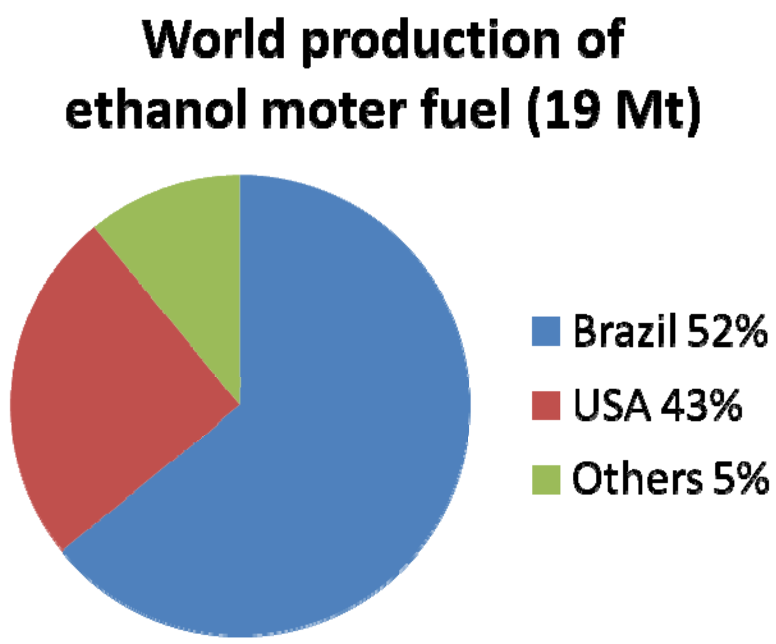

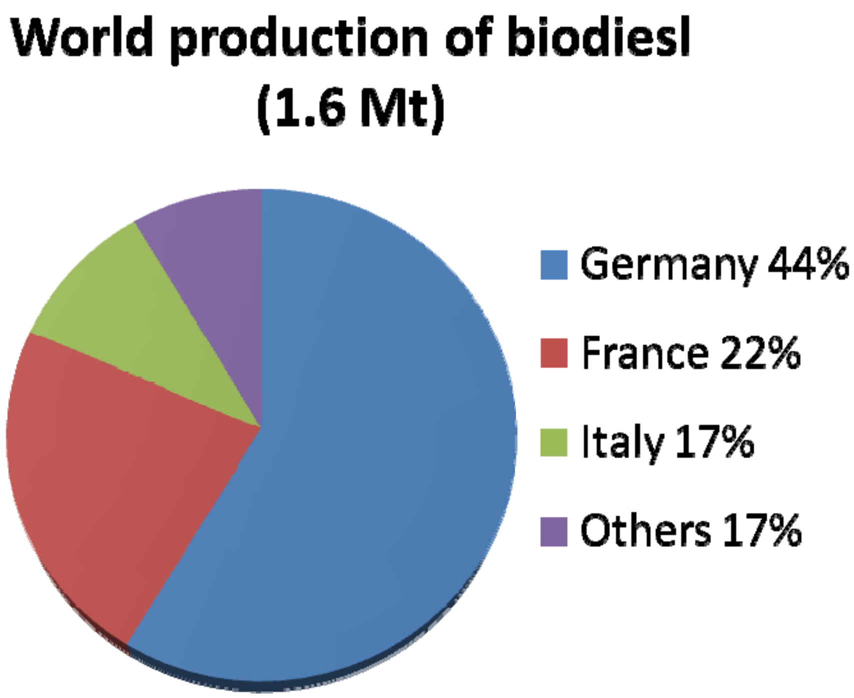

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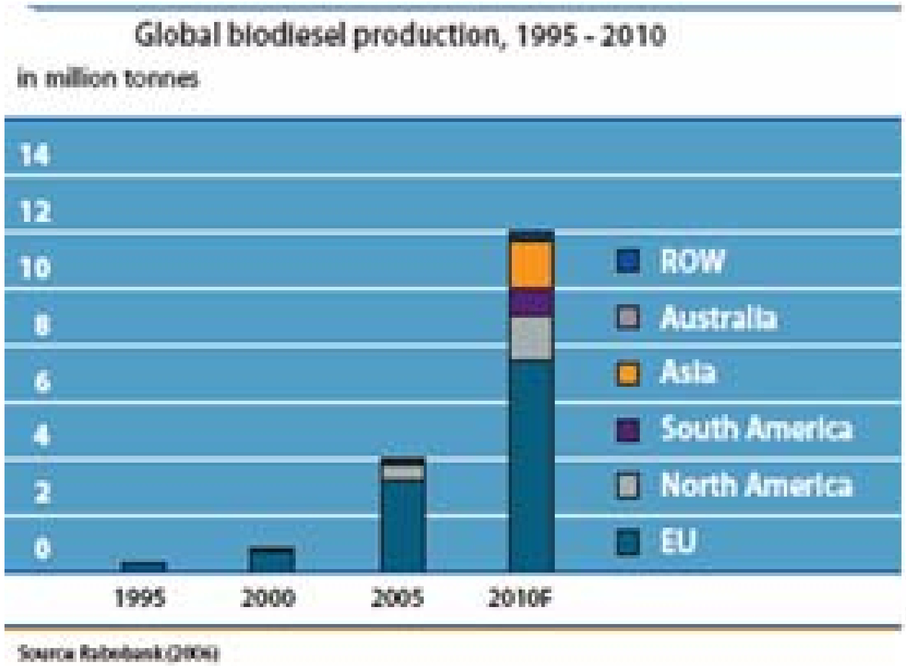

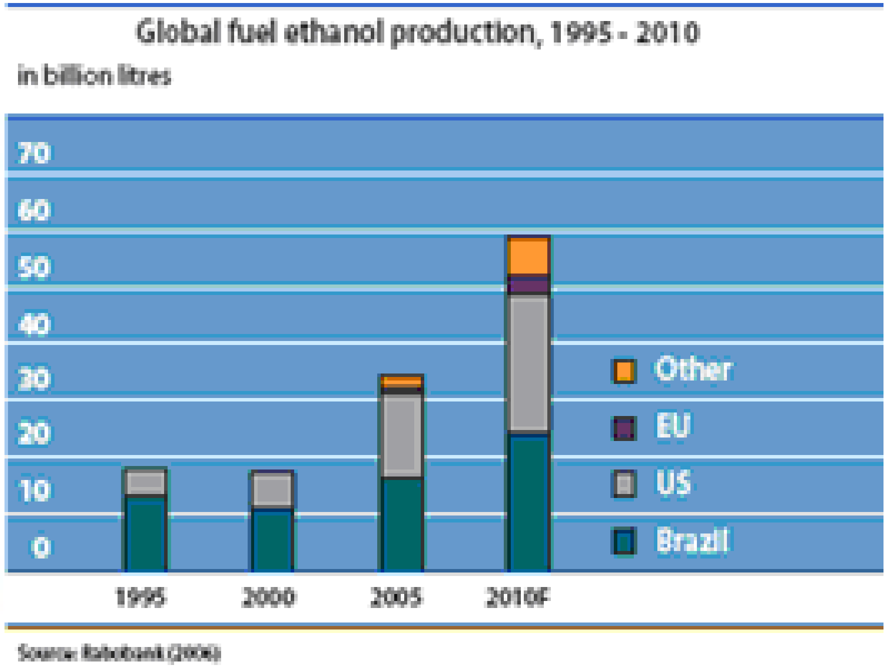

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First Generation Biofuel (1st GB)

Second Generation biofuel (2nd GB), (The New Future)

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Sources:

- ✓ Sugar crops: sugar cane, sugar beet, fruits, potatoes
- ✓ Starches: corn, cereal, cassava, sweet potatoes and sorghum, Jerusalem artichoke
- ✓ Energy crops: soya, rapeseed, sunflower seed
- ✓ Palm
- ✓ Bacteria (e.g., cyanobacteria → H_2)
- ✓ Algae
- ✓ Fermentation microorganisms (Fungi, Bacteria, Yeast)

