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# *Bioenergy in Brazil*

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**Minas Gerais - Brazil**

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## Bioenergy in Brazil

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- ✓ Brazil: background
- ✓ Brazil: energy and bioenergy data
- ✓ Traditional and innovative uses of bioenergy
- ✓ Modern bioenergy systems in Brazil
  - ✓ Biofuels
  - ✓ Electricity from biomass
  - ✓ Iron production based on charcoal
- ✓ Institutional aspects
- ✓ Final comments

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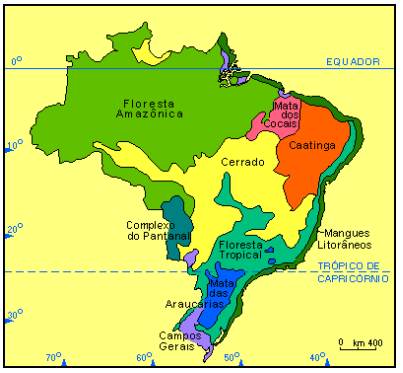
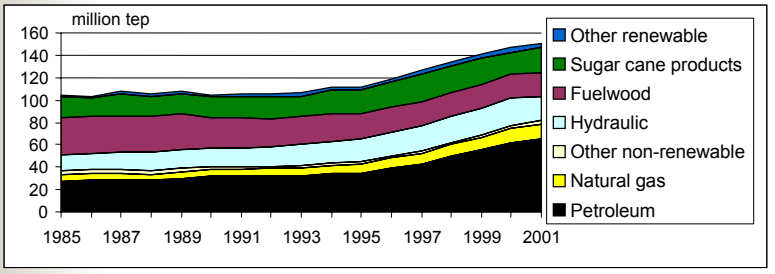
# Brazil: background

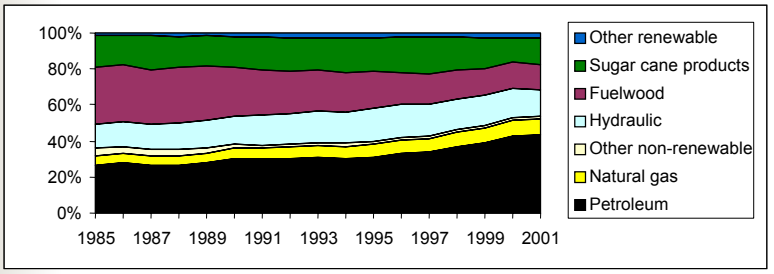
- Surface: 8.54 million km² ( 73% potentially arable)
- Climate: mainly tropical wet
- Population: 170 million inhabitants (~20% rural)
- Life expectancy: 68.8 years
- Illiteracy: 9.5%
- Unemployment: 7%
- GDP: US$504 billion
  - 8% agriculture
  - 35% industry
  - 57% services
- Income distribution
  1% goes to 50% poorest
  13% goes to 1% richest





