Environmental Comparison of Conventional and Organic Technological Routes for Sugar Obtaining Concerning to Greenhouse Gases Emissions

Charles Prado Monteiro
Marcelo Almeida Costa
Emilia Satoshi Miyamaru
Luiz Alexandre Kulay

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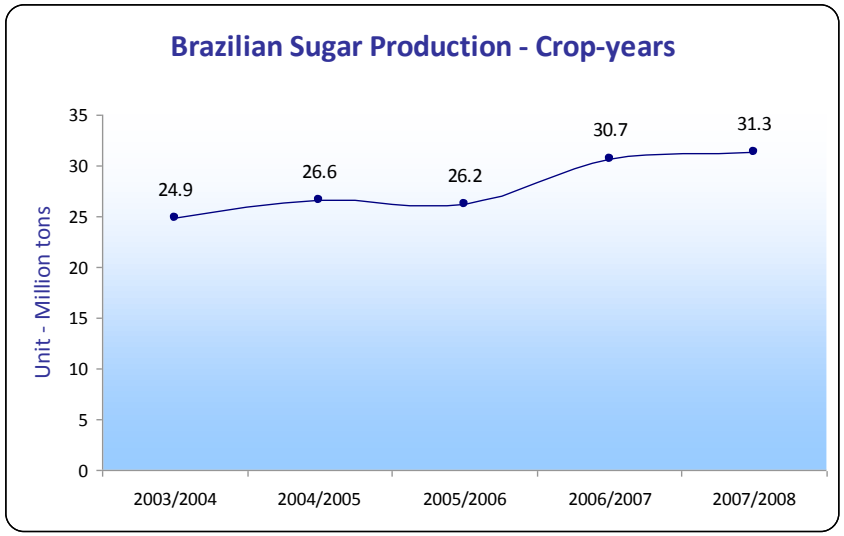
1. INTRODUCTION

- Brazil and India are the largest sugar producer in the world.
- Brazilian sugar represents about 50% of the international sugar market.
- The Brazilian sugar is obtained from the sugarcane.
- Since the sugar is an important product in the human diet, as a source of energy, it is one of the most traded product in the world.

2. SUGAR SCENARIO IN BRAZIL

- 2007/2008: 515.8 million tons of sugarcane produced in 6.7 mil ha.
- 2007/2008: 31.3 millions tons of sugar produced
- 2008/2009 Estimate: 558.7 million tons of sugarcane in 7.1 mil ha.
- 2008/2009 Estimate: 32.8 millions tons of sugar



2. SUGAR SCENARIO IN BRAZIL/WORLD

- Two technological options:
  - Conventional Sugar:

    Produced through chemical fertilizers, herbicides and insecticides.

    About 80% of sugarcane is burned before the harvest.

  - Organic Sugar:

    Vinasse and Filter Cake (wastes from sugar indutrial process - refinery)

