Biomass Conversion Program in Brazil

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Brazil has based its economic development largely on imported petroleum and petroleum based technologies. The high hike in the price of this fossil fuel and uncertainties in its availability have forced the country to search for alternative fuels and chemicals for substitution of petroleum derivatives. The return to the traditional use of biomass as fuel, but employing more efficient processes and technologies specially for liquid fuels, has been taken as a challenge to combat petroleum crisis.

The paper describes and discusses briefly the technological state of art, the socio-economic and environmental impacts of a program of large biomass cultivation, conversion into biofuels and chemicals, and their use as petroleum derivatives substitutes.

1 Introduction

Most countries have been adversely affected by the petroleum crisis. The effect has been worse on those which had based their economic growth largely on imported petroleum. The cheap price and easy availability of this fossil fuel were responsible for the installation of an automotive transport system and petroleum based industries in Brazil.

The overnight trippling of petroleum prices in 1973 and their unpredictable steep hikes ever since as well as ucertainties in its obtention are bound to have grim consequences for imported petroleum dependent countries. For developing countries, the new situations are offering impediments to the pace of development. Brazil importing more than 80% of its petroleum needs had naturally to share the consequences of petroleum crisis.

Substitution of petroleum needs a multidisciplinary research and development of sources, processes and technologies for production and use of liquid fuels. For Brazil, the highly viable source for substitution of petroleum derivatives is biomass due to territorial vastness of the country and its localization in a tropical region extremely favorable for production of biomass. Furthermore, the country has been

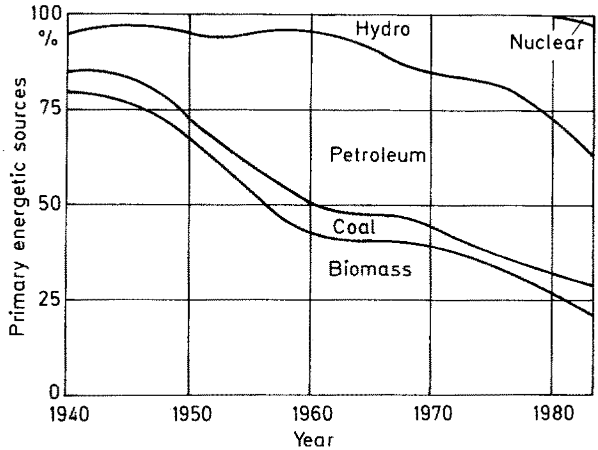

Fig. 1. Evolution of primary energetic sources participation in Brazil

traditionally utilizing biomass as a primary source of energy even during the period when the price of petroleum in the international market was low.

Wood has always played a very important role as a source of energy for food cooking in rural areas, in production of charcoal for steel industry and even as fuel for locomotives in the decades of the 40's and 50's.

There has been secular tradition in the sugar industry of Brazil for the use of bagasse as a primary source of energy. Moreover, the production of ethanol from sugar has always been an alternative whenever there was a fall in sugar prices in the international market.

However, the accelerated process of industrial development, mainly in the Southern region, starting from the decade of 1950, occurred in the automobile industry which made us strongly dependent on liquid fuels.

Figure 1 [12] shows the evolution of primary energetic sources in our country since 1940. It can be seen that in 1940, 77% of our basic energy consumption originated from biomass (wood, bagasse and charcoal), 7% from coal, 7% from hydropower and only 9% from petroleum. Between 1940 and 1980, the employment of biomass energy has been reduced to one third whereas that of petroleum increased 5-fold.

Furthermore, accompained by this development, there occurred an accelerated process of importation of associated technologies. Conjugation of these facts associated with elevated prices of petroleum have led the country to increasing external debts.

It is within this context that the biomass program for energetic and non-energetic aims presents itself as one of the best strategies for development of the country.

In spite of the traditional use of biofuels in Brazil, it was only in 1978 [2] that after the realization of "I Seminar about Energy from Biomass in the Northeast" that the basis for the establishment of a biomass program for energetic and non-energetic goals was delineated with a global outlook.

In the following sections, we shall discuss the technological and socio-economic aspects of the bioconversion program in Brazil.

2 Technological Aspects

Under the impact of steep elevation in the price of petroleum since 1973, the National Economic Development Council-CDE, an organ of the Presidency of the Republic, looked for the identification of indispensable elements for establishment of a National Alcohol Program — PROALCOOL in 1975, with the purpose of substitution of gasoline and petrochemicals.

Initially, this program aimed at production of alcohol in distilleries annexed to the sugar factories. In the second phase, autonomous distilleries based on sugar cane are being installed. In Table I the number of existing distilleries, as well as those to be implanted under PROALCOOL, is given.

