# BIOMASS ENERGY USE IN LATIN AMERICA: FOCUS ON BRAZIL

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## Abstract

Reliable energy statistics data is of vital importance for any country for its economical and social, as well as for its environment-related development. Due to its non-centralized and multi-faceted characteristics, biomass energy statistical data is not, generally, widely available as electricity and fossil origin energy data.

Among the so-called "developing countries", Brazil is one that utilizes large amounts of bioenergy, consuming 49% of all biomass energy consumed in Latin America. The 1997 National Energy Balance (BEN97: Balanço Energético Nacional, MME/DNDE)[1] shows that 21% of the total energy consumption is bioenergy, mainly sugar cane ethanol for transportation, fuelwood for the industrial, commercial and residential sectors and charcoal for the industrial sector.

Reliable statistical data is available for the sugar cane products from several sources. The same can not be said for fuelwood. The charcoal consumed by the industrial sector has good statistical figures. Vegetal oils do not show reliable statistical data.

The difficulties associated to consistent data collection are commented for each energy source. New activities concerning biomass and statistical data in Brazil are presented.

## 1. Introduction

Biomass energy statistical data are very important to Brazil, since 21% of its total energy consumption comes from sugar cane, ethanol for transportation, fuelwood for the industrial, commercial and residential sectors and charcoal for the industrial sector. Biomass energy utilization in Brazil amounts to almost 2 quads, representing 49% of the total biomass energy consumption in Latin America.

Fuelwood production in Brazil amounts to 0.87 quad (21.9 Mtoe) and sugar cane products equals to 1.01 quad (25.5 Mtoe). This fact points to the indispensable availability of biomass energy statistical data for Brazil, and for all the countries consuming large amounts of bioenergy. Sugar cane energy products, fuelwood and charcoal are the most important biomass fuels in Brazil.

Ethanol fuel is important for its economic, social and environmental aspects: savings in oil imports favoring trade balance, over one million job opportunities, and zero net carbon dioxide emission.

Reliable data is available for sugar cane products from producer associations, Ministry of Commerce and Industry, Petrobras (Brazilian holding oil company), private consultancy companies and other. This favorable situation concerning sugar cane energy product statistics can be ascribed to the once strong Proalcool Program.

It is not the same situation for data on fuelwood. Due to its de-centralized characteristics, fuelwood is produced by tens of thousands of producers and consumed in small and large industries as well as millions of households making it very difficult to gather reliable data. Charcoal, by the other side, primarily consumed in Brazil by the metallurgical and cement industries, has good statistical figures collected by the Brazilian Renewable Forests Association (ABRACAVE).

Vegetal oils, energetic of smaller importance in Brazil but of high potential as substitutes of diesel oil, do not show reliable statistical data.

The difficulties associated to consistent data collection are commented for each case.

## 2. Sugar cane energy products

In the 1997/1998 season, sugar cane production has reached 293 x $10^6$ metric tons [1] being 30% of that amount transformed in non-energy products (14.2 x $10^6$ metric tons of sugar), 43% in ethanol fuel (15 x $10^9$ liters), 12.6% consumed in the industrial processes (process vapor from bagasse) and the remainder 14.4% utilized by the industry energy sector.

The bagasse by–product reached 79 x $10^6$ metric tons (of which 3.7% has reached the electricity distribution lines in the form of electricity co-generation).

Total ethanol consumption in 1996 was 16,6 billion liters (being 92.5% to the transport sector and the remainder 7.5% for non-energy use).

Ethanol fuel is presently utilized in Brazil in the hydrated form (93% ethanol 7% water = fuel E-00) and in the anhydrous form composing with gasoline the fuel E-22 (78% gasoline – 22% ethanol) known as gasohol. Production figures for 1997 were 5.3 x $10^9$ liters of anhydrous ethanol and 9.6 x $10^9$ liters of hydrated ethanol.

An important issue is that most of the sugar cane product plants in Brazil can produce both sugar and ethanol. There is, consequently, the possibility of a plant to modify their alcohol/sugar production mix according to the market demand.

The production of sugar cane, alcohol, sugar and bagasse as well as import figures have reliable statistical data. Shown in table 1 are the figures for sugar cane, hydrated and anhydrous ethanol and sugar for the last fourteen years.[2,3]

The ethanol/sugar production data shown in ***Table 1*** and the alcohol-driven vehicles production figures shown in ***Table 2*** permit some scenario exercises.

