# BETTER SUGAR; BETTER BUSINESS

## MILL ISSUES AND CO-PRODUCTS

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# WORLD CROP LAND

| CROP | AREA (MMHA) |
|---|---|
| Sugar cane | 20.1 |
| Wheat | 207.5 |
| Rice | 153.0 |
| Maize | 144.8 |
| Soybeans | 91.6 |

**Notes:**
**Rice - 42,5MMha in India and 29,4mmha in China**
**Wheat - 27,3mmha in India and 21,7mmha in China**
**Corn - 29,7MMha in USA and 25,6mmha in China**

**Source: FAO, 2004**

# MAIN SUGAR CANE PRODUCERS

| COUNTRY | AREA (1000HA) | SUGAR CANE (1000 TONNES) |
|---|---|---|
| Brazil | 5,455 | 411,009 |
| India | 4,100 | 244,800 |
| China | 1,316 | 93,200 |
| Thailand | 1,050 | 63,707 |
| Pakistan | 1,049 | 52,040 |
| Cuba | 700 | 24,000 |
| Mexico | 639 | 45,126 |
| Australia | 415 | 36,892 |
| Other | 5,377 | 347,097 |
| TOTAL | 20,100 | 1,317,871 |

Source: FAO, 2004

# BRAZILIAN CROP LAND AND PRODUCTION

| CROP | AREA (MMHA) | PRODUCTION (MM TONNES) |
|---|---|---|
| Soy Beans | 21.5 | 49.5 |
| Corn | 12.3 | 41.8 |
| Sugar Cane | 5.6 | 416.3 |
| Beans | 4.0 | 3.0 |
| Rice | 3.7 | 13.3 |
| Wheat | 2.8 | 5.7 |
| Coffee | 2.4 | 2.5 |
| Other | 5.7 | - |
| TOTAL | 58.0 | - |

Source: IBGE, 2004

# BRAZIL LAND USE

| TYPE | AREA (MMHA) |
|---|---|
| Total Country | 851 |
| Brazilian Native Amazon | 370 |
| Secondary Amazon and other Native Forests | 180 |
| Planted Forests (cellulose and energy) | 6 |
| Pasture | 197 |
| Arable Land | 59 |
| Permanent Crop | 7.6 |
| Agricultural Area | 263 |
| Land for Crops/Low Impacts (*) | 90 |

Source: FAO, 2002 and EMBRAPA (*)

# BRAZILIAN MODEL FOR SUGAR CANE INDUSTRY

- **JOINT PRODUCTION OF SUGAR AND ETHANOL**

| | 1990 | 2002 |
|---|---|---|
| Sugar only mills | 27 | 15 |
| Ethanol distilleries | 180 | 104 |
| Sugar/Ethanol mills | 168 | 199 |
| Total | 375 | 318 |