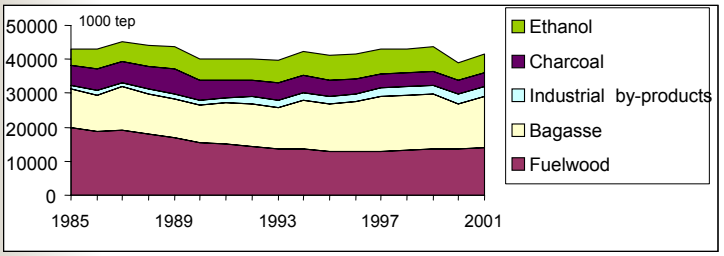

# Brazil: energy balance syntesis



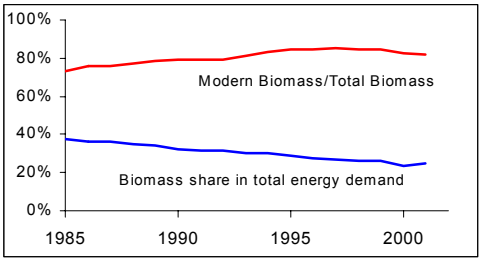




*Source: BEN/MME, 2002*

# Brazil: bioenergy demand




Biofuels are becoming “modern” and diversified

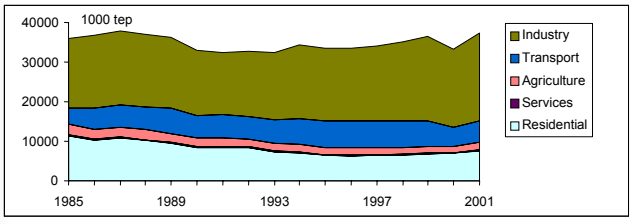



*Source: BEN/MME, 2002*

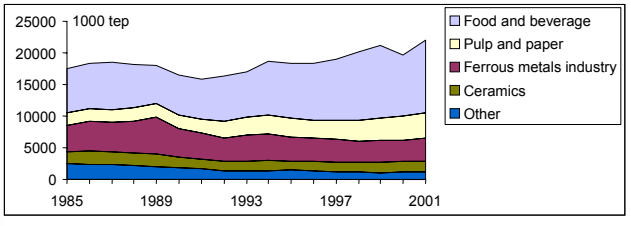


# Brazil: bioenergy demand

## Sectorial demand



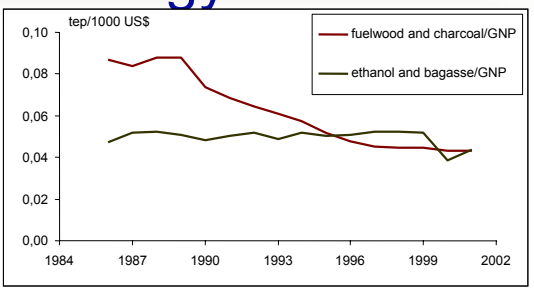

## Industrial demand

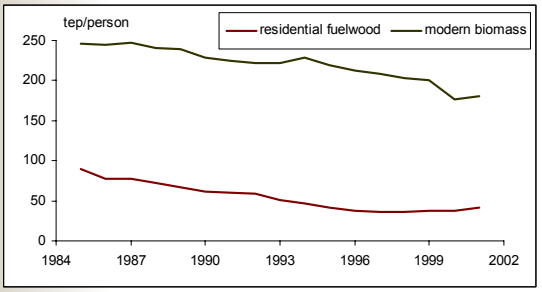



*Source: BEN/MME, 2002*

# Brazil: bioenergy demand

**Evolution of demand with GNP**




**Evolution of demand with population**

*Source: BEN/MME, 2002*



# Brazil: energy balance trends

**From the past decades to the current situation, one observes that:**

- biofuels represents about 1/3 of total energy demand in Brazil
- due to urbanization, fuelwood as fuel for cooking in households is losing importance
- modern bioenergy is increasing its role in industry and transportation, mainly from sugarcane
- even with the partial recovery of conventional fossil fuels in the Brazilian energy matrix, biofuels will keep a significant share

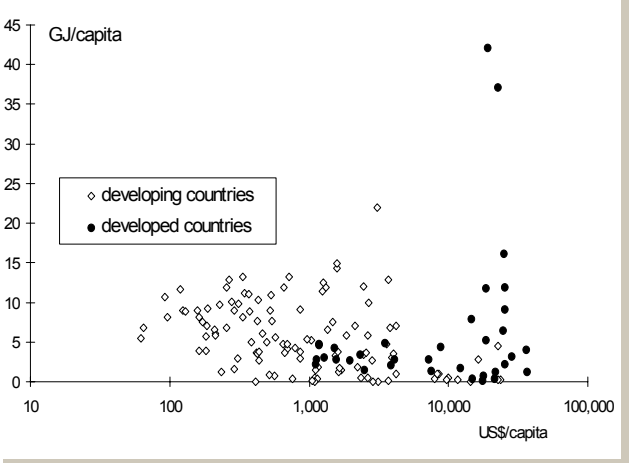
# Traditional and Innovative uses of Bioenergy

| | Fuel supply | Typical end users | Conversion technology | Economic aspects | Environmental impacts |
|---|---|---|---|---|---|
| **Traditional** | Collection | Households<br>Traditional industry | Simple and inefficient | No prices | Can be predatory |
| **Innovative** | Planted material or agroindustrial residues | Transportation<br>Power generation<br>Agroindustry | Efficient, complex and integrated | Prices and costs known | Potentially important, due intensity and process |

Although modern bioenergy tends to displace the traditional one, this trend should be supported by proper social, environmental and technical guidelines...