***Table 1.*** **Sugar cane, alcohol and sugar production in Brazil, 1984 to 1997**

| | Sugar Cane [1] | Sugar [1] | Alcohol [2] | | |
|---|---|---|---|---|---|
| | | | Anhydrous | Hydrated | Total |
| 1984/85 | 202,765 | 8,849 | 2,102 | 7,150 | 9,252 |
| 1985/86 | 224,364 | 7,819 | 3,208 | 8,612 | 11,820 |
| 1986/87 | 227,873 | 8,157 | 2,168 | 8,338 | 10,506 |
| 1987/88 | 224,496 | 7,985 | 1,983 | 9,476 | 11,459 |
| 1988/89 | 221,339 | 8,070 | 1,726 | 9,997 | 11,723 |
| 1989/90 | 223,410 | 7,173 | 1,206 | 10,699 | 11,905 |
| 1990/91 | 222,163 | 7,365 | 1,288 | 10,495 | 11,783 |
| 1991/92 | 228,791 | 8,652 | 1,987 | 10,765 | 12,752 |
| 1992/93 | 224,581 | 9,264 | 2,216 | 9,513 | 11,730 |
| 1993/94 | 215,921 | 9,340 | 2,523 | 8,767 | 11,290 |
| 1994/95 | 240,782 | 11,667 | 2,869 | 9,828 | 12,697 |
| 1998/96 | 251,346 | 13,235 | 3,040 | 9,631 | 12,671 |
| 1996/97 | 288,469 | 13,606 | 4,591 | 9,779 | 14,370 |
| 1997/98 | 292,749 | 14,220 | 5,344 | 9,633 | 14,977 |

Notes: (1) thousand metric tons; (2) thousand cubic meters.

***Table 2.*** **Alcohol-powered vehicle sales and estimated vehicle fleet, 1980 to 1997 [3,4]**

| | Alcohol-Powered Vehicle Sales | | Estimated Vehicle Scrapping | Estimated Alcohol Fleet |
|---|---|---|---|---|
| | annual sales | % of total sales | | |
| 1980 | 240,638 | 28.5% | 89 | 164,956 |
| 1981 | 137,307 | 28.7% | 3,060 | 369,765 |
| 1982 | 233,497 | 38.1% | 7,316 | 553,810 |
| 1983 | 581,373 | 88.5% | 11,024 | 966,415 |
| 1984 | 568,163 | 94.6% | 19,261 | 1,517,847 |
| 1985 | 647,445 | 96.0% | 33,639 | 2,083,617 |
| 1986 | 698,564 | 92.1% | 47,168 | 2,759,476 |
| 1987 | 459,238 | 94.4% | 62,963 | 3,250,977 |
| 1988 | 565,699 | 88.4% | 80,355 | 3,693,083 |
| 1989 | 405,302 | 52.5% | 96,286 | 4,110,735 |
| 1990 | 81,998 | 11.6% | 112,638 | 4,220,390 |
| 1991 | 150,547 | 19.2% | 130,262 | 4,190,122 |
| 1992 | 195,546 | 25.6% | 142,728 | 4,235,291 |
| 1993 | 262,644 | 23.2% | 157,964 | 4,314,339 |
| 1994 | 142,015 | 11.0% | 186,420 | 4,363,773 |
| 1995 | 40,685 | 2.4% | 211,131 | 4,236,118 |
| 1996 | 7,647 | 0.5% | 237,766 | 4,033,570 |
| 1997 | 500* | 0.03%* | 250,000 | 3,800,000 |

* - Estimated values

After reaching a peak of 95% of the total vehicle sales, the alcohol powered vehicle share steadily decreased to a close to zero figure by mid-1997. As a consequence of the net-alcohol vehicle sales paralysis, the hydrated ethanol national consumption has decreased 15% in the first five months of 1997 as compared to the same period in 1996.

By the other side, the anhydrous ethanol consumption has grown 18.92% in the same period of 1997 as compared to 1996.

As a result of the alcohol-powered vehicles fleet reduction, the participation of ethanol fuel in Otto cycle fuel consumption has fallen from 57% in 1988 to 40% in 1997. [1]

If no answer is given to the Proalcool Program, in approximately twelve years (2009-2010) there will be no more an "alcohol vehicle fleet" in Brazil, with obvious environmental losses. Of course there will continue to exist a market for ethanol fuel. The Brazilian vehicle fleet, around 15 million vehicles in 1997, has to reach a number of 22 million gasoline powered vehicles to absorb the present alcohol production in the form of the E-22 fuel (78% gasoline/22% ethanol).