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Advantages

- ✓ Produce heat, electricity, gas or liquid fuels
- ✓ Renewable & Sustainable,
- ✓ Available worldwide
- ✓ Clean (low emissions) energy resources
- ✓ Some CO_2 saving

Its use →

Reduce oil, coal, and gas use

Reduce emission of GHG

Less impact on the environment

Reduce imported energy

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One tonne of biomass for electricity-generation prevents as C emission equivalent--- Coal 0.5 t, oil 0.44 t, natural gas (0.28 t)

Biomass for liquid fuels --- prevents 0.2-2 t C/hectare

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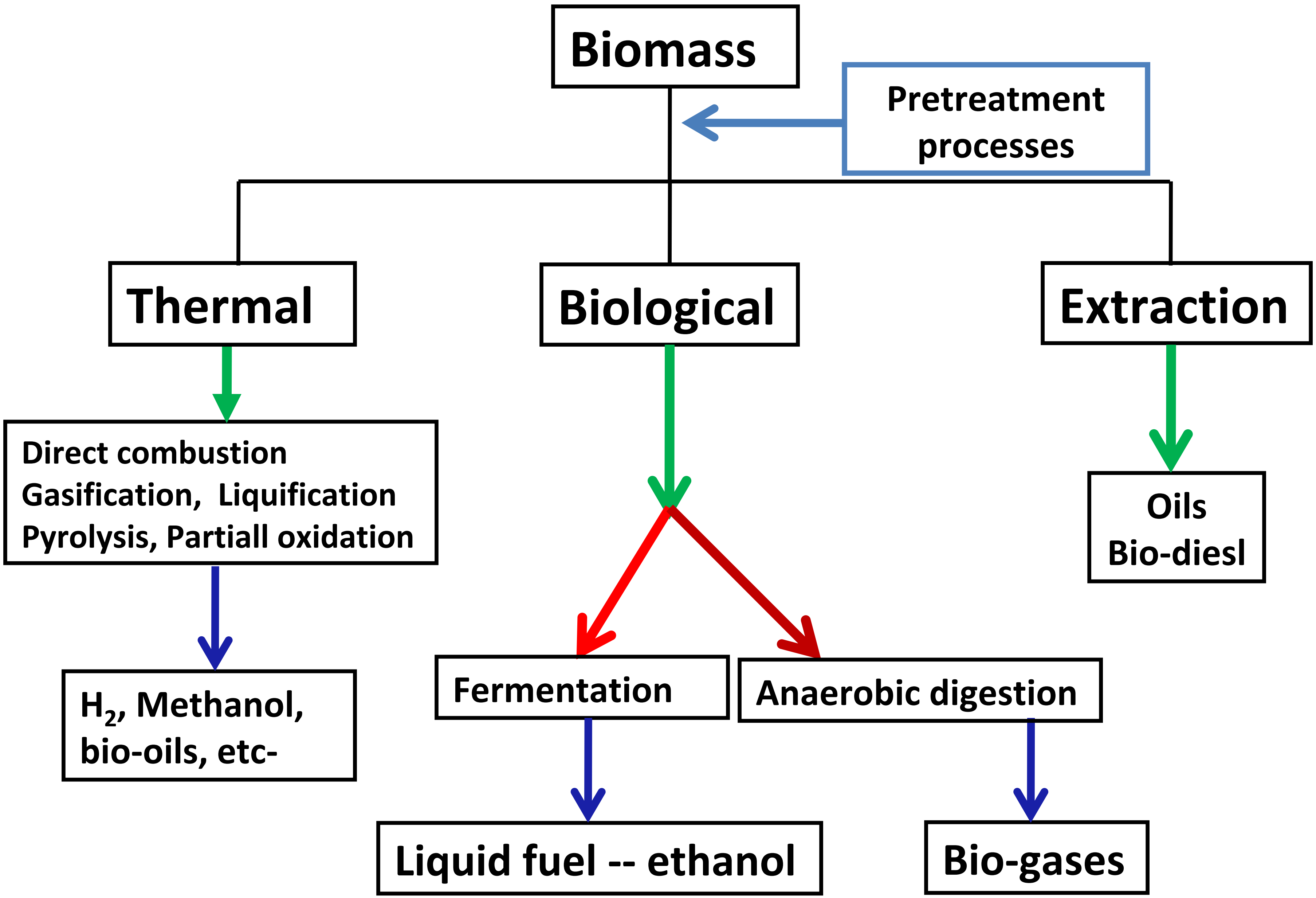
Disadvantages