# The two worlds of bioenergy...




***Woodfuels demand vs. GNP per capita***

*Source: WEIS/FAO, 1998*

# Modern bioenergy systems in Brazil

- **Biofuels for automotive engines (ethanol, ethanol blends and biodiesel)**
- **Power generation using fuelwood, bagasse and other residues (IPP and cogeneration)**
- **Iron and steel production using charcoal from forestry**



# Alcohol from sugar cane

- Basic data

- 4,5 million ha planted for cane (0.8% of agricultural land)
- 55% of cane is crushed for ethanol in more than 300 mills
- the recent harvest of 300 million ton is producing about 13 billion liters of ethanol, 60% in São Paulo State
- about 610 thousand people work directly in ethanol and sugar production

# Alcohol from sugar cane

## Technical parameters

- Average productivity (in São Paulo)

  agriculture : 70 ton/ha

  industry : 85 liters/ton

- Bagasse production (with 50% moisture, per ton of cane)

  total : 250 kg/ton cane

  surplus : up to 30% plus 140 kg as tops and leaves (“barbojo”)

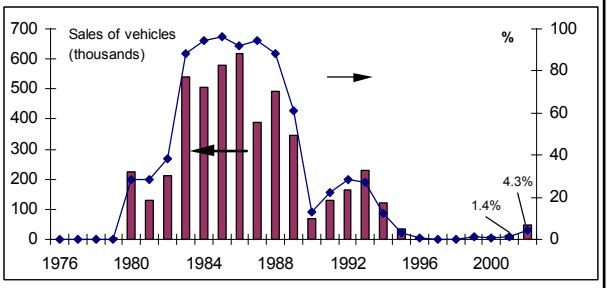
- A typical mill annually processes 1 million ton of cane and costs about US$25 million



# Alcohol from sugar cane

## Evolution

- Proalcool: National Alcohol Program, launched in 1975
- Started with limited fleet → converted motors and blends with gasoline → ethanol new cars (since 1979)
- After some years of low performance, the interest in ethanol returns



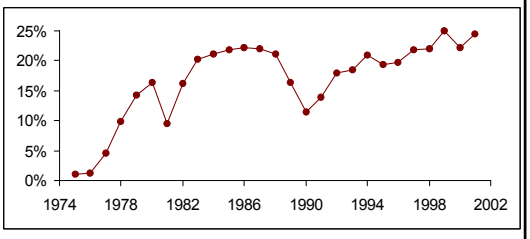

*Source: ANFAVEA, 2002*

# Alcohol from sugar cane

## Brazilian automotive fuels

- Nowadays in Brazil, in the gas stations there are only two different fuels for Otto motors:
  - Gasohol (sold as regular (IAD 87) and super (IAD 91))
  - Hydrous ethanol (94.5 %)
- The anydrous ethanol content in gasohol varies according to availability

**Ethanol content in gasohol**




*Source: BEN/MME, 2002*



# Alcohol from sugar cane

## Energy balance in ethanol production

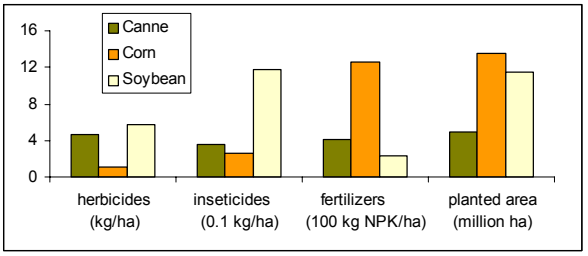
| | Average | Best values |
|---|---|---|
| **Energy demand (MJ/ton canne)** | | |
| **Agricultural activities** | **189.9** | **175.5** |
| **Industrial activities** | **46.1** | **36.4** |
| **Energy production (MJ/ton canne)** | | |
| **Ethanol produced** | **1996.4** | **2045.3** |
| **Bagasse surplus** | **175.1** | **328.5** |
| **Output/Input** | **9.2** | **11.2** |