This is not, however, a disastrous forecast, since the 22% ethanol in E-22 fuel substitutes with environmental advantages the MTBE or lead compound additives.

Also important as an electricity source is the co-generation from bagasse.

Figures are modest by now but with the introduction of already existent new technologies like gasification and combined cycle (gas turbine/steam turbine), bagasse co-generation can reach a potential of 2000 MW in São Paulo state alone[5], considering the actual sugar cane planted area. Present co-generation capacity in São Paulo State sugar/alcohol plants is 700 MW[5] with most of the produced electricity being consumed by the sugar cane plants. There is however an increasing electricity surplus offer to the utilities as can be seen in ***Figure 1***.[6]

## 3. Fuelwood, reforestation and deforestation

Almost one half of all biomass energy in Brazil comes from fuelwood, both native or reforested. According to the National Energy Balance[1], in 1996 Brazil produced and consumed 71.7 million tons of fuelwood, divided into five categories, shown in ***Table 3***.

***Figure 1.*** **Bagasse co-generation surplus electricity from sugar/alcohol plants injected into the distribution grid in São Paulo state [6]**

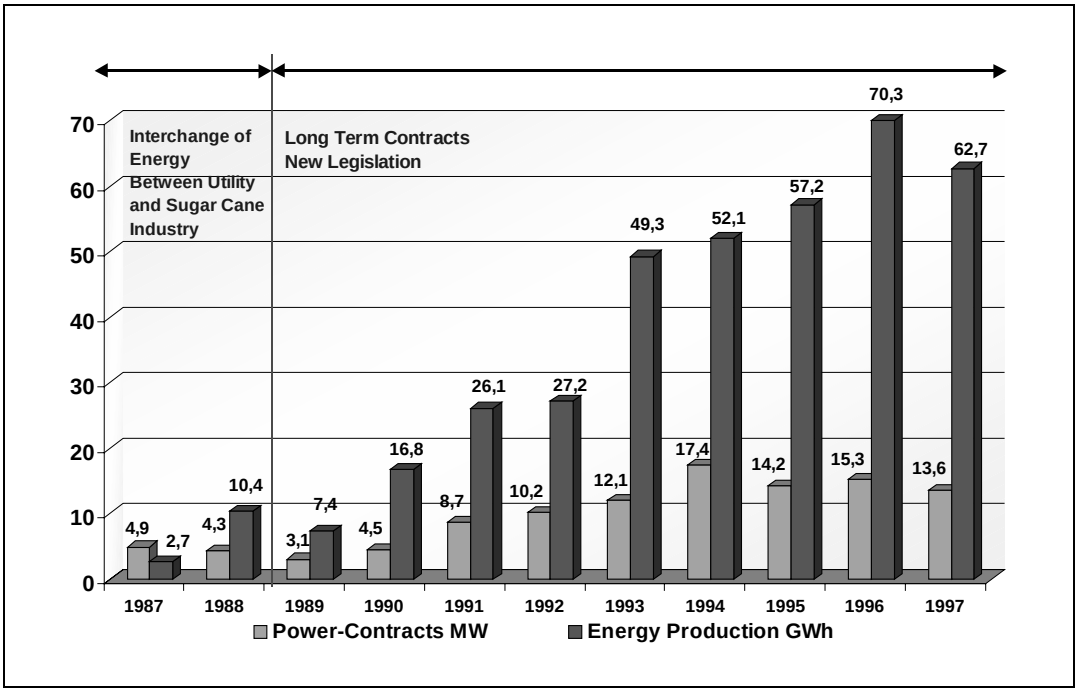


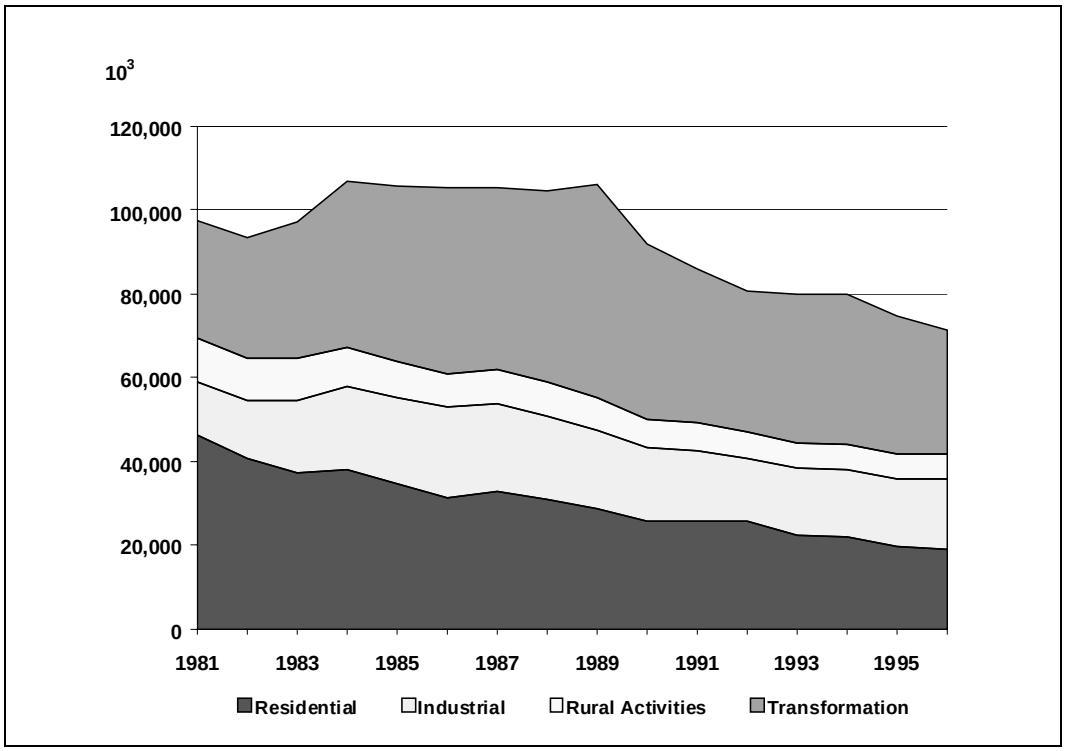

***Table 3.*** **Fuelwood consumption in Brazil, 1996 [1]**

| | **Thousand metric tons** | **%** |
|---|---|---|
| Residential sector | 19.0 | 26.5% |
| Commercial sector | 0.3 | 0.4% |
| Rural activities | 6.0 | 8.3% |
| Industry | 16.8 | 23.4% |
| Transformation (charcoal & electricity) | 29.5 | 41.4% |
| Total | 71.7 | 100.0% |

The National Energy Balance[1] shows the fuelwood consumption changes from 1975 to 1996. It is important to verify that this consumption is steadily decreasing from 110 million tons to 72 million tons in a 20 year span. The use of fuelwood changed quite a bit along these years. Till 1975, at least one half of the fuelwood was utilized for residential purposes, while today this share is around 25%. The rural activity cut down the use of