- **LAND OWNERSHIP**

  Mills = 65%

  Independent Cane Growers (70,000) = 35%

- **HARVESTING SEASON**

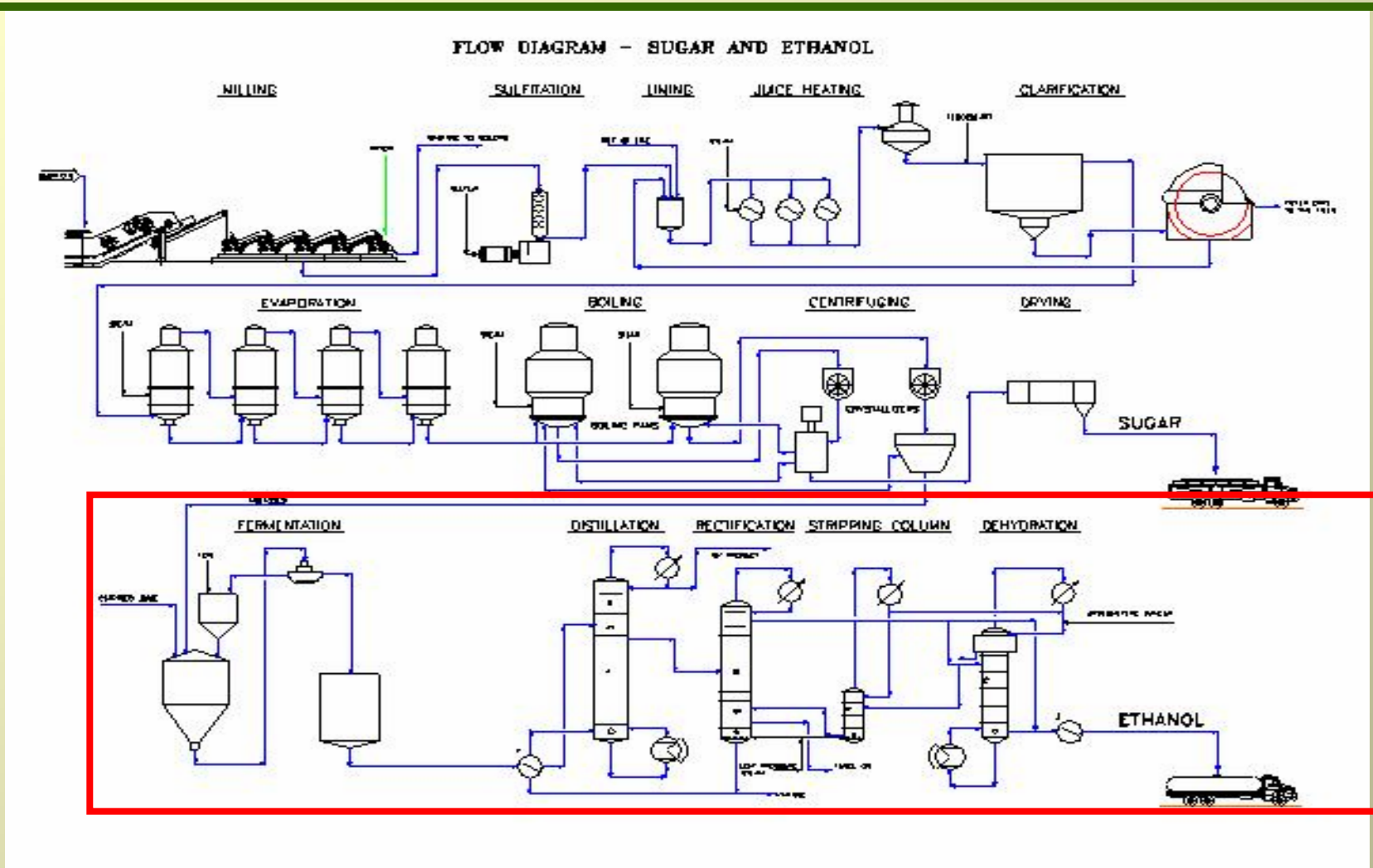
  Center-South : May - November

  North-Northeast: September - March

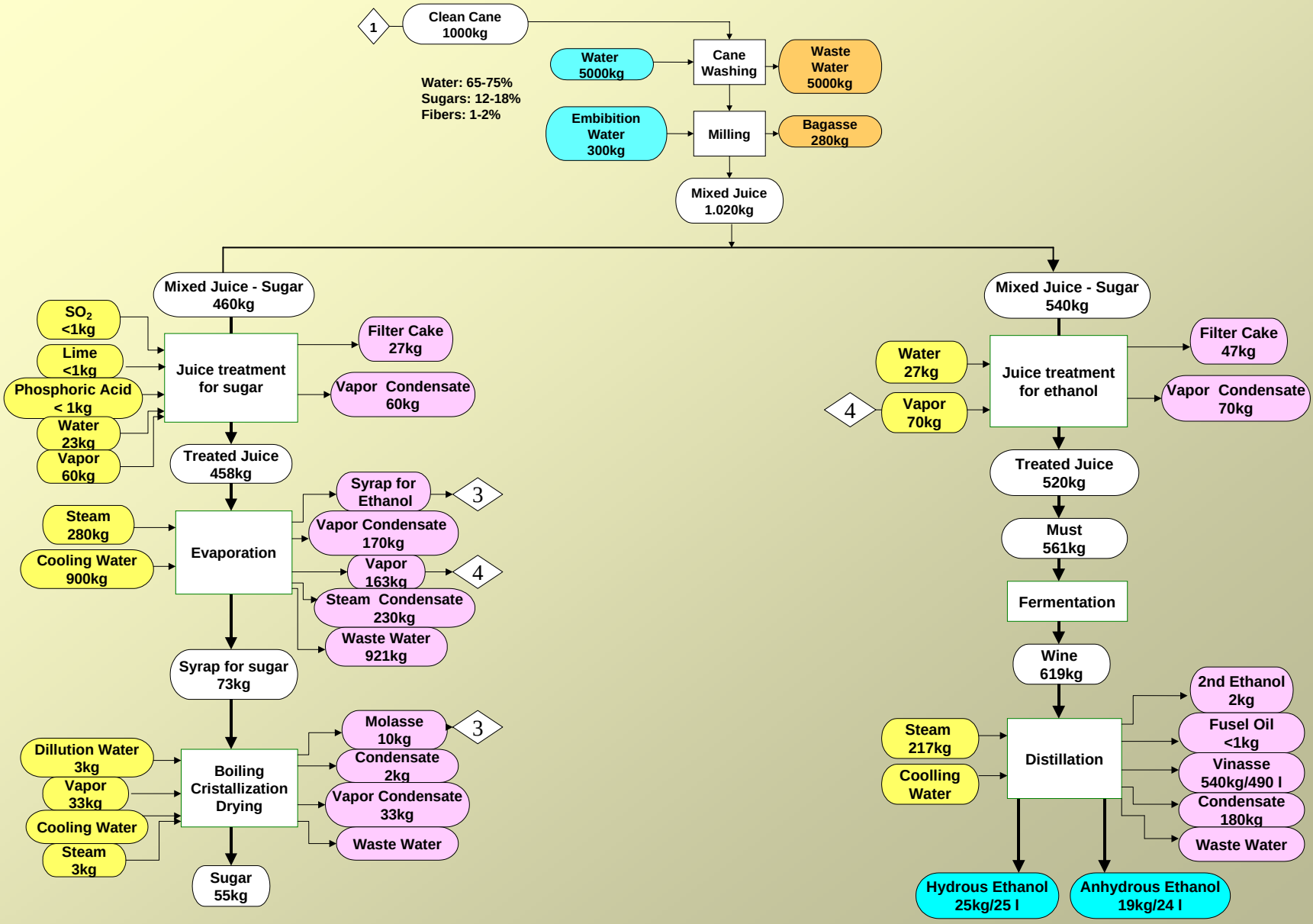
- **MILL SIZE:** <500.000 to 7.000.000 t/season

# PROCESS FLOW DIAGRAM

## *BRAZILIAN PROCESS*



# SUGAR CANE PROCESSING



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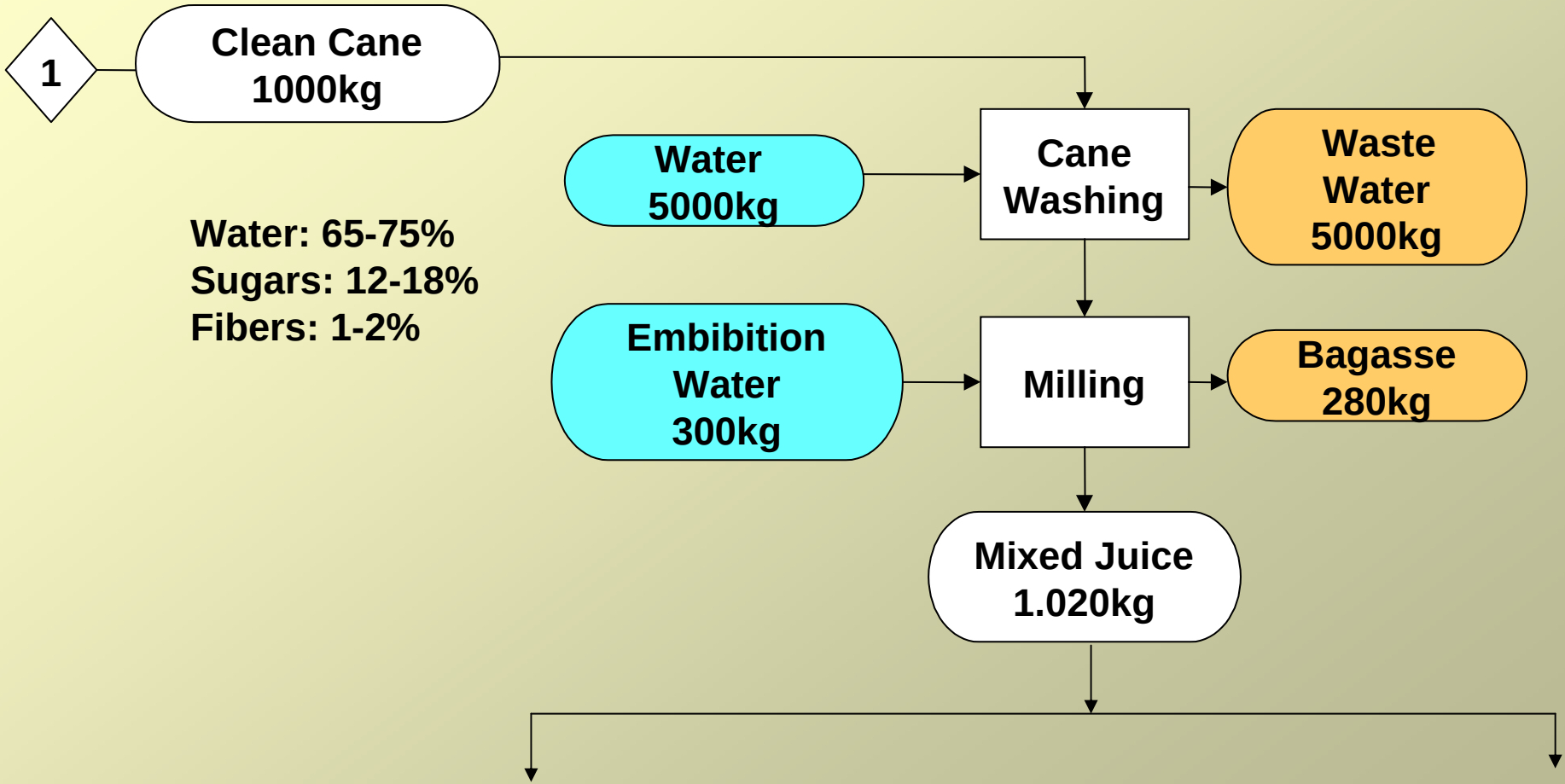