    No synthetic chemical inputs in the entire production chain

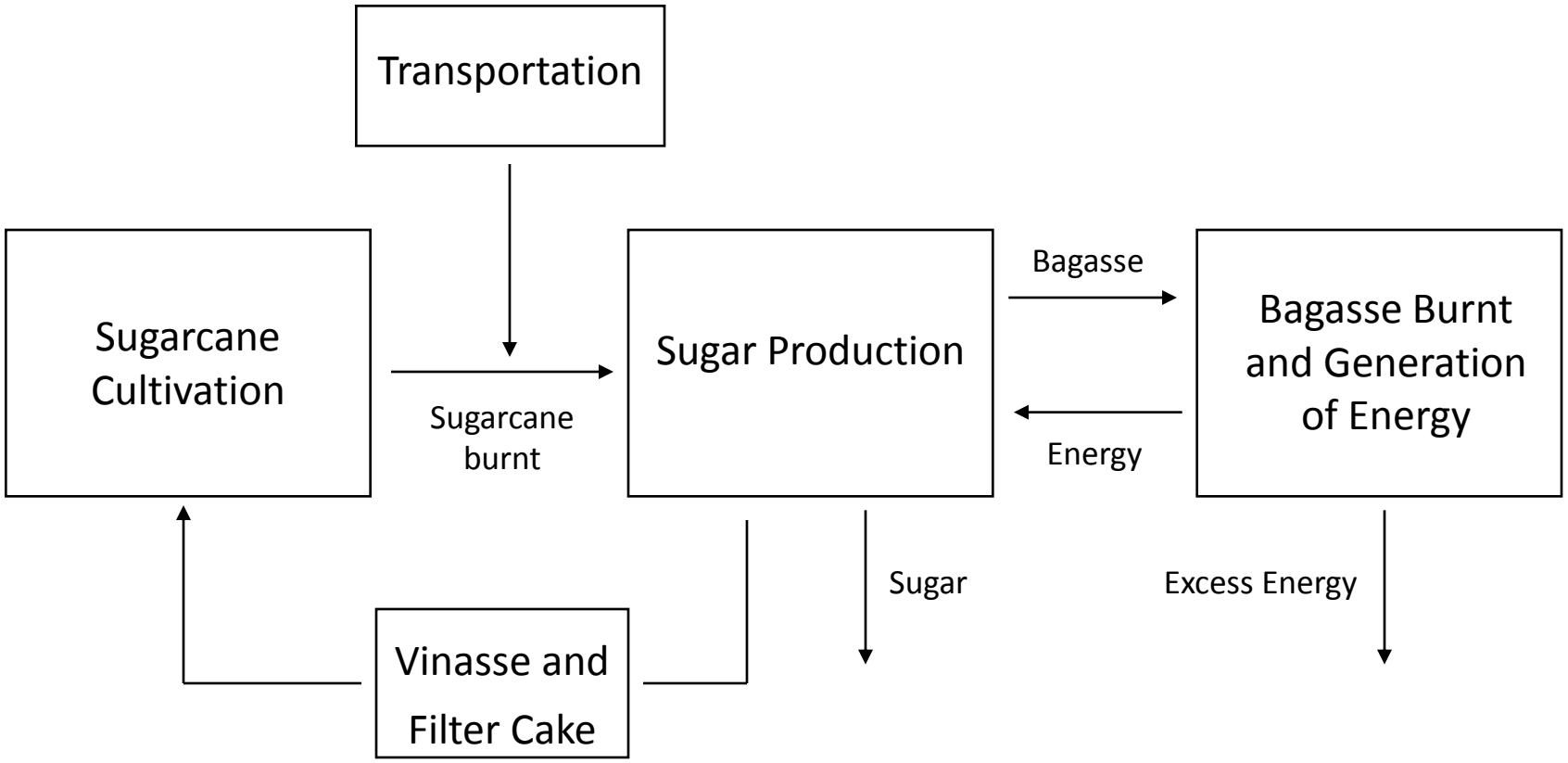
3. GHG EMISSIONS IN SUGAR LIFE CYCLE – ORGANIC ROUTE x CONVENTIONAL ROUTE

- 3.1 Definition of goal and scope
  - Objective: to compare the environmental performance in terms of greenhouse gases (CO_2, CH_4 and N_2O) from organic and conventional routes of sugar production.
  - Function: To supply the energetic needs for an adult human being (70 Kg of body mass) for an year.
  - Function Unit: supply 730,000 kcal
  - Reference Flow: 4,000 kcal/kg of sugar – 182.5 kg of sugar/year
  - Approach: cradle to gate

3. GHG EMISSION IN SUGAR LIFE CYCLE - ORGANIC ROUTE X CONVENTIONAL ROUTE

- Exclusion Criteria: exclusion of Unit Processes and environmental loads:
  - Quantitative: contribution below 1.0% were excluded from the product system
  - Environmental Relevance
- Data Quality criteria
- Allocation factors
- Impact Assessment Model – IPCC (2001) GWP 100