This agroindustry is very efficient, mainly due to the high photosynthetic efficiency of sugar cane, by-products availability and residues recycle

*Source: Macedo, 2002*

# Alcohol from sugar cane

- Agrochemicals demand




- Production costs

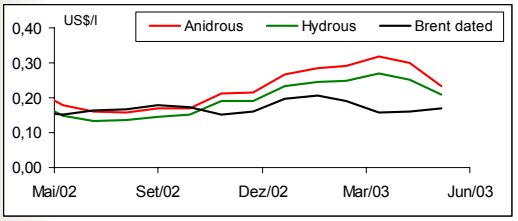
  In mills of good performance from São Paulo State, ethanol production costs are under US$ 0,20 per liter (ex-taxes)

*Source: Macedo, 2002*



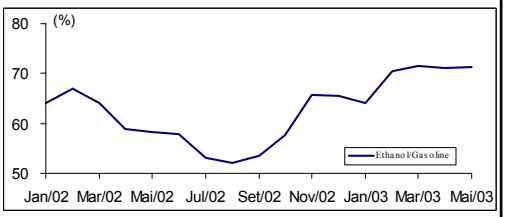
# Alcohol from sugar cane

- Ethanol prices




Ethanol and oil prices at producer gate (ex-taxes)

Ethanol/gasohol prices ratio in gas stations



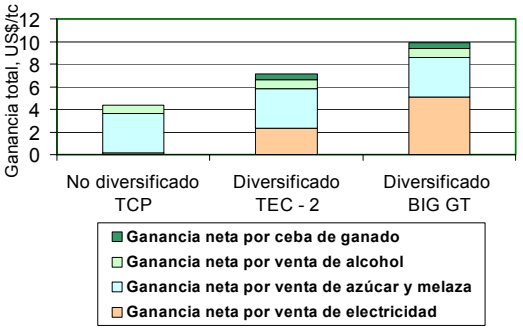

*Source: ANP,2003*

# Alcohol from sugar cane

- New trends

  - Diversification

    many schemes integrating energy and food (sugar, grains and meat) have been proposed




*Source: Silva e Nogueira, 2001*



# Alcohol from sugar cane

- New trends

  - Flexfuel cars

Make possible the use of any blend of gasoline-ethanol in the same engine, with good performance and under the allowed emission limits

**1st Brazilian flexfuel vehicle, in the market on March 2003**


*Source: VW Brasil, 2003*

# Alcohol from sugar cane

- Sustainability

  With a good energy balance, relatively low use of chemicals, competitive prices and social acceptance, ethanol fuel production from cane is an example of a real sustainable bioenergy system.

- Related questions...

**Pre-harvest burning ban and "barbojo" use**

**Mechanical harvest expansion**



# New Biofuels in Brazil

- Alcohol-Diesel blends

  Some experiences have been carried out (buses in Curitiba) using blends of diesel with up 8% of ethanol and a co-solvent. No conclusive results yet.

- Biodiesel

  Brazil is a large oil seeds producer (50 Mton of soybean in 2003), so there is great interest in developing methyl or ethyl esters for fossil diesel substitution. Some tests have been done and a Brazilian specification has been proposed. High costs remain a problem.