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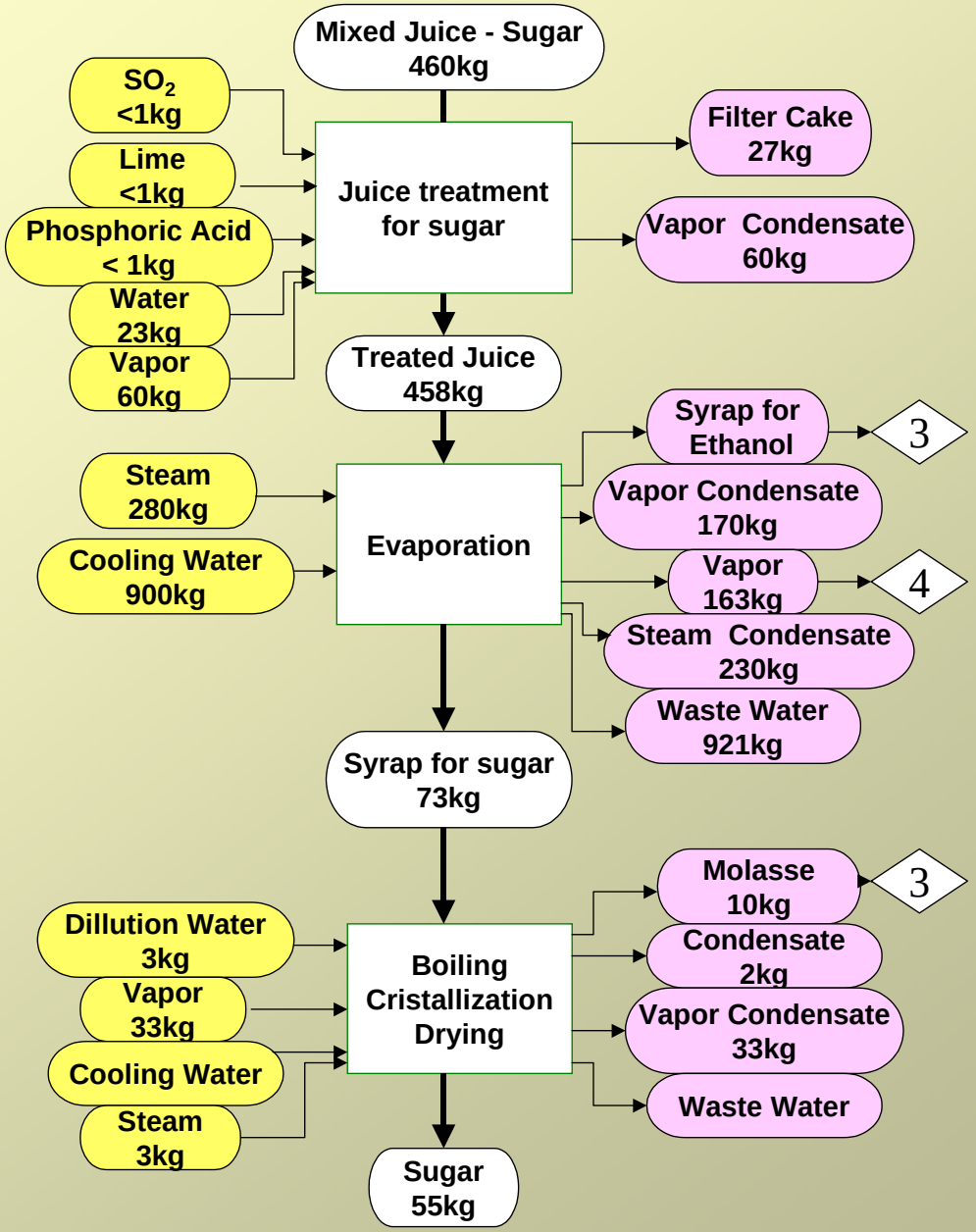