3.3 PRODUCT SYSTEM: CONVENTIONAL SUGAR



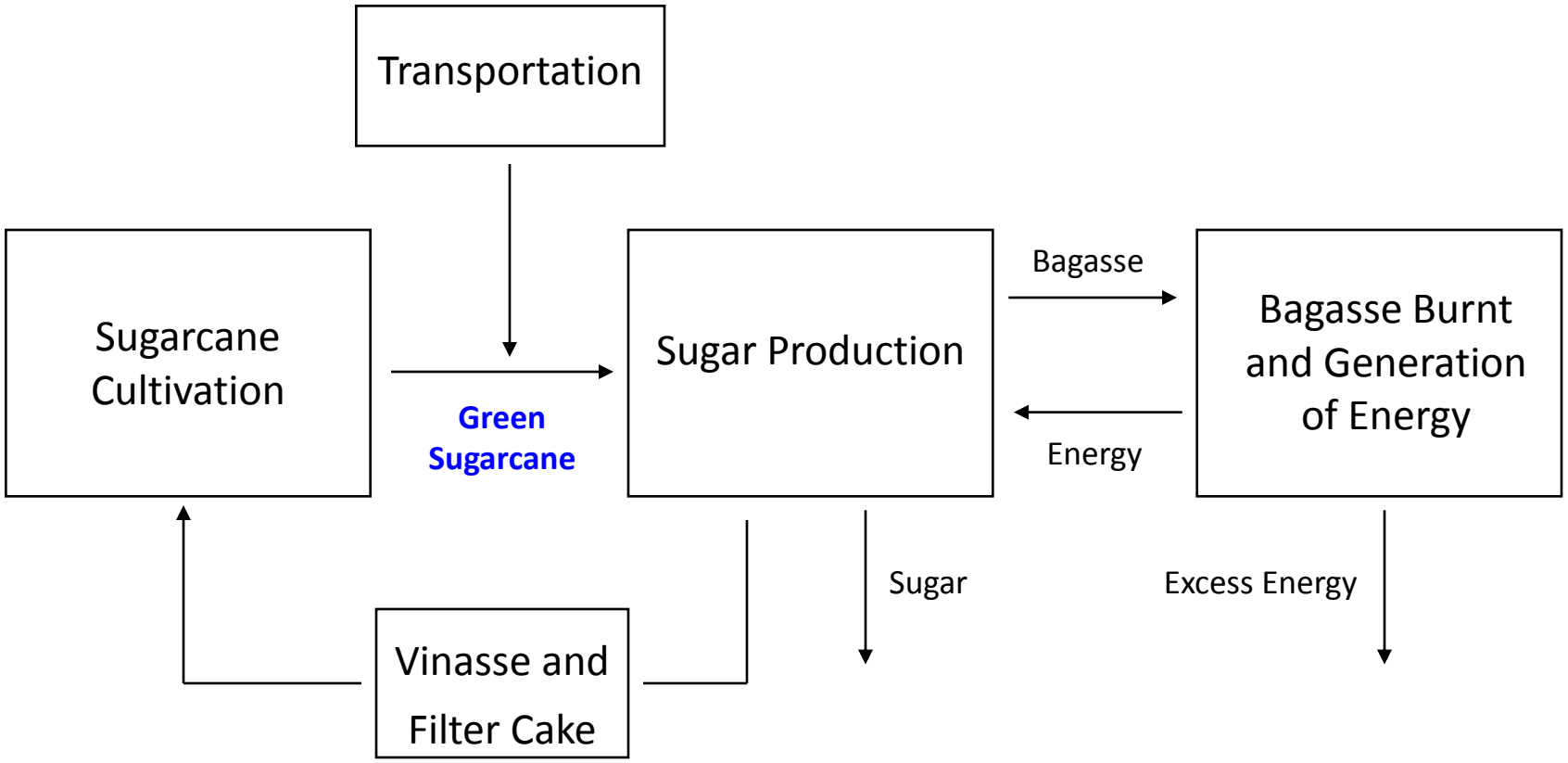
3.3 PRODUC SYSTEM MODELING
Conventional Sugar – Agricultural Phase

- Production cycle: 5 crops in 6 years.
- Yield: 68.7 ton/ha.year
- Fertilizer Comsuption (ha.yr) with Vinasse and Filter Cake:
  - N – 60 kg – Urea and Ammonium Nitrate
  - P – 8.3 kg – Single Superphosphate
  - K – 13.3 kg – Potassium Chloride
  - Vinasse: 76.2 m^3 and Filter Cake: 5.6 ton
- Operational Profile (Crops):
  - Mechanic Harvest – 35%; Mannual Harvest – 65%
  - Green Sugarcane – 20%; Burned Sugarcane – 80%
- Transportation
  - Seed
  - Sugarcane for Refinary

3.3 PRODUC SYSTEM MODELING
Conventional Sugar – Industrial Phase

- Yield: 120 kg sugar/ton sugarcane
- Grinding of Sugarcane
  - Juice: sugar and molasses (industry of ethanol)
  - Bagasse: energy production (self-sufficient)
- Primary Treatment - Cush Cush, Sieves and hydrocyclones.
- Chemical Treatment
  - Addition of SO_2 (sulphur dioxide) to the juice
  - Addition of $Ca(OH)_2$ (hydrated lime) to the juice.
- Evaporation / Crystallization
- Separation and drying
  - Sugar
  - Molasses

