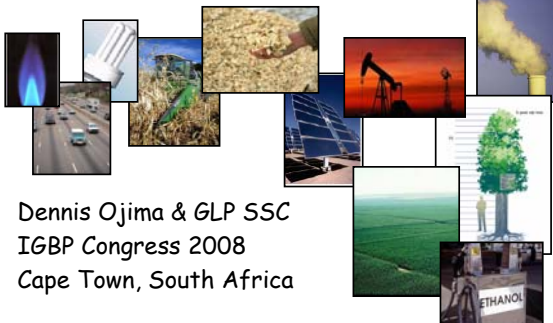


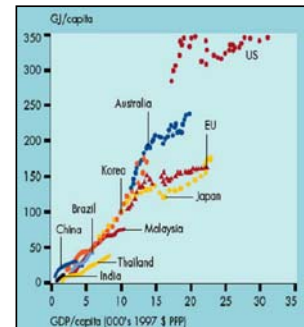
BIOFUELS: Ecological and Land Use Issues Related to Opportunities and Constraints to Future Development



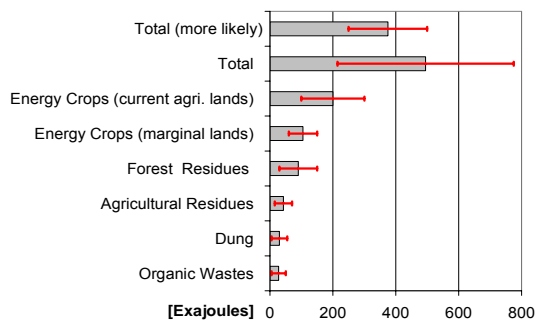
Dennis Ojima & GLP SSC
IGBP Congress 2008
Cape Town, South Africa

World wide Energy Consumption and Economic Connections

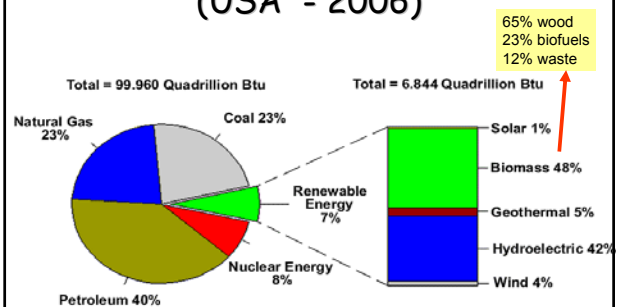
- There is a linear relationship between energy consumption and gross domestic product
- Many developing countries are adopting the U.S. social, economic and energy-use model
- The U.S. consumes roughly 26% of the worlds energy; yet we represent about 6% of the world's population



Expected BioEnergy Production (FAO 2006)



Renewable Energy (USA - 2006)



Source: <http://www.cia.doe.gov/>

BioFuel: Opportunities And Constraints

- Critical Climate Mitigation Option
- Improved economic return
- International trading in biofuels
- Environmental considerations
- World trade concerns

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BioFuel Strategies

- Improved plant material for biofuels generation
- Biomass produced with low inputs
- Improved methods for conversion of cellulose into useable carbohydrate
- Enhanced microbial engineering;
- Enhanced efficiency in energy generation, utilization, and storage via chemistry, engineering and physics.

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Land Based Fuel Options

- • Ethanol from corn & sugar crops
- • Biodiesel from soybean & other oil crops
 - Methane from animal manure
- • Corn grain for heat
- • Grass pellets
- • Short Rotation Woody Crops
- • Wood/chips/pellets

Heat, CHP,
Syngas/oil,
co-gen. elec.

- • Ethanol from cellulose in wood, crop residues and grass energy crops is a future possibility

Feed Stock Sources

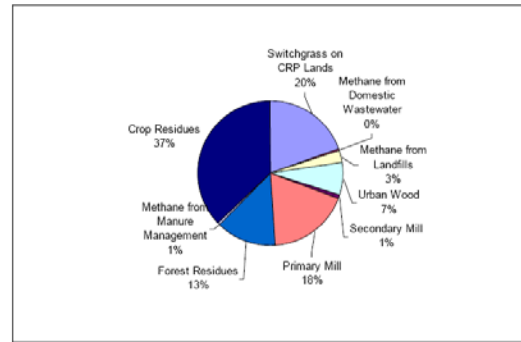


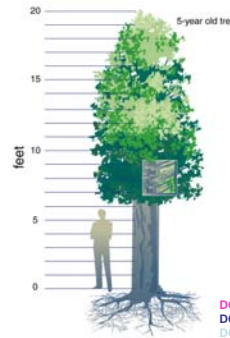
Figure 29 Percent Feedstock from Total Biomass
<http://www.nrel.gov/docs/fy06osti/39181.pdf>

Populus as a Model for Biofuels Production

- Fastest-growing deciduous tree in U.S.
- Genus occurs across broad geographic range
- Perennial and clonal
- Readily propagated and grown in intensive plantation



Fully Domesticated Poplar



- Reduced recalcitrance of cellulose degradation
- Reduced height growth
- Compact crown
- Higher productivity per unit area
- Greater number of stems per unit area
- Compact root system
- Drought/Stress tolerance
- Enhanced radial growth
- Nutrient use efficiency
- Greater product yield
- Reduced flowering

DOE Bioenergy Sciences Center
DOE Feedstocks for Bioenergy project
DOE Carbon Sequestration Project
ORNL Drought Tolerance Project