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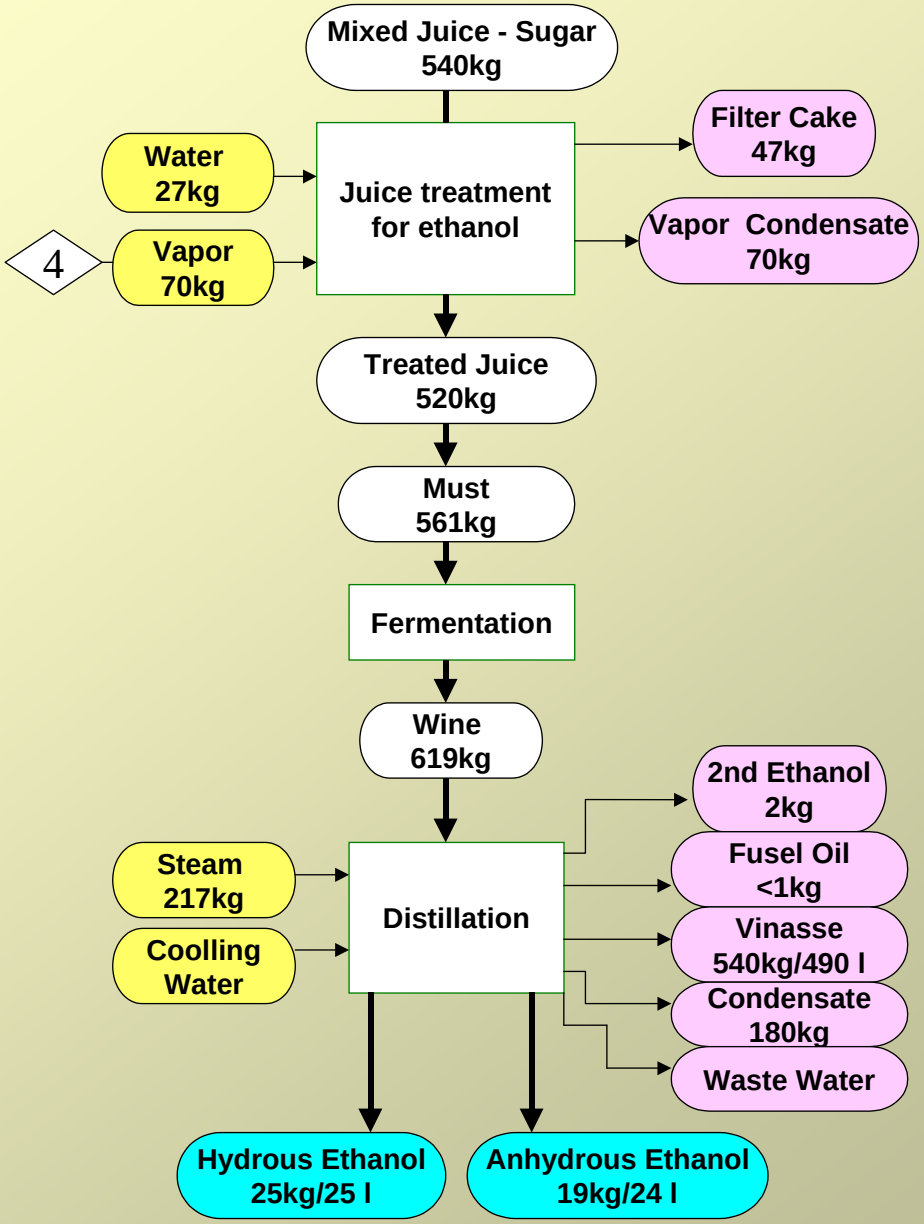
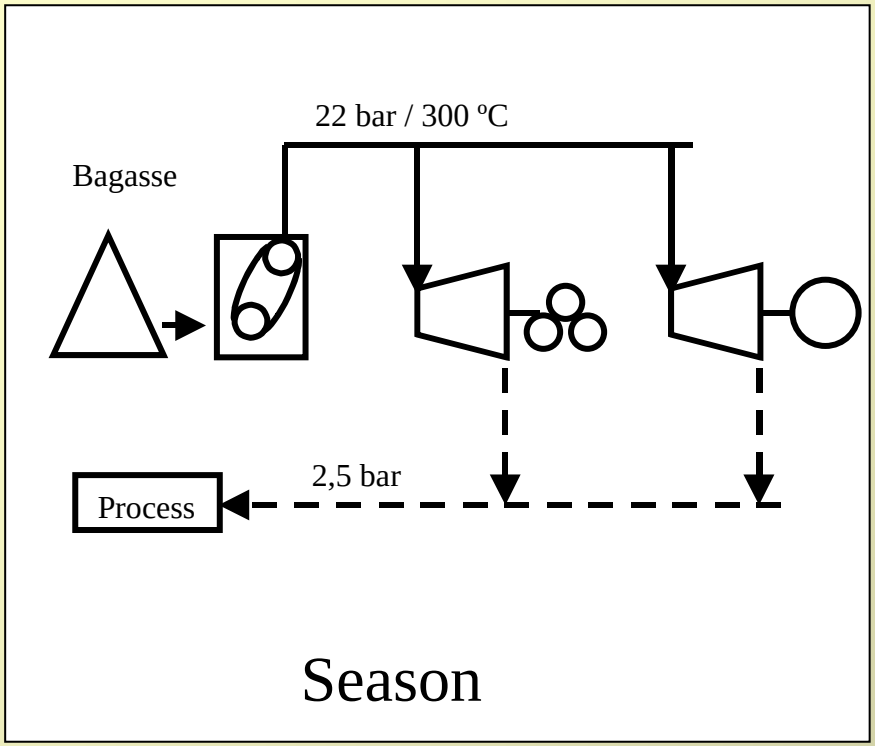
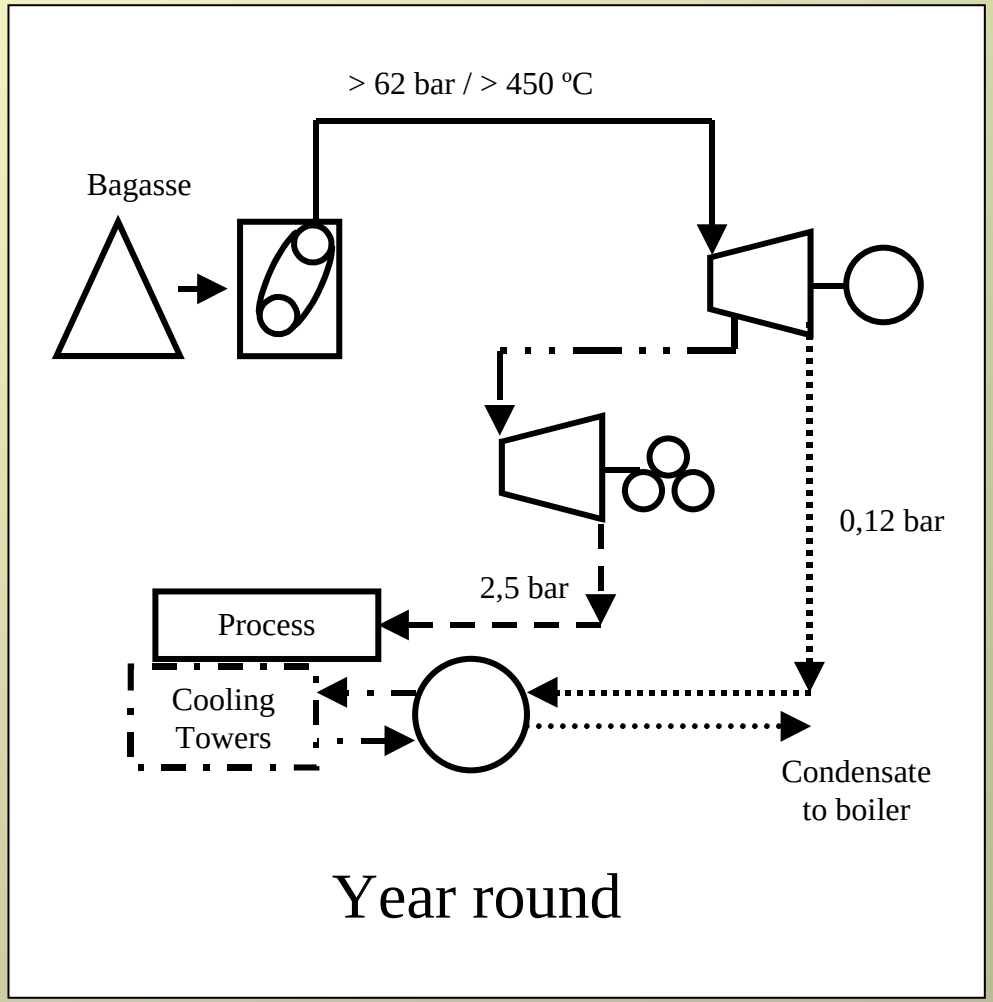