# Electricity from biomass

- Steam plants fuelled by wood were the first prime movers for power generation in Brazil, early replaced by hydro stations
- Nowadays, new routes to use biomass solid fuels in power generation seem to be feasible and attractive
- Current possibilities...
  - ✓ Utility generation X Self production
  - ✓ Steam cycles X Gasified biomass cycles
  - ✓ Single cycle X Cogeneration
  - ✓ Planted biomass X Residues utilization



# Electricity from biomass

- **In the industrial context**

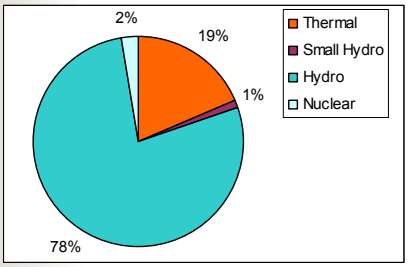
  In this situation, the biomass use for power generation is increasing in Brazil, aiming to produce electricity up to self sufficiency or with low surpluses. The cycle is selected just for power or for cogeneration. As fuel, always is burned residues (bagasse, wood industry residues, rice husks or cellulosic black liquor).

- **As IPP or Utility Power generation**

  In this context bioenergy for power remains a possibility, depending basically on the availability of cheap fuels or good tariffs.

# Electricity from biomass

## Power Plants (all kinds)




Total installed capacity

83,420 MWe

Thermal installed capacity

15,400 MWe

### Thermal Power Plants

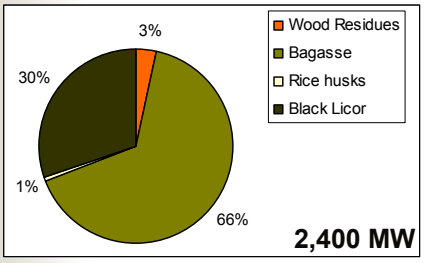
| Fuel | Power Plants | Capacity (kW) | % |
|---|---|---|---|
| Oil and coal | 500 | 12.503.660 | 81,15 |
| Biomass | 212 | 2.400.247 | 15,58 |
| Other | 13 | 503.880 | 3,27 |
| Total | 725 | 15.407.787 | 100 |

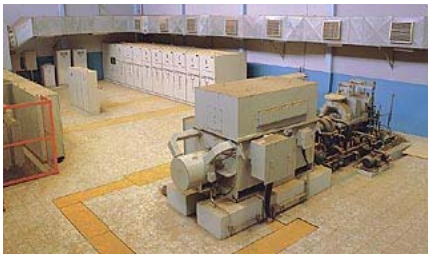
*Source: ANEEL, 2003*



# Electricity from biomass

## Biomass Power Plants



| Fuel | Power Plants | Capacity (kW) | % |
|---|---|---|---|
| Wood residues | 11 | 78.200 | 3,26 |
| Bagasse | 184 | 1.582.407 | 65,93 |
| Rice husks | 3 | 14.400 | 0,6 |
| Black liquor | 13 | 725.210 | 30,21 |
| Biogas | 1 | 30 | 0 |
| Total | 212 | 2.400.247 | 100 |

*Source: ANEEL, 2003*

# Electricity from biomass

## Biomass Power Plants (examples)

**Sugar mills**

Burning bagasse as fuel in steam cogeneration schemes, with capacities ranging from 5 to 60 MW, the power production in such plants has been improved as the steam condition increases, allowing high surplus of energy to be exported to the grid. These systems have been designed and built in Brazil, fostering the associated industry. Prof. Moreira from CENBIO estimated around 3,8 GW as the total potential to be developed in conventional cogen systems in this sector. The capacity costs vary from 600 to 1200 US$/kW.



# Electricity from biomass

## Biomass Power Plants (examples)

**Sawmills**

With capacities going from 1 to 30 MW, many small steam plants have been built associated to sawmills, generating power and useful waste heat. They usually operate interconnected to the grid, using their own wood residues or taking from other neighbour sawmills.

**Madeireira S.J. do Rio Claro**

**9 MW, ~ 66 GWh/year (85% sold to utility), capital cost of approx. US$ 7 million**

*Source: Koblitz, 2003*

# Electricity from biomass

## Biomass Power Plants (examples)

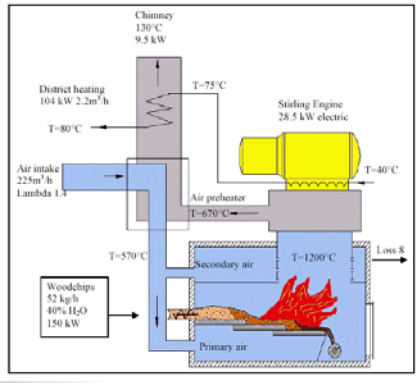
**Rice mills**

Mainly located in the South of Brazil. Some rice mills are recently using their residues (rice husks) to produce power. One example, Indústria de Alimentos Zoeli, in Uruguaiana, has 8 MW as installed capacity, exporting 6 MW to the utility. The investment was about US$ 4 million. Two Brazilian EPC companies, Koblitz and Brennand, are very active in this field, with more than 1 GW of installed/designed biomass thermal plants.



