Ethanol Fuel

Biomass to Chemicals and Fuels: Science, Technology and Public Policy.

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Reasons for the study

- Personal Interest in the Energy subjects
- Course taken in the summer of 2002 at WSU Pimentel's negative energy balance
- Fascinated by the idea of renewable sources of energy playing a major role on the energy matrix

Ethanol “propaganda”

- Reduction in carbon dioxide emissions
- Energy efficiency

Energy balances (output/input)

Output – Energy embedded in ethanol produced

Input – energy required for Agricultural, Industrial activities and distribution of ethanol

Results:

- Brazil (Sugarcane) - 3.70 (1.3)*

- US (Corn) – 1.10 (0.7)*

* Considering energy required to clean up residues

Reasons for the difference

- Brazilian distilleries energy requirements are met by burning the bagasse (sugarcane milled)

- Sugarcane yield per hectare (ha) is bigger

  (80 Mg per ha x 8 Mg per ha for corn)

- High amount of energy for the conversion of corn to ethanol

  (~ 12.4 GJ/m^3)

CO_2 Balance

Basic assumption

CO_2 released as a result of ethanol combustion is not accounted because it will be captured again by the plant (corn or sugarcane)

Emissions per m^3 of ethanol produced:

Brazil: 522 Kg CO_2/m^3

US: 1400 Kg CO_2/m^3

Automobile emissions

US – Ford Taurus Flex fuel

Gasoline: 7.4 Mg CO_2/car

E85: 5.0 Mg CO_2/car

Savings: 2.4 Mg of CO_2

Brazil – Volkswagen Gol 1.6

Gasohol : 3.8 Mg CO_2/car

Ethanol : 1.2 Mg CO_2/car

Savings: 2.5 Mg of CO_2

Ecological Footprint (EF)

Accounting tool based on the concepts of sustainability and carrying capacity.

Estimates the resource consumption and waste assimilation requirements of a defined human population or economy sector in terms of corresponding productive land area

e.g. forest area required to assimilate CO_2

EF Results

	For CO_2 Assimilation	For Harvest Production	Total EF
US, Ford Taurus			
Gasoline (ha)	1.1	—	1.1
E85 (ha)	0.8	1.0	1.8
Brazil, Volkswagen Go1			
Gasohol (ha)	0.6	0.1	0.7
Ethanol (ha)	0.2	0.4	0.6

Values refer to fuel acreage for 1 automobile per year

Scale-Up ethanol area requirements

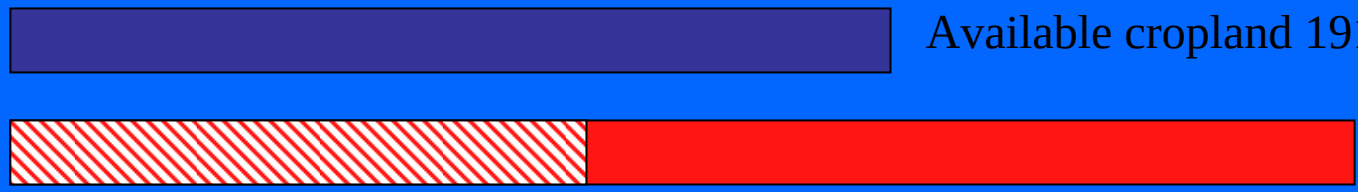
US automobile fleet – 138 Million (M)

Area of corn crops required to produce ethanol for the whole country – 129 M ha or ~ 70% or cropland area in the country.

Brazilian automobile fleet – 16 M
Area of sugarcane required ~ 6 M ha or ~ 10% of the cropland area.