# ENERGY SYSTEM



# ENVIRONMENTAL ISSUES

- **Water use**
- **Boiler Emissions**
- **Effluents**
- **Cane burning**

# WATER USE IN SUGAR MILLS

| TYPE | FLOW ($M^3$/TC) | POLLUTION POTENTIAL | TREATMENT | NOTES |
|---|---|---|---|---|
| Cane Washing | 5 | Organic matter, (180 to 500mg/l BOD) | Settling ponds and pH adjustment (closed circuit); settling ponds stabilization ponds (open circuit) | 1 |
| Barometric condenser | 6 | Organic matter (10 to 40mg/l BOD), temperature around 50°C | Cooling pond (closed or open circuit) to bring T < 40°C | 2 |
| Fermented cooling | 3 | Temperature around 50°C | Cooling pond (closed or open circuit) | 2 |
| Distillation condenser | 4 | Temperature around 50°C | Cooling pond (closed or open circuit) | 2 |
| Waste water | 4 | Grease, oil, acid, caustic and sugar (all in very small quantities) | Dilution in other water streams, mix with vinasse | 3 |

**Notes:**

**1 - Tendency to be discontinued or replaced by dry cleaning systems**

**2 - The circuits are being closed aiming zero leakage system**

**3 - Water from floor and equipment cleaning, spillage and other uses**

**Source: CTC, A. Elias Neto, 1996**

# WATER USE IN SUGAR MILLS IN BRAZIL AVERAGE FIGURES

- **Water Intake : 3$m^3$/tc**
- **Consumption : 1.6 $m^3$/tc**
- **Discharge : 1.3 $m^3$/tc**

**Source: CTC, A. Elias Neto, 1996**

# PARTICULATE EMISSION STANDARDS FOR BAGASSE BOILERS

| COUNTRY | STANDARD ($mg/Nm^3$) |
|---|---|
| Australia (1991) | 450 |
| Australia (1990, for new boilers) | 250 |
| Brazil (1996, for new boilers) | 200 (*) |
| South Africa (1991) | 450 |
| South Africa (1996, for new boilers) | 120 |
| Hawaii | 870 |
| India (1992, inclined grate boilers) | 250 |
| India (1992, spreader-stoker boilers) | 800 |
| Mauritius (1999) | 400 |
| Malaysia (1999) | 400 |
| World Bank (1997, for project funding) | 100-150 |

**Source: Joyce and Dixon, Lora and Jativa in O.D. Cheesman**

**(*) To be approved**

# TECHNOLOGIES TO CONTROL BOLLER PARTICULATE EMISSIONS

| CONTROL DEVICE | EMISSION LEVEL ($mg/Nm^3$) |
|---|---|
| None | 5 000 |
| Multicyclone | 1 500 |
| Scrubber | |
| - Conventional | 200 |
| - Venturi type | 100 |
| Bag filter | 80 |
| Electrostatic precipitator | 60 |

# MAIN EFFLUENTS

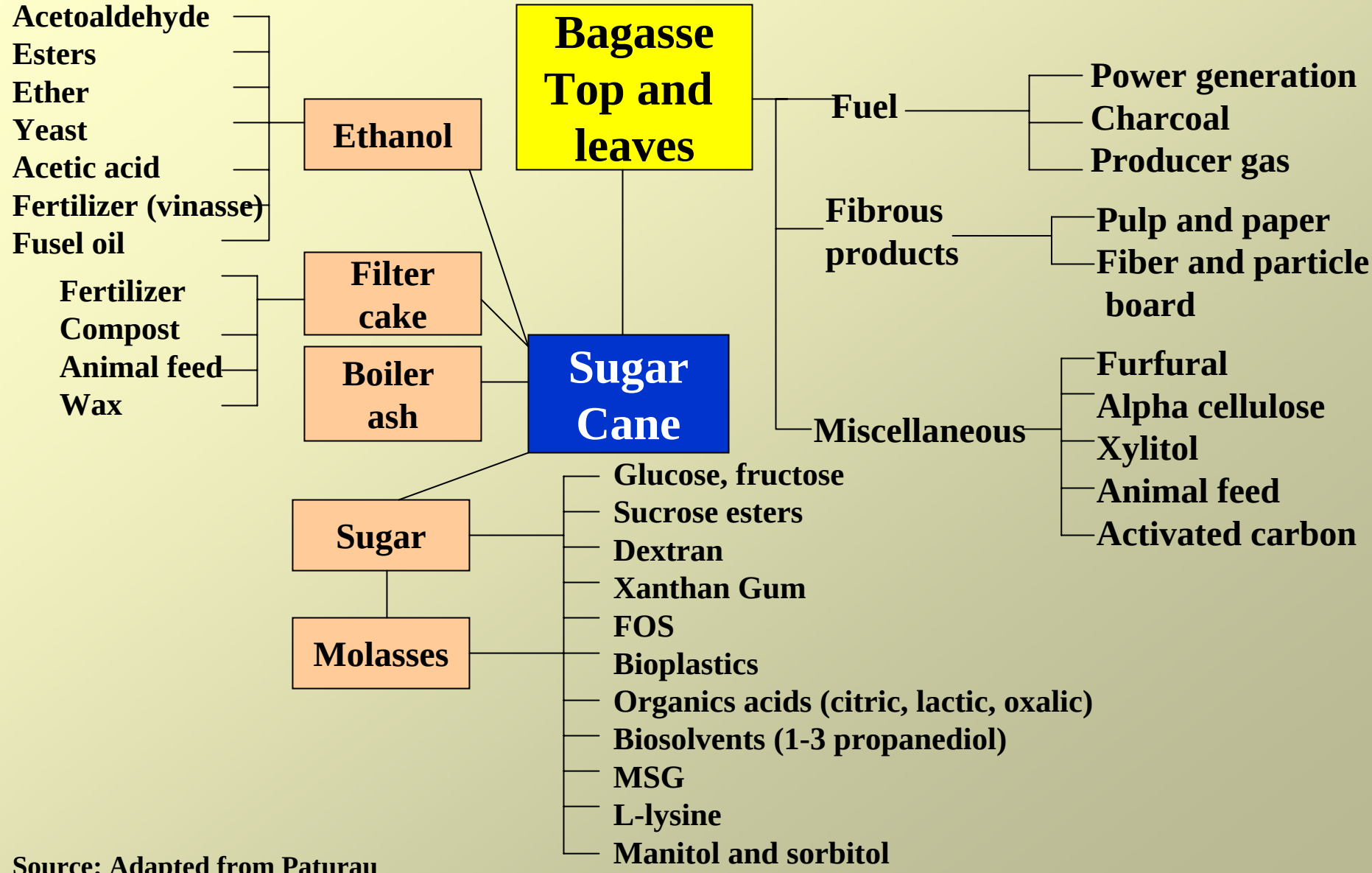
| TYPE | CARACHTERISTICS |
|---|---|
| Vinasse (Brazil only) | Corresponds to 10-15 l/liter of ethanol; high content of organic matter and minerals, recycled to cane fields for fertirrigation (N, K and OM). |
| Filter Cake | Waste from the clarifier mud filters, amounts to around 40kg/tc (30 to 80), used normally as fertilizer (N, P and OM); other uses possible. |
| Boiler Ashes | Both boiler bottom and fly ashes (from scrubbers) are mixed with solid effluents and recycled to the cane fields. |
| Waste Water | Resulting from floor washing, equipment cleaning, boiler blowdown, process stream spilling; should be treated to reduce BOD and COD and contaminant levels before being dumped in water bodies. Can be diluted in vinasse and used in fertirrigation. |