# Electricity from biomass

## New possibilities in Biomass Power Plants




**Reciprocating Stirling Engine**

**Unit in test at UNIFEI (in co-operation with Technical University of Denmark), in commissioning, to be fuelled with wood residues, 28.5 $kW_e$ , 4 cylinders, 1010 rpm**

# Electricity from biomass

**New possibilities in Biomass Power Plants**

**Integrated Biomass Gasification and Gas Turbine**

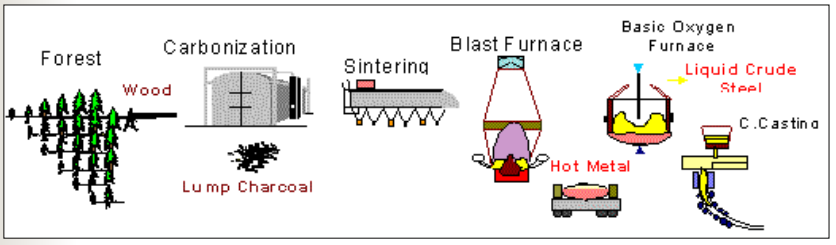
**Experimental Unit at UNIFEI, with fluidized bed gasifier, designed for bagasse, 245 $kW_{th}$, approx. 40 $kW_{el}$ , 75% hot efficiency**



# Iron production based on charcoal

- Basic data

- in Brazil, since 1920 steel has been produced using charcoal
- 7,8 million ton of pig iron were produced in 2001 using charcoal from eucaliptus planted forests
- about 240 thousand people work directly in forestry and charcoal production related to metals industry




*Source: Campos, 2002*

# Iron production based on charcoal

- Technical parameters

- Apparent density (for eucaliptus)

  wood in piles: 0,62 ton/stereo

  charcoal : 0,25 ton/$m^3$

- Charcoal from wood conversion ratio(typical)

  0,50 $m^3$ charcoal per fuelwood stereo

- Charcoal specific consumption in iron ore reduction

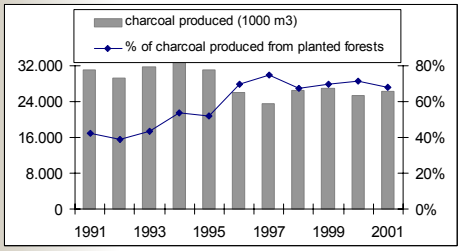
  2,9 $m^3$ charcoal per pig iron ton

*Source: Campos, 2002*



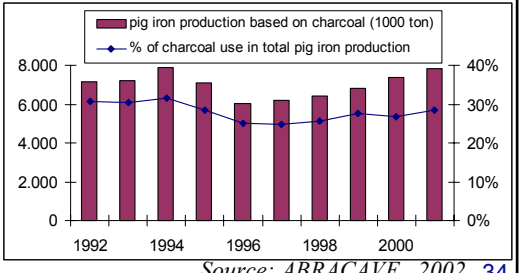
# Iron production based on charcoal

- Evolution of charcoal use and production




**charcoal production**

**charcoal use**




*Source: ABRACAVE, 2002*

# Iron production based on charcoal

- Forestry for energy
  - *In Brazil about 4.8 million ha are covered with planted trees. For energy, mainly eucaliptus is adopted*
  - The selected *Eucaliptus* species are *Camaldulensis, Grandis, Cloesiana, Urophylla and Pellita,* among other
  - *There is good expertise in forestry. Aiming to produce charcoal, about 50 thousand ha are planted every year for replacement of aged forests, in Minas Gerais State*