fuelwood, from 12 to 6 million tons. By the other hand the industry increased its share from 12 to 17 million tons and the transformation sector from 23 to 41 million tons. In general, there is a tendency of a more efficient use of fuelwood in Brazil. The transformation sector produces charcoal and electricity while industry concentrates fuelwood use for mining, cement, chemistry, food and beverage, paper and pulp and ceramic. These applications are certainly more efficient than household

cooking, bakeries, manioc flour and milk candy production. ***Figure 2***[1] shows the behavior of fuelwood consumption in Brazil from 1975 to 1996.

***Figure 2.*** **Fuelwood consumption in Brazil (thousand tons), 1975 to 1996 [1]**




As far as charcoal is concerned, the national consumption of both, native origin and reforestation, are presented in ***Table 4***, according to ABRACAVE[7].

***Table 4.*** **Charcoal consumption by origin, 1986 to 1995 [7]**

| | Charcoal Native Origin | | Charcoal Reforestation | | Total Charcoal |
|---|---|---|---|---|---|
| | thousand $m^3$ | % | thousand $m^3$ | % | thousand $m^3$ |
| 1986 | 29,049 | 82.7 | 6,065 | 17.3 | 35,114 |
| 1987 | 27,725 | 80.7 | 6,624 | 19.3 | 34,349 |
| 1988 | 28,563 | 78.0 | 8,056 | 22.0 | 36,619 |
| 1989 | 31,900 | 71.2 | 12,903 | 28.8 | 44,803 |
| 1990 | 24,355 | 66.0 | 12,547 | 34.0 | 36,902 |
| 1991 | 17,876 | 57.7 | 13,102 | 42.3 | 30,978 |
| 1992 | 17,826 | 61.1 | 11,351 | 38.9 | 29,177 |
| 1993 | 17,923 | 56.5 | 13,777 | 43.5 | 31,700 |
| 1994 | 15,180 | 46.0 | 17,820 | 54.0 | 33,000 |
| 1995 | 14,920 | 48.0 | 16,164 | 52.0 | 31,084 |
| 1996 | 7,800 | 30.0 | 18,200 | 70.0 | 26,000 |

In spite of the slowing down of fuelwood consumption in Brazil in the last 6 years, clearly native charcoal consumption is being reduced substantially while charcoal from reforestation is increasing. This scenario shows that the energy sector is no longer the main responsible for deforestation in Brazil. By the other hand, the use of biomass in a sustainable way is one of the reasons for the very low carbon dioxide emission indexes of the country.