Scale-Up is Unrealistic — EF

US, Corn (E85, 168 M vehicles)



Available cropland 191 M ha

EF 292 M ha *

(CO_2 assimilation area) (harvest area)

Brazil, Sugarcane (ethanol, 16 M vehicles)

Available cropland 60 M ha

EF 10 M ha *

**** Ecological footprints do not include BOD assimilation!***

Environmental Impacts

Coupled environmental impacts of US ethanol production

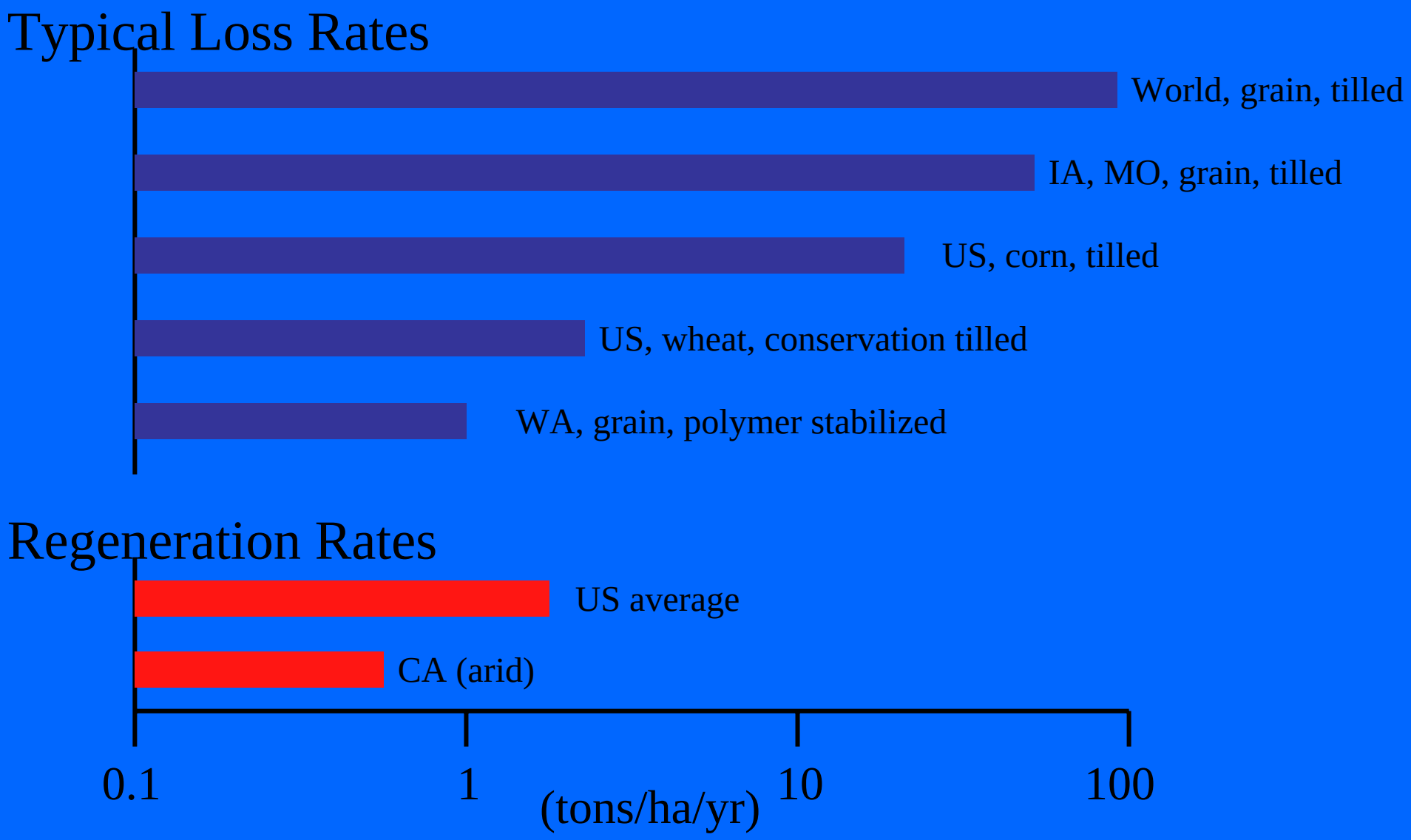
- Environmental impacts of agriculture production