**dry fuelwood productivity:**

**typical**: 9 ton/ha.year

**best values**: 14 ton/ha.year

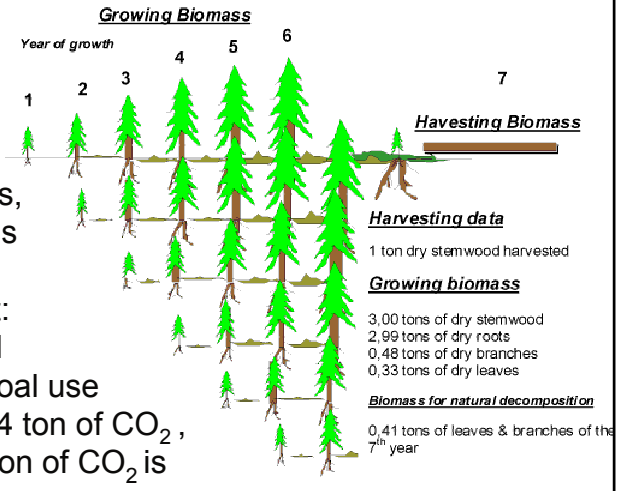
*Source: Couto, 2002*



# Iron production based on charcoal

- Impact of forestry for energy

Besides the absence of sulfur and related problems, charcoal in steel mills has an important environmental effect: per each ton of steel produced, the charcoal use sequester about 16,4 ton of $CO_2$ , while for coke 1,65 ton of $CO_2$ is added to atmosphere




*Source: Campos, 2002*

# Iron production based on charcoal

- Carbonization process

Traditional kilns

**4,4 ton wood/ton charcoal**

Modern kilns

**3,6 ton wood/ton charcoal**

*Source: Campos, 2002*



# Iron production based on charcoal

- The dark side of charcoal production


Piquiá, 1984 Piquiá, 2000

Although in Minas Gerais State, due to environmental restrictions, almost just planted trees are cut for charcoal production, in Northern Brazil the expansion of pig iron production has caused serious damage to the Amazonic forest

*Source: CNPM/EMBRAPA, 2001*

# Iron production based on charcoal

- The dark side of charcoal production


Charcoal production is generally associated to very bad working conditions, children labour and slavery. These worrying features are not intrinsic to charcoal production. In many cases they were eliminated.



# Institutional aspects

Even without a clear definition of an institution responsible for bioenergy promotion and monitoring in Brazil, all mentioned programs have been granted a strong assistance from the Brazilian government, both through financial and tax special schemes, and R&D support. However, the lack of continuity in this assistance is a frequent complain.

Examples of the government role could be given as the implementation of Proalcool and the establishment of energy forests by the FISET scheme.

# Institutional aspects

A recent initiative in supporting bioenergy is the PROINFA - Programa de Incentivo às Fontes Alternativas de Energia Elétrica (Law 10.438, 2002), aiming to promote the construction of power plants using renewable energy, with 15 years PPA´s assured for Eletrobrás.

Particularly for biomass, PROINFA proposed to add 1100 MW (7 TWh/year) until 2006 and more 6500 MW (40 TWh/year) until 2016, reaching with renewable sources about 10% of the incremental capacity. A preliminary suggestion for biomass electricity supply tariff is about 48 US$/MWh.



# Final comments

- In the Brazilian energy matrix, modern and conventional bioenergy have an important share
- Bioenergy played and will be playing an essential role in getting sustainability for the Energy Sector, as could be seen in the alcohol program, in several power plants fuelled by biomass and in iron production using charcoal
- The Government support and assistance is crucial for developing bioenergy
- It is very important to consider the social impacts and environmental constraints to develop sound bioenergy systems

## Annex - Forestry for bioenergy and climate change

***Relative value of area to be annually reforested to offset 15% of expected reduction in carbon emission of Annex I countries***

