MASS AND ENERGY FLUXES OF BRAZILIAN AGRICULTURE PRODUCTION FOR EXPORTATION TO ASIA: SUGAR CANE

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Brazilian Context

- Brazil - a positive handicap regarding renewables use.
- 2004 - renewable energy – 43.9% of Domestic Energy Supply
  (2002: World average – 13.6%, in OECD’s countries - 6%).
- Brazilian electric energy supply - hydropower plants (75.5%).
- Brazilian sugar cane agribusiness - 2.2% of GDP (income of over US$ 8 billion, 1m direct jobs).
- A positive environmental differential = efficient production of fuel grade ethanol from sugar cane.
- Fuel ethanol in Brazil - 25% blend with gasoline (gasohol), or as fuel in dedicated alcohol engines vehicles or used in the newly produced flex fuel vehicles.
- Ethanol production in 2004/ 2005 crop season - 16 billion liters.
- São Paulo State - 89.6% of 380 million tons of sugarcane (and 24 million tons of sugar).
- Extra bonus - sugar cane processing generates bagasse, replacing fossil fuels in the production of industrial heat and electricity in the sugar mills and distilleries.

- How to promote a development policy based on the expansion of agribusiness - a complex question.
- The evolution of land use to crop sugarcane is totally correlated with the increase in the total production, mainly since 2000.


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Brazilian Main Energy Figures

![Graph showing energy figures for Brazil (2004), OECD (2002), and World (2002).]
Brazilian Main Energy Figures

Brazil, 2004

World, 2002

Brazil – Asian Countries
agro-products Trade
Brazil – Asian Countries agro-products trade

Brazil – Japan sugar and ethanol trade
Characterization of sugarcane agriculture

Main Axis of National Integration and Development

Environmentally Protected Areas
Sugarcane Cultivated Areas

Characterization of sugarcane agriculture: Land Use, Mean Productivity and Total Production

Year

Land Use (1000ha)
0 100000 200000 300000 400000 500000 600000 700000
Mean Productivity (10kg/ha)
Total Production (1000ton)
Brazilian Automobile Productions: gasoline, ethanol and flex-fuel

![Graph showing Brazilian automobile productions from 1957 to 2010](image)

Brazilian sugarcane agribusiness: environmental issues

- **Brazilian sugarcane agribusiness** - an important example of sustainable agriculture.
- **A high environmental performance:**
  - lower worldwide levels of erosion;
  - use of biological control of plagues and of soil fertile irrigation with the organic residues from the sugarcane industrial processing
- **Low use of pesticides and herbicides due to biological control**
  - a mineral fertilizers use lower than corn and soybean crops (optimized management of filter residues, vinasse and sugarcane leaves can improve this figure).
- **Regarding soil and water use:**
  - diminished problems due to a high grow of the plant and use of rotation of cultures;
  - water is supplied by the aqueous emissions of the industrial process, treated or not, and by rain.
- **The energy output/input ratio (either renewable or fossil) is 9.2:**
  - mean energy = use in sugarcane production / 190MJ/Ton of Sugarcane + in ethanol production / 46MJ/Ton of sugarcane
Environmental Issues Characterization

- The increase in the area of sugarcane crops for alcohol production causes the intensification of at least two great environmental problems:
  1) the ecosystem degradation and atmospheric pollution related to the forest fires and,
  2) the pollution of water resources due to the application of vinasse as fertilizer and irrigation.
- **Vinasse**
  - main by-product of sugarcane agrindustry, both for presenting a highly polluting characteristic and to its huge volume, making difficult to transport and to eliminate.
  - rich in organic substance and mineral nutrients as potassium (K), calcium (Ca) and sulphur (S).
  - each liter of alcohol produced generates between 10 and 15 liters of vinasse.
  - the infiltration of vinasse in the underground water increases the concentration of ammonia, magnesium, aluminium, iron, manganese, chloride and organic substance.
- **Filter cake**
  - a residue that comes out from the clarification process of the sugar.
  - each ton of the 40 sugar cane produces 30 kg of cake.
  - an organic compound (85% of its composition) rich in calcium, nitrogen and potassium.
- **Sugar cane bagasse**
  - its fiber content ranges 12.8 %.
  - 1 ton of sugar cane generates approximately 250 kg of bagasse, equivalent to 560,000 kcal.
  - These figures produces 70 liters of alcohol, or 392,000 kcal of energy.
  - 240 kg of bagasse removed from a ton of sugar cane provides the equivalent of 70 kWh of energy.
Life cycle GHG emissions of ethanol from sugarcane

- **Group 1**: Carbon flows associated with the uptake of atmospheric carbon by photosynthesis and its gradual release by oxidation.
  - 1.a - Uptake of atmospheric carbon (photosynthesis);
  - 1.b - Carbon release during cane field burning, before harvesting (around 80% of tops and leaves are burned with an efficiency of 90%);
  - 1.c - Oxidation of unburned residues, in the field;
  - 1.d - CO2 release in the fermentation of sucrose to ethanol;
  - 1.e - CO2 release by the combustion of all bagasse, for power and heat generation, in the boilers of the mills or in other industries boilers (surplus bagasse);
  - 1.f - CO2 release by the combustion of ethanol in automobile engines.

- **Group 2**: Carbon flows associated with the use of fossil fuels in the production of chemicals and inputs used in the agricultural and industrial sectors, in the manufacture of equipment, construction of buildings and their maintenance.
  - 2.a - CO2 release due to the use of fossil fuels in the cane fields: tillage, irrigation, harvesting, transportation etc.;
  - 2.b - CO2 release due to the use of fossil fuels in the production of agricultural inputs (seeds, herbicides, pesticides, fertilizers, lime etc.);
  - 2.c - CO2 release due to the use of fossil fuels in the production of agricultural equipment, spare parts and their maintenance;
  - 2.d - CO2 release due to the use of fossil fuel for industrial inputs (lime, sulfuric acid, biocides, lubricants etc.);
  - 2.e - CO2 release due to the use of fossil fuels in the manufacture of equipment, construction of buildings, and their maintenance in the industrial area.

- **Group 3**: The GHG flows not associated with the use of fossil fuels are mainly N2O and methane.
  - 3.a - Release of other GHG (non CO2) in the process of cane field burning;
  - 3.b - Release of N2O from the soil, due to fertilizer decomposition;
  - 3.c - Release of other GHG (non CO2) in the combustion of bagasse in steam boilers;
  - 3.d - Release of other GHG (non CO2) in the combustion of ethanol in engines.

- **Group 4**: "Virtual" flows of GHG emissions: they would take place if, in the absence of ethanol, the fuel demand was met by gasoline and if in the absence of surplus bagasse, fuel oil was used. These emissions can be characterized as:
  - 4.a - GHG avoided emission by substituting ethanol for gasoline;
  - 4.b - GHG avoided emission by substituting bagasse for fuel oil in other industrial sectors.

Life cycle main GHG-related fluxes of ethanol from sugarcane

(Photonsynthesis cycle is not included since all carbon flow by the cane is released as CO2 during burning, burning/oxidation of fuels, ethanol burning, fermentation, except for a small fraction that remains inert.)
Future Trends

- To improve the use of biological control of plagues
- To improve the use of soil fertile irrigation with the organic residues from the sugarcane industrial processing, and the optimized management of filter residues, vinasse and sugarcane leaves can improve this figure.
- To improve sugarcane productivity
- To improve sugar content on sugarcane
- To customize sugarcane to resist to semi-arid weather conditions (low water availability)
- 2nd Generation Ethanol – To develop microorganism to decompose sugarcane fibers