# SUGAR CANE BURNING EMISSIONS (KG/t BURNED CANE)

| POLLUTANT | DARLY AND LEARMAN, 1995 (1) | ASOCANA COLOMBIA, 1992 (1) | SHEARRER 1971 (1) | EPA 1977 (2) | WHO 1997 (2) |
|---|---|---|---|---|---|
| Particulate | 3.6 | 2.8 | 1.26 | 2.5-3.5 | 8 |
| CO | 35.3 | - | 8.4 | 25-33 | 42 |
| HC | 5.2 | - | 1.68 | 2.0-6.6 | 15 |
| NOX | - | - | 0.17 | - | 3 |

**Notes:**
**(1) - Measured**
**(2) - Estimated**

# CO-PRODUCTS OF THE SUGAR CANE INDUSTRY




Source: Adapted from Paturau

# MILL AS OTHER PRODUCTS PRODUCER

- **RAW MATERIALS:** **sugar, syrup, molasses, ethanol, bagasse/trash, yeast, CO2, fusel oil, filter cake.**

- **AVAILABLE UTILITIES:** **high (20 to 80bar)and low pressure (2,5 bar) steam, electricity, cooling water, treated water, effluent disposal.**

# ROUTES FOR CO-PRODUCTS

- **CHEMICAL PROCESSING**

  **High productivity, fast process, easy products separation, difficult effluents, high pressure and temperature.**

- **BIOCHEMICAL PROCESSING**

  **Low productivity, energy intensive, more complex downstream processing, lower environmental impacts.**

- **MIXED PROCESSING**

# PRODUCTS OF SUGAR, SYRUP AND MOLASSE-CHEMICAL PROCESSING

- **Glucose, fructose**
- **Manitol, sorbitol**
- **Sucrose esters**
- **Oxalic acid**

# PRODUCTS OF SUGAR, SYRUP AND MOLASSE-BIOCHEMICAL PROCESSING

- Ethanol
- Fructooligosaccharides (FOS)
- Polyhydroxybutirate (PHB)
- Lactic acid and polylactic polimer
- Organic acids: citric, gluconic, malic, other
- Monosodium glutamate
- L-lysine
- 1-3 propanediol, acetone, butanol
- Xanthan and dextran gums
- yeast and co-products

# PRODUCTS OF ETHANOL

- **CHEMICAL PROCESSING**

  **Acetoaldehyde, acetic acid, esters, ether, ethyl cloride.**

- **BIOCHEMICAL PROCESSING**

  **Vinegar, acetic acid, esters.**

# BAGASSE / TRASH

- **COMPOSITION:** cellulose, hemicellulose, lignin.
- **HYDROLYSIS:** acid, enzymatic, organosolv.
- **HYDROLYSIS PRODUCTS:** pentoses, hexoses, lignin.

# PRODUCTS OF BAGASSE / TRASH

- **PENTOSE PRODUCTS**
  - **Xylose, xylitol**
  - **Furfural, furfurilic acid, resins**
- **HEXOSE PRODUCTS**
  - **Same as sugar**
- **LIGNIN PRODUCTS**
  - **Glues, polymers**
- **ANIMAL FEED**
- **PULP AND PAPER**
- **BOARDS**
- **FUEL**

# FILTER CAKE

- **WAX**
  - **2 to 3% of filter cake;**
  - **Industrial waxes (household and food industry);**
  - **Sterois for drug industry.**

- **FERTILIZER**
  - **In natura;**
  - **Composting.**

# BARRIERS FOR THE PRODUCTION OF CO-PRODUCTS IN MILLS

- High investment costs
- Necessity to operate plant year round
- High complexity of process
- Effluents difficult to treat and dispose of
- Lack of good downstream processing technologies
- Scale up problems
- Competition from petroleum derived products

# FUTURE CHANGES

- **Market saturation and vegetative growth;**
- **Highly conservative sector: evolution is slow and technology spreads faster than changes;**
- **Probable evolution: sugar industry to sugar + energy industry;**
- **Energy: electricity and ethanol.**

# SUGAR CANE PRIMARY ENERGY

**1 TONNE OF CANE STALKS**

| | Energy (MJ) |
|---|---|
| •150kg of sugars | 2.300 |
| •140kg of fiber | 2.500 |
| •140kg of fiber in leaves | 2.500 |
| TOTAL | 7.300 (0.16 TOE) |

# COUNTRIES TURNING TO CANE ENERGY

- **Electricty generation: Mauritius, Reunion, Guadeloupe, Hawaii (USA), Brazil, India, Guatemala, Colombia, Australia.**

- **Ethanol: Brazil, India, Colombia, Guatemala, Thailand, Australia, Venezuela, Peru, Equador.**

# CANE ENERGY ALTERNATIVES

- **SUGAR → ETHANOL**

- **FIBER → ELECTRICITY AND/OR ETHANOL**

# ELECTRICITY GENERATION ALTERNATIVES

| TECNOLOGY | OPERATION | FUEL AVAILABILITY | PROCESS STEAM COMSUMPTION (kg/TC) | SURPLUS ELECTRICITY (kWh/TC) |
|---|---|---|---|---|
| • 22bar/300°C steam back pressure TG | Season | Bagasse | 500 | 0 - 10 |
| • 82bar/480°C steam back pressure TG | Season | Bagasse | 500 | 40 - 60 |
| • 82bar/480°C steam extraction/ condensing TG | Year round | Bagasse+ trash | Year round | 100 -150 |
| • BIG/GT (*) | Year round | Bagasse+ trash | Year round | 200 - 300 |