***1.6 % of deforestation area in developing countries***

***10.8 % of area under forest fires in developing countries***

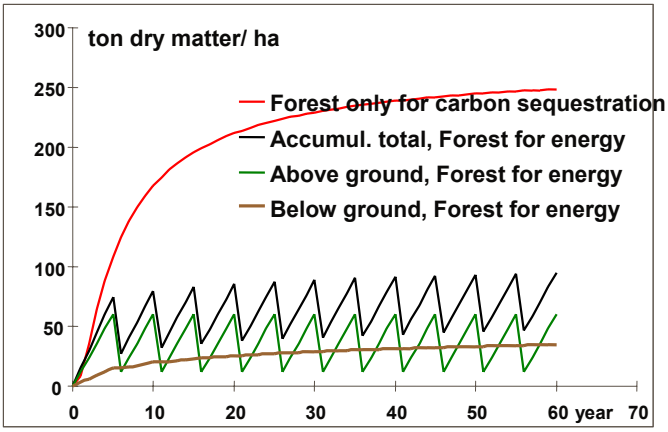
***7.9 % of reforestation in developing countries***

***5.5 % of global effort in reforestation (excl.Russian Federation )***



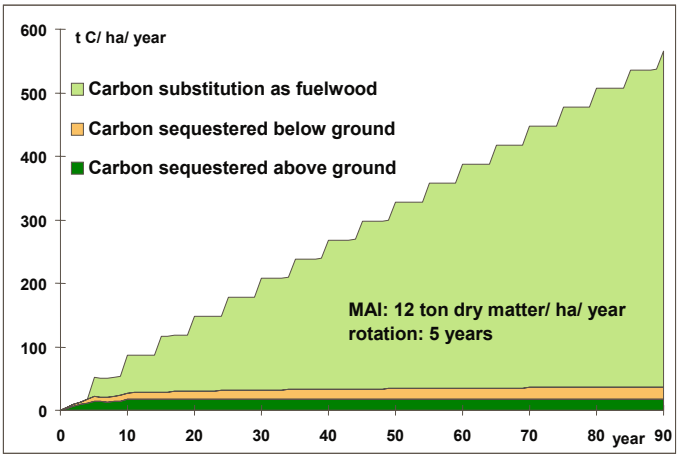
## Annex - Forestry for bioenergy and climate change

***Passive and active carbon fixation in forests***



# Annex - Forestry for bioenergy and climate change

***Carbon substitution effect of wood energy***

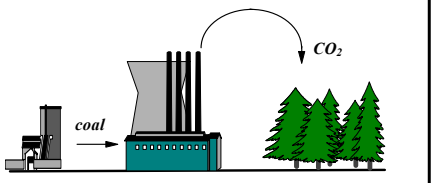




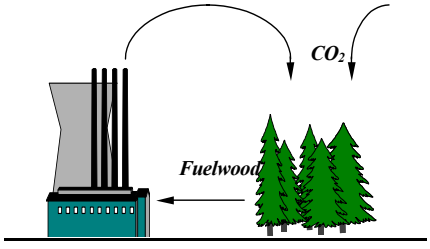

# Annex - Forestry for bioenergy and climate change

***Comparison of forestry for carbon emissions curb in power generation***

***Carbon sequestration***




**a Coal Power Plant (1 MW) operating 30 years requires 481 ha of permanent forests to sequester $CO_2$ emission**




**a Biomass Power Plant (1 MW) requires 507 ha of production forests, which can offset carbon emission of this plant and more a Coal Power Plant with 0.28 MW, due sequestration effect**

***Carbon sequestration and substitution***

# Sources of information

- Main references from:

Eucaliptus/woodfuel production: Couto, Laércio
Charcoal production and use: Campos, Omar
Power generation/gasification: Lora, Electo S.
Sugarcane/alcohol: Macedo, Isaías
Institutional aspects: Poppe, Marcelo

- Some reference institutions:

ABIOVE - Vegetable Oil Industry Association
CENBIO - National Reference Center on Biomass
CETEC - Technology Institute of Minas Gerais
EMBRAPA - Brazilian Agricultural Research Corporation
ÚNICA - Sugar and Alcohol Industry Association
UNIFEI - Federal University of Itajubá