- ✓ Compete with food production (1st GB)
- ✓ CO_2 saving not significant
- ✓ Long-term use and effects not well Known
- ✓ Affect biodiversity
- ✓ Land intensive and Land availability
- ✓ Impact water resources
- ✓ Comparatively more expensive
- ✓ Social – Culture implication
- ✓ Complex production processes --- involved multi disciplinary approaches

An example of some biomass pretreatments, conversion methods, and end products



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Lignocellulosic Biomass (the future) 2^{nd} GB

Ligoncellulosic Biomass Waste (ubiquitous)

- **Source :** Forest, agriculture , MSW, and industrial wastes, e.g., pulp & paper-waste sulfite liquors, and food industry wastes

- **Structure:** Lignocellulose (structural polymer of plants) is difficult & expensive to hydrolyze –> Limiting step in 2nd GBP

  ✓ In lignocelluloses

cellulose (20-50% of plant dry weight) is embedded in covalently bonded matrix of hemicelluloses (20-40%), pectin (2-20%), and Lignin (10 -20%) → very resistant structure for biodegradation

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Lignin: cannot be converted to ethanol, but can be used as fuel or as source of bioplastics

Sugar residues of hemicelluloses contain mixtures of hexoses and pentoses

Cellulose

Cellulose hydrolysis is an essential step in biofuel/biogas production → pre-treatment with acid, heat or enzymes

Acid treatment → Environmental damage & requires neutralization of the effluents

Heat treatment → high energy consumption

Enzyme treatment → preferable

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Enzymatic treatment (EM)

EM preferable, but still very inefficient being unviable from economic point of view

--- It involves synergistic actuation of several enzymes

--- So far, no know single microorganism that can produces all the necessary enzymes

→enzymatic cocktail of different enzymes from several microorganisms

→ Practical actions to improve the enzyme application on the biomass saccharification → Increase in the specific activity and thermal tolerance of the enzymes

→ Reduction of inhibition by hydrolysis products

→ Broader action on different natural substrates and products → agriculture, food, forest residues, MSW

Although modern research have improved the economical feasibility of lignocellulosic biomass conversion to ethanol, it still cannot compete with traditional feedstock

Conversion of lignocelluloses to ethanol includes:

- ✓ **Growing, harvesting, storing, transporting of the feed stock**
- ✓ **Pre-treating lignocellulosic feedstock to open the cell-wall matrix and to remove lignin**
- ✓ **Exposing the feedstock to a mixture of purified enzymes to hydrolyze hemicelluloses and cellulose to five- and six carbon sugars**

Conversion of lignocelluloses to ethanol includes:

- ✓ **Fermenting the sugars to ethanol**
- ✓ **Separating the produced ethanol**
- ✓ **More effective and cost-efficient enzymes for hydrolysis of feedstock, and more robust and efficient fermentative microorganisms**
- ✓ **Solid substrate fermentation of lignocelluloses by fungi and yeast and bacteria --- technology is not mature yet**

Improvements are needed in every step to make the technology cost-effective.

Biomass waste

Besides fuel and energy production, Biomass wastes may provide a very wide variety of bio-based added-value products for a wide number of technological applications → economically viable industry

Examples of bio-based products

Detergent formulation, textile industry, soil bioremediation, photocatalyst, pesticide and carbon black dispersants, water treatment, industrial cleaning, complexing agents for micronutrients, leather tanning, flotation and wetting aids in ore processing, surfactants for enhanced oil recovery, dispersants/fluid loss control agents for oil-well drilling mud and cements, bio-binder emulsion agent for road industry, etc.

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