(*) Technology not commercial

# $CO_2$ EMISSION REDUCTION POTENTIAL WITH ELECTRICITIY GENERATION

- **EXISTING TECHNOLOGY: HIGH PRESSURE BOILER / STEAM TG – 150 kWh/TC**
- **DISPLACING NG FIRED POWER PLANTS: 500 kg $CO_2$/MWh**
- **AVOIDED CO2 EMISSIONS: 75 kg $CO_2$/TC**

# ETHANOL FROM FIBER

## 1 TONNE OF BAGASSE OR TRASH (DRY BASIS)

| COMPONENT | MASS (KG) | ETHANOL (LITER) | ENERGY (MJ) |
|---|---|---|---|
| Cellulose | 400 | 220 | |
| Hemicellulose | 220 | 80 | |
| Lignin | 200 | - | 4 800 |
| Other | 180 | 220-300 | - |
| TOTAL | | | |

Source: CTC, C. E. Rossell

# ENERGY BALANCE

# ENERGY BALANCE IN CANE AND ETHANOL PRODUCTION LIFE CYCLE ANALYSIS: NON – RENEWABLE ENERGY INPUT

| | AVERAGE (MJ/TC) | BEST VALUES (MJ/TC) |
|---|---|---|
| **Sugar Cane Production (total)** | **201.80** | **192.00** |
| Agricultural Operations | 38.10 | 38.10 |
| Cane transportation | 42.90 | 36.50 |
| Fertilizers | 66.50 | 63.40 |
| Lime, herbicides, etc. | 19.20 | 19.20 |
| Seeds | 5.90 | 5.60 |
| Equipment | 29.20 | 29.20 |
| **Ethanol Production (total)** | **49.40** | **39.70** |
| Electricity (bought) | 0.00 | 0.00 |
| Chemicals and Lubricants | 6.30 | 6.30 |
| Buildings | 12.00 | 9.30 |
| Equipment | 31.10 | 24.10 |

# EXTERNAL ENERGY FLOWS, (AGRICULTURE + INDUSTRY)

| | AVERAGE (MJ/TC) | | BEST VALUES (MJ/TC) | |
|---|---|---|---|---|
| | **Input** | **Output** | **Input** | **Output** |
| Agriculture | 201.80 | | 192.00 | |
| Industry | 49.40 | | 39.70 | |
| Ethanol produced | | 1921.30 | | 2051.10 |
| Bagasse surplus | | 168.70 | | 316.40 |
| Total (external flows) | 251.20 | 2090.00 | 231.70 | 2367.50 |
| **Output/Input** | | **8.3** | | **10.2** |

# COMPARATIVE ENERGY BALANCE IN ETHANOL PRODUCTION

| PROCESS | Corn[1] | Switchgrass[1] | Sugar cane[2] |
|---|---|---|---|
| | (GJ/ha.yr) | (GJ/ha.yr) | (GJ/ha.yr) |
| Crop production energy comsump. | 18.9 | 17,8 | 13.9 |
| Biomass Energy | 149.5[3] | 220.2 | 297.1[4] |
| Agricultural energy ratio | 7.9 | 12.3 | 21.3 |
| Ethanol production energy coms. | 47.9 | 10.2 | 3.4 |
| Energy in ethanol | 67.1[5] | 104.4 | 132.5[6] |
| Total energy ratio | 1.21 | 4.43 | 8.32 |

Notes:

1- Source: ORNL, 2- Source: Copersucar/UNICAMP, 3-No credit for corn stover, 4- No credit for sugar cane leaves, 5- includes credits for co-products, 6-Includes credits for surplus bagasse 8%

# ENVIRONMENTAL IMPACTS OF CANE ENERGY

- **ELECTRICITY GENERATION**
  - **Boiler emissions**
  - **Condenser cooling water**
  - **Use of fossil fuels**

- **ETHANOL**
  - **Vinasse**
  - **Biogas**
  - **Displacement of fossil fuels**

***VINASSE***

# *DEFINITION*

- ***Vinasse is a byproduct of alcohol distillation process.***

- ***On average to produce one liter of alcohol 13 liters of vinasse is produced. This value ranges from 10 to 15 liters, depending on cane quality and the industrial process.***

# *MAIN CHARACTERISTICS*

| Vinasse characteristics | Units | Minimum | Avg | Maximum |
|---|---|---|---|---|
| pH | ---- | 3,50 | 4,15 | 4,90 |
| Temperature | $^0$C | 65 | 89 | 111 |
| Biochemical Oxigen Demand (BOD5) | mg/l | 6.680 | 16.950 | 75.330 |
| Chemical Oxigen Demand (COQ) | mg/l | 9.200 | 28.450 | 97.400 |
| Total Solids | mg/l | 10.780 | 25.155 | 38.680 |
| Total Suspended Solids | mg/l | 260 | 3.967 | 9.500 |
| Fixed Suspended Solids | mg/l | 40 | 294 | 1.500 |
| Volatile Suspended Solids | mg/l | 40 | 3.632 | 9.070 |
| Total Soluble Solid | mg/l | 1.509 | 18.420 | 33.680 |
| Volatile Soluble Solids | mg/l | 588 | 6.580 | 15.000 |
| Fixed Soluble Solids | mg/l | 921 | 11.872 | 24.020 |
| Sediments residues (1 h) | mg/l | 0,20 | 2,29 | 20,00 |