According to ABRACAVE[7], Brazil consumes 14.9 million cubic meters of native charcoal and 16.2 million cubic meters reforestation charcoal. This corresponds to 3.43 and 3.72 million tons of charcoal, respectively, totalizing 7.15 million tons of charcoal. According to ABRACAVE[7], the use this charcoal is the following:

| | |
|---|---|
| steel integrated plants | 25% |
| independent producers of pig iron | 50% |
| ferroalloys | 9% |
| cement | 5% |
| primary metals | 2% |
| others | 9% |

In Brazil the steel, iron and metals industry is responsible for more than 80% of the total charcoal consumption. Geographically, the state of Minas Gerais comprises 76% of this consumption, once this is the state where most of these industries are located. The iron and steel industry in Brazil produces 25 millions metric tons of pig iron and 25 million metric tons of steel and has sales summing up to more than 4 billion dollars in 1995 and 1996.

The charcoal industry is very much concerned with reforestation. The reforested area related to the charcoal and pulp industry is presented in ***Table 5***.

***Table 5.*** **Reforested area for the production of charcoal and pulp (ha), 1986 to 1995 [7]**

| | Charcoal | Pulp | Total |
|---|---|---|---|
| 1986 | .. | 64,430 | .. |
| 1987 | 58,488 | 81,547 | 140,035 |
| 1988 | 54,352 | 90,997 | 145,349 |
| 1989 | 88,357 | 111,516 | 199,873 |
| 1990 | 125,000 | 104,438 | 229,438 |
| 1991 | 51,305 | 84,859 | 136,164 |
| 1992 | 80,067 | 82,196 | 162,263 |
| 1993 | 46,653 | 89,153 | 135,806 |
| 1994 | 37,026 | 89,417 | 126,443 |
| 1995 | 30,351 | 97,621 | 127,972 |
| 1996 | 32,752 | 118,000 | 150,752 |

As it can be seen, the reforestation area in Brazil was, in the last 10 years, always greater than 100,000 ha per year. Considering that sustainable fuelwood production

in Brazilian forests may reach 550 $m^3$/ha for Eucalyptus, the 30,000 ha of sawed wood for charcoal produce the 16.2 million $m^3$ of charcoal as reported in ***Table 4***.

According to IBAMA report[8], there are 6.8 million ha reforested in Brazil, amount enough for 50 years of steady present use of fuelwood for charcoal and pulp. The problem of deforestation of native forest in Brazil is related to the expansion of agricultural activities and has little to do with the energy sector.

As far as the data collection is concerned, the industrial energy consumption is adequately measured, but the fuelwood utilized in the residential sector and the one transformed into electricity provide not quite reliable information. The accuracies of native and reforestation fuelwood are different, the latter being more precise.

## 4. Conclusions and perspectives

Information on biomass energy is available in Brazil with a variable degree of accuracy depending on its origin. Sugar cane energy products data are available from several sources with great details and good accuracy. Charcoal, as sugar cane, has good statistical data on production and on the end-uses. On the other hand data of firewood for residential use is roughly estimated but its contribution to the energetic matrix is becoming less and less important.

Considering the importance for governmental planning, the Secretary of State of Energy is supporting an energy database at the University of São Paulo called INFOENER. This activity aims the production of all available information in energy for planning, managerial decisions and special studies. Through the constant and close contact with the main international organizations, INFOENER intends to become a reference center, specially for Brazilian and Latin American energy events and information. By the federal government side, noteworthy is the fact that the Ministry of Mines and Energy, through DNDE – National Energy Development Department is actively working in the structure of an Energy Information System – SNIE – National Energy Information System.

Another concurrent activity is the creation of CENBIO – National Reference Center for Biomass. The center, supported by the Ministry of Science and Technology, São Paulo State Secretary of Energy, Biomass Users Network and São Paulo University has among its activities the setting up of a comprehensive database on biomass-related subjects.

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