Source: DOE 2007

Innovation in Biofuels



- New developments in biofuel production from algae

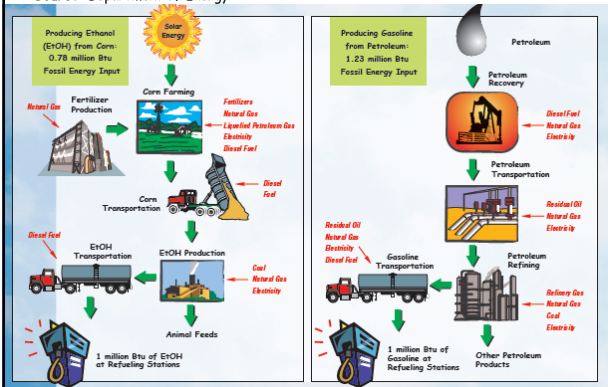
Socio-Environmental Concerns about BioFuels

- Energy Balance
- Net emissions of GHG
- Biodiversity and habitat effects
- Inadvertent pollution of soil and water
- Social-economic effects (i.e., Food vs Fuel conflict)

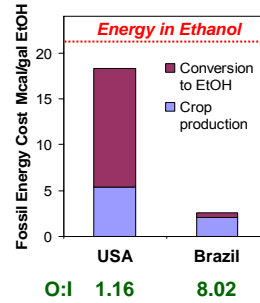


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Fossil Energy inputs used to produce and deliver a million Btu of EtOH and gasoline to a refueling station
Source: Department of Energy



Energy Balance for EtOH - USA & Brazil



Sugarcane is a carbon crop

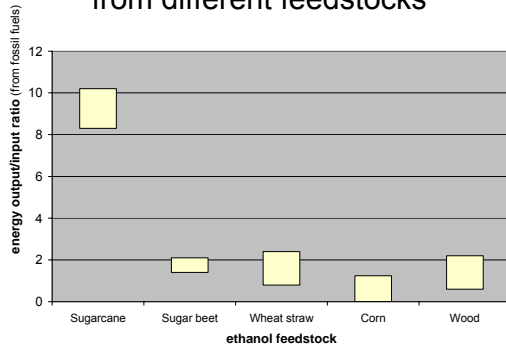
Cane has 4 ratoon crops reducing planting cost

Bagasse is used to generate energy for cane conversion to ethanol

Low N inputs

Sugar cane ethanol is 6 x more energy efficient compared to corn ethanol

Energy balance of alcohol production from different feedstocks



Sources: (Macedo et alii, 2004; UK DTI, 2003 and USDA, 1995)

Land Use for Ethanol

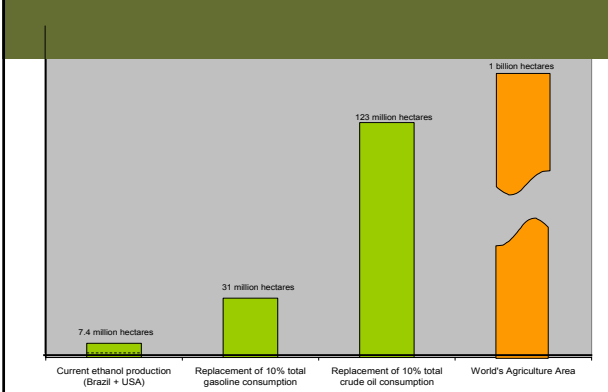
- World crude oil consumption: 4,478 billion litres/year
- World gasoline consumption : 1,292 billion litres/year

	Ethanol Production from Sugar Cane		Agricultural Area (million ha)	
	(billion litres/year)	(million barrels/day)	Sugar cane to ethanol	Sugar cane (total)
Current Brazilian production	16	0.28	2.5	5.5
Sugar cane agricultural area in the world				20
Replacement of 10% total gasoline consumption	189	33	31	
Replacement of 10% total crude oil consumption	746	13	123	

- USA ethanol production from maize: 18 billion litres (0.32 million bbl/day)
- agricultural area:
 - USA's maize to ethanol: 5 million hectares
 - USA's maize total: 30 million hectares
 - World's maize total: 147 million hectares

World total agriculture area: 1,228 million hectares

Land Use to Ethanol



Opportunities and Constraints

- Development of novel energy products and system design
- Innovation incentives
- C and GHG emission trading opportunities



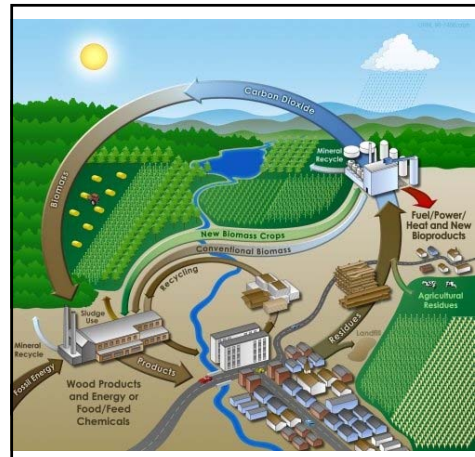
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Opportunities and *Constraints*

- Water and Nutrient Usage
- Release of Invasive or Genetically modified organisms
- Energy and GHG emission inefficient
- Social-Economic Disruption (competition with food and fiber)



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- ENVIRONMENT:**
- Energy Balance
 - GHG
 - Land Use
 - Biodiversity
 - Water
 - Nutrients
 - Invasive Biota
- SOCIAL:**
- Food vs Fuel
 - Aesthetics
 - Economic
 - Jobs/Training
 - Equity
 - Certification