plus

- Environmental impacts of the fossil fuels used during the process

Result = Increase of environmental impacts

Agricultural Soil Losses Are Severe



Brazilian environmental problems

- Water use in distilleries

  3 m^3 per Mg of sugarcane

  3.9 m^3 – personal observation

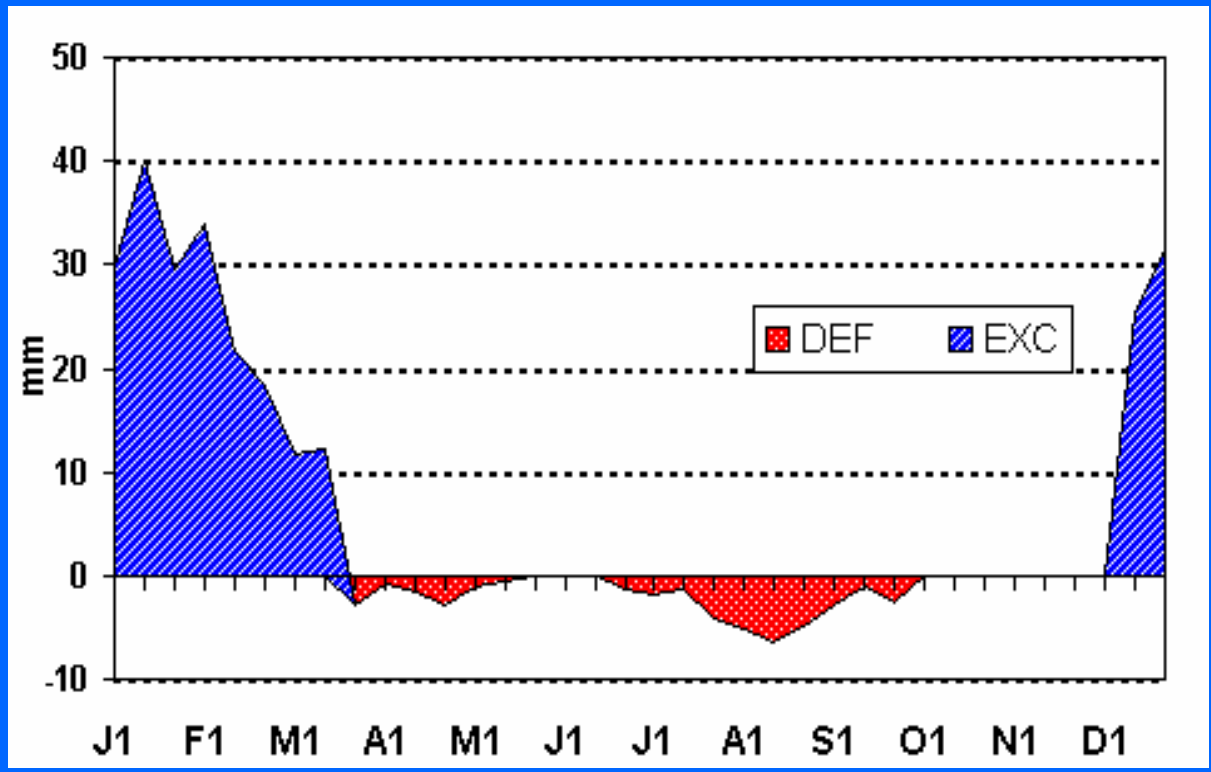
Average production from 1999 to 2004

12.4 billion liters (www.ibge.gov.br)

Water consumption enough to supply for 1 year

~ 13.8 million people

- Harvesting coincides with dry season



Hydro balance or water budget for Piracicaba
(source: Depto Ciencias Exatas – ESALQ – Universidade de Sao Paulo

Piracicaba River (wet season)

Piracicaba River (dry season)

Other Problems

- Pre – harvest burning
- Reduction of native vegetation
- Loss of biodiversity

Final considerations

- Replacing fossil fuels will take more than one source of alternative energy
- Ethanol can contribute, but still have to find more sustainable and efficient ways of production
- No alternative energy source comes free from environmental impacts