3.4 PRODUCT SYSTEM: ORGANIC SUGAR



3.4 PRODUCT SYSTEM MODELING
Organic Sugar – Agricultural Phase

- Production cycle: 5 crops in 6 years.
- Yield: 81.7 ton/ha.year
- Fertilizer Applied:
  - Green Manure (*Cotrolaria juncea*)
  - Cattle's Manure – 2.45 ton/ha.yr
  - Vinasse: 90.7 m^3/ha.yr
  - Filter Cake: 6.66 ton/ha.yr
- Operational Profile (Crops)
  - Mechanic Harvest – 100%
  - Green Sugarcane – 100%
- Transportation
  - Seed
  - Sugarcane for Refinary

3.4 PRODUCT SYSTEM MODELING
Organic and Conventional Sugar – Industrial Phase

- Yield: 147.5 kg organic sugar/ton sugarcane
- Sugar refining: the same for organic and conventional routes.
- Brazilian model of sugar refining - two products: sugar and molasses
- Molasses: ethanol production
- Economic Allocation: 86% sugar; 14% to ethanol

4. RESULTS AND DISCUSSIONS

Kg CO_2 eq./FU – Agrictural Phase	
Organic Sugarcane	- 806.68
Conventional Sugarcane	- 631.89

Kg CO_2 eq./FU – Industrial Phase	
Organic Sugar	22,631
Conventional Sugar	26,100

4. RESULTS AND DISCUSSIONS

- Difference between GHG emissions are related to agricultural stage – sugarcane cultivation.

- Direct GHG emissions from the conventional sugarcane (ha.year):
  - N_2O: 3.05 kg - 58% nitrogenous fertilizers, 15% Biomass burnt, 13% vinasse and 14% filter cake
  - CH_4: 15.17 kg – Biomass burnt

- Direct GHG emissions from the organic sugarcane (ha.year):
  - N_2O: 1.86 kg - 46% manure cattle's, 29% filter cake and 25% vinasse

4. RESULTS AND DISCUSSIONS

- Agricultural stage of the organic sugarcane emits less GHG, compared with the cultivation of the conventional sugarcane

- Organic sugarcane harvesting is carry on by through mechanized equipments (diesel consumption).

- In this specific subject, the organic sugarcane emits more GHG than the conventional sugarcane (mechanized crop represents 35% of the production).

4. RESULTS AND DISCUSSIONS

- GHG direct emissions in industrial stages: bagasse burned and energy generation.
- Process Control Measures: residual CH_4 and N_2O
- Direct GHG emissions from the conventional and organic sugar (boiler):
  - CH_4: 4.75×10^{-6} kg/Kg sugar
  - N_2O: 1.00×10^{-3} kg/kg sugar

- Electricity: average energy generation: 16.83 KWh/ton sugarcane
  - 65% Refinary comsuption
  - 35% Sold to the concessionary

4. RESULTS AND DISCUSSIONS

- Analyzing the Life Cycle Assessment of the sugar industrial phase, we noticed a high emission of GHG:
  - CO_2 eq. Fossil (70% of total): comsuption of natural gas, coal and heavy oil in chemical production industry – soda powder, lime and sulphur dioxide.
  - CO_2 eq. Biogenic (12% of total): it burns of biomass for generation of energy and Brazilian Grid (3.2% it burns of biomass).
  - The other 18% are regarding several stages included in the LCA sugar model, such as model, such as industrial process, transport, equipments and structures.

5. CONCLUSION

- The greenhouse gases emission were higher in conventional route than organic sugar process.

- Cultivation by conventional route without sugarcane burnt – legal exigency in 2014 in Sao Paulo – emits more GHG than the organic cultivation, because the emissions of N_2O from the nitrogenous fertilizers are higher than N_2O generated due to the cattle manure.

- The most significant GHG emissions are in the industrial phase. Three main products responsible for this are sulphur dioxide (53%), Soda Powder (33%) and Lime (14%).

THANKS FOR YOUR ATTENTION!!!

Contact:

Charles Prado Monteiro: monteiro.charles@terra.com.br