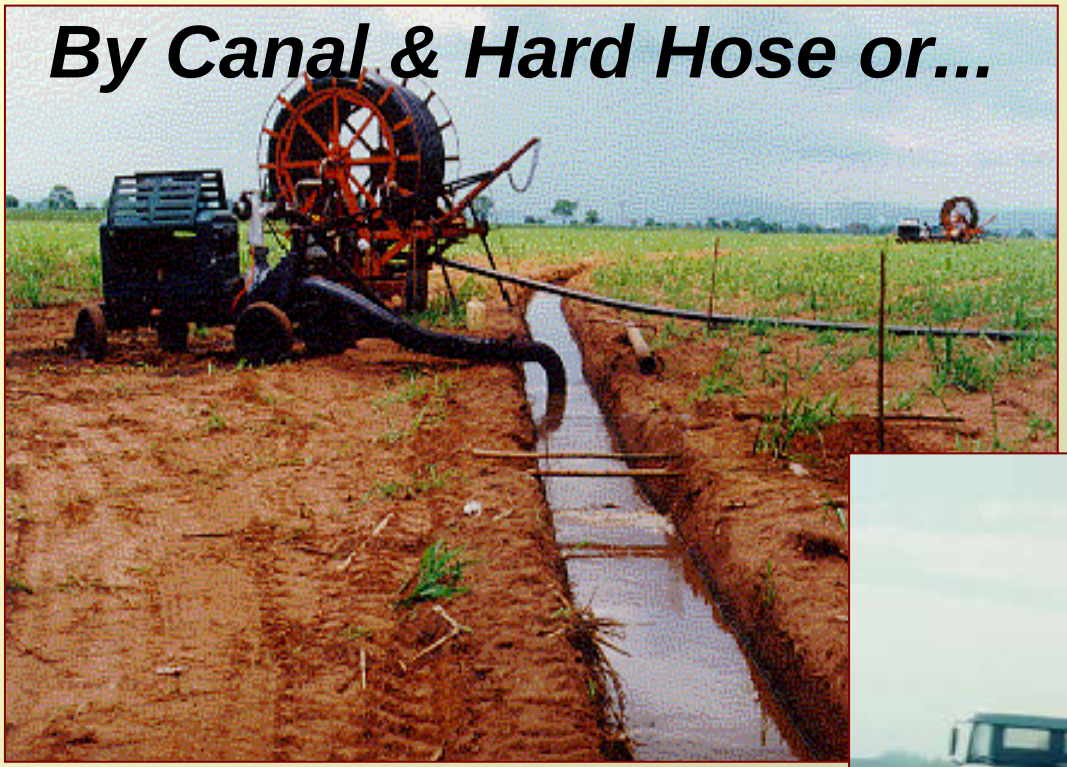
Source: CTC, Elias Neto & Nakahodo (1995)

# *VINASSE - DISTRIBUTION METHODS*

***“Canal + Big Guns”***

# *VINASSE - DISTRIBUTION METHODS*

***By Canal & Hard Hose or...***



***Trucks & Hard Hose***

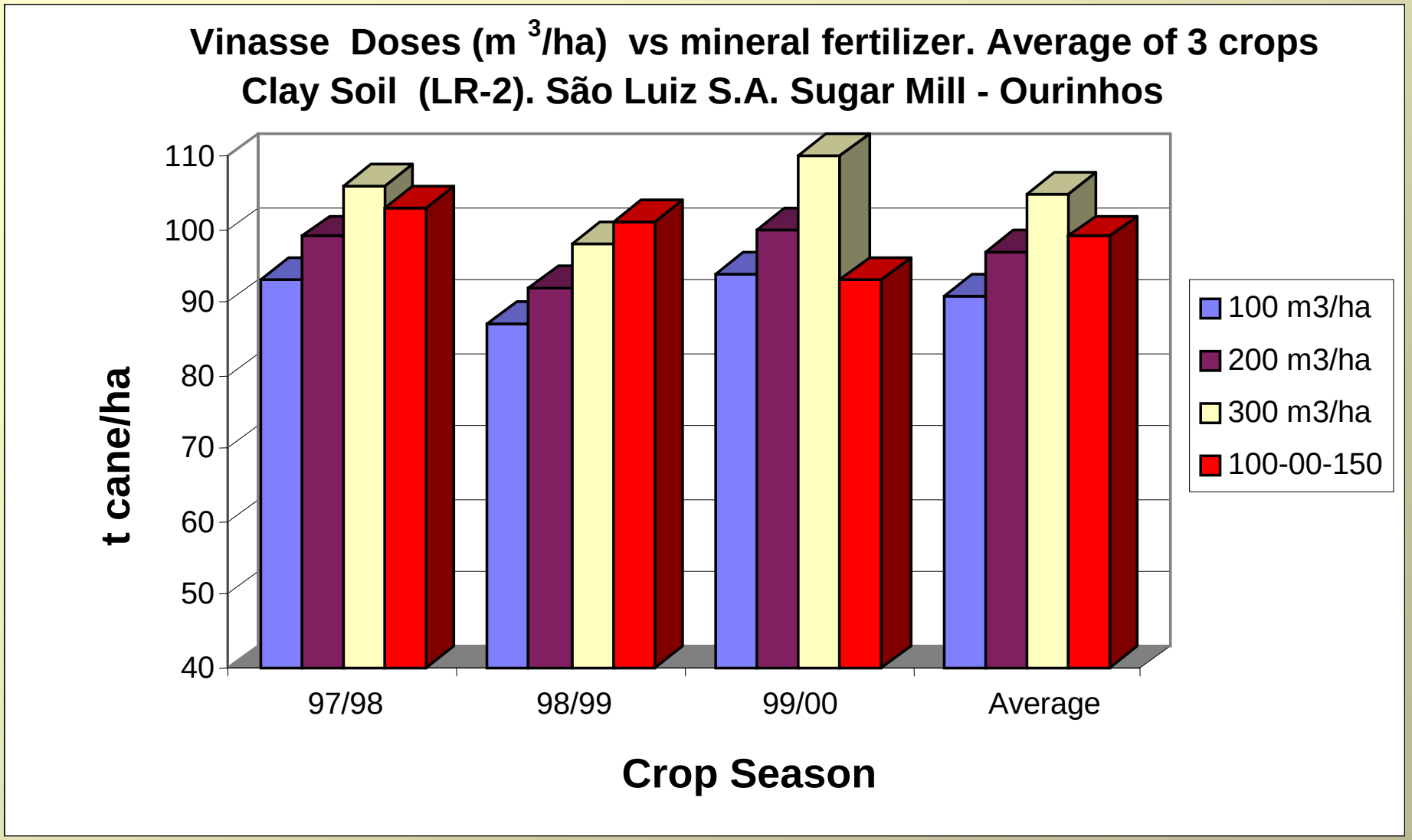
# *EFFECTS ON SOIL - REVIEW*

**Ferreira & Monteiro (1987): The best choice is to use natural vinasse to apply in soils. There are no doubts that the natural vinasse is an excellent fertilizer and brings several benefits to physical, chemical and biological soil properties.**

- **Increases soil pH;**
- **Increases Cation Exchange Capacity (CEC);**
- **Increases on some nutrients availability;**
- **Soil structure Improvement by O.M addition;**
- **Increases water retention;**
- **Improvement of soil micro flora and micro fauna;**

**"Eventually side effects of vinasse use were noticed on soils and plants due to misuse, that is excessive dose or inadequate soils"**

# *EFFECTS IN CANE YIELD*




**Source: CTC, J. L. Donzelli**

# *SUGAR CANE NUTRITION - REVIEW*

***How CTC Does Recommend Vinasse Application Doses?***

***BASED ON:***

- **Soil Analyses;**
- **Potassium Concentration in Vinasse;**
- **Plant (Yield/TCH);**
- **Environment.**