Acknowledgments

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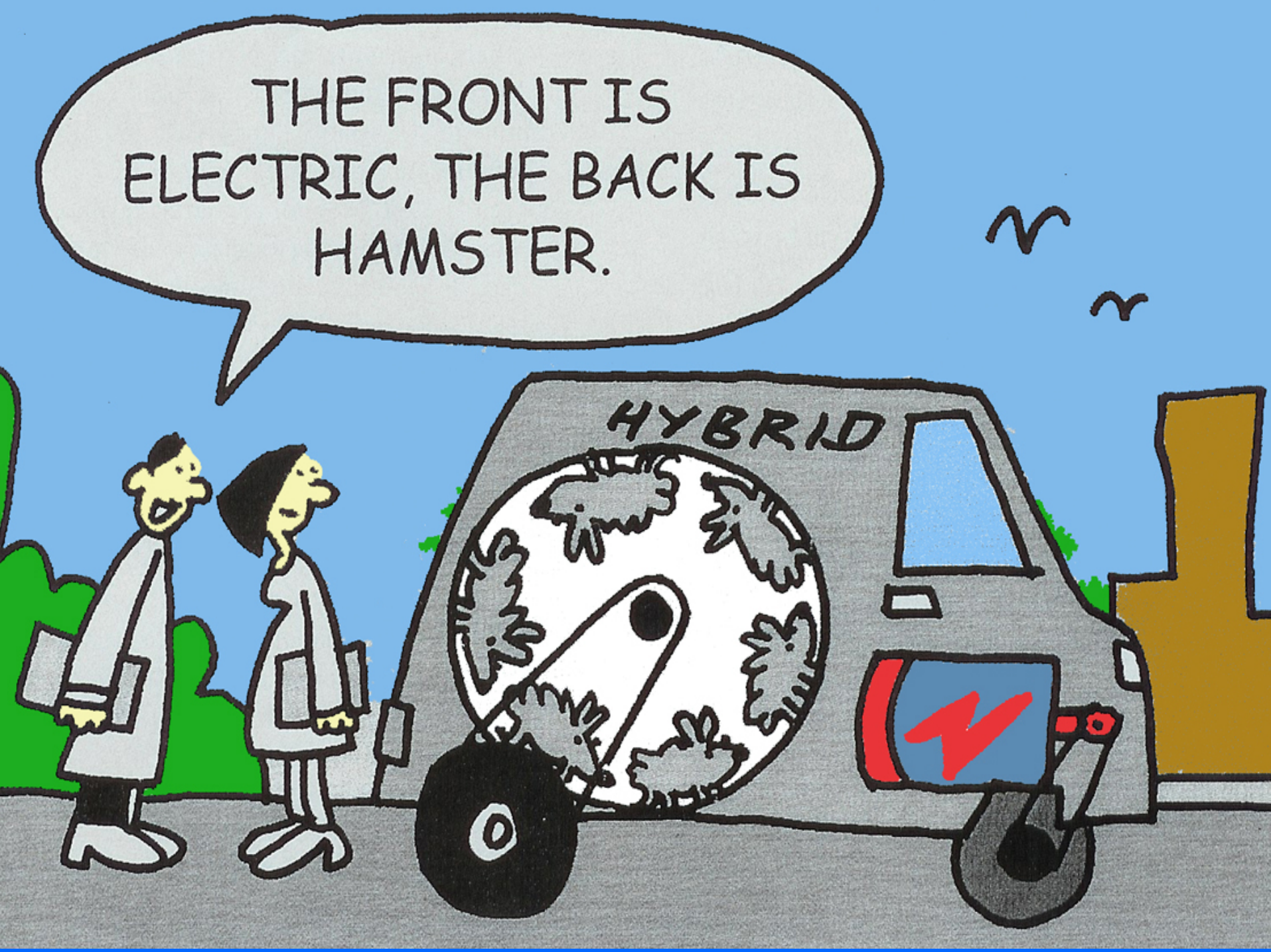
THE FRONT IS ELECTRIC, THE BACK IS HAMSTER.
HYBRID