Parallel to these efforts, the brazilian Government implanted — through its organ PETROBRAS and with the help of the National Institute of Technology INT — a

Table 1. Statewise distribution of existing and projected annexed and autonomous distilleries — July 1978

	Existing		Projected	
	Annexed	Autonomous	Annexed	Autonomous
North and Northeast	48	12	13	21
Amapá	—	—	—	—
Rondonia	—	—	—	—
Roraima	—	—	—	—
Acre	—	—	—	—
Amazonas	—	1	—	1
Pará	1	—	—	—
Maranhão	1	—	—	4
Piauí	1	—	—	3
Ceará	2	—	1	5
R.G. do Norte	2	1	—	1
Paraíba	5	4	—	2
Pernambuco	27	1	2	2
Alagoas	7	4	10	2
Sergipe	2	—	—	—
Bahia	—	1	—	1
Central/South Region	107	14	4	42
Minas Gerais	8	2	3	3
Espirito Santo	1	—	—	2
Rio de Janeiro	15	3	1	4
São Paulo	74	6	—	11
Paraná	3	2	—	11
Santa Catarina	3	—	—	2
R.G. do Sul	—	—	—	—
Mato Grosso	1	1	—	3
Goiás	2	—	—	6
Distrito Federal	—	—	—	—
Brazil	155	26	17	63

Source: Ministerio da Industria e Comercio — Secretaria de Tecnologia Industrial, Projeto de Referencia 1980 technology for the production of alcohol from cassava. A factory with the capacity of 60,000 $l\,d^{-1}$ was installed in the municipality of Curvelo in the State of Minas Gerais [19].

Another miniunit, also based on cassava, with a capacity of 12,000 $l\,d^{-1}$ was installed by our Nucleus in the municipality of Caucaia (State of Ceará) for research and development of improved technologies in the process of alcohol production from amilaceous materials such as cassava [7] and babassu mesocarp [6].

Within the same spirit and considering the necessity to utilize less noble lands for the production of energy (fuels), the Brazilian Government decided in 1979 [9] the implantation of a program for production of ethanol from wood. Main purpose of this program is to achieve more flexibility for PROALCOOL, making it independent of the fluctuations in the price of sugar in the international market.

In spite of the option made in favor of ethanol as gasoline substitute in Ottocycle motors, the Brazilian Government decided also to develop the technology for production of methanol from wood. To achieve this purpose, the Energetic Company of São Paulo — CESP, in collaboration with the Institute of Technological Research of São Paulo — IPT has already developed the basic engineering for production of 1,000 $t\,d^{-1}$ of this fuel from wood [3]. Presently, research is being conducted at the pilot plant level for the development of technology for gasification, which utilizes electrical energy in the process.

The technology for production of ethanol from mollase or sugar cane is according to our point of view, sufficiently old and therefore is in need for urgent improvements. At the I Seminar about Energy from Biomass in the Northeast [2], the possibility to utilize diffusors was indicated for substitution of traditional grinders for the purpose of increasing the quantity of extracted sugar. As emphasized by Pratas [15], our process for production of alcohol from sugar cane can be substantially improved through utilization of diffusion technology, increasing the yield from 66–77 $l\,t^{-1}$.

In relation to alcoholic fermentation, only recently a company — Usina Santa Adelaide of São Paulo is introducing the continous process, in spite of the tremendous efforts dedicated for more than two decades by Professor Walter Borzani of the University of São Paulo for development of this process in the country [4]. Much research work still needs to be done in the field of yeast which could work at elevated alcoholic concentrations or at temperatures higher than 35 °C.

The technology for distillation employed in the country was introduced in the decade of 1940 and remains unchanged until even today, in spite of the incredible technological development introduced in the distillation columns in petrochemical processes. With the use of bubble cap and direct injection of vapor, the country is spending approximately 100 million dollars per harvest due to problems caused by corrosion [13].

Only now with the installation of Caucaia plant, we are introducing a system of distillation with perforated trays and employing vapor in indirect form for the distillation of alcohols for surmounting the corrosion problem as well as for production of a reduced amount of stillage.

The enormous volume of stillage presently produced, about 50 billion l per year, is continuing to constitute a great threat to our ecology and consequently to PROALCOOL.

Four alternatives are being discussed for treatment of this enormous quantity of effluent from the distilleries. The first alternative, which is being mostly employed presently consists in its utilization "in natura" as fertilizer. With a proper dosage employed in an adequate manner, its use has shown an increase in agricultural productivity. The second alternative which is in early stages of implantation in Brazil is the process of concentration in multiple-stage evaporators for production of animal feed, fertilizer or fuel and fertilzer. The large majority of equipments produced in the country is based on foreign know-how, which justifies obviously the elevated price of these equipments. The third option consists in the anaerobic treatment of stillage for production of biogas and biofertilizers. This option appears to be becoming very useful for the country due to the possibility of improvements in the energetic balance of the distilleries in addition to production of fertilizers. A lot of effort is being dedicated for the development of this process in the country [8,16,18].

Finally, the last alternative seeks to produce single cell proteins. In spite of the fact that this process has been practiced in the country [1] it is still critical in the yield obtained. The research group of National Institute of Technology is undertaking much efforts for the improvement of the process.

In the same form as ethanol is an alternative fuel to gasoline, charcoal offers itself as an alternative primary material to mineral coal, considering the fact of our elevated external dependence, about 80% on this material.

Since Brazil does not possess high quality coal for steel industry, it turned to the use of charcoal and until 1946 all our steel industry was totally based on this renewable reducing agent. This fact made possible the development of steel technology based on charcoal. Presently, 50% of the total production of gusa in the country employs charcoal.

According to the National Steel Plan, the production of lingots has increased from 5.3×10^6 t in 1970 to 20×10^6 t in 1980 [11].

In order to have an idea as to the importance of wood for the brazilian steel industry we present in Table 2, some data about the production of gusa using

Table 2. Steel production, charcoal consumption and estimated reforestation area

Year	Steel production (gusa) (10^6 t)	Charcoal consumption (10^6 t)	Charcoal production from reforestation (10^6 t)	Eestimate forest plantation area (ha)
1975	3.575	13.059	0.759	58,669
1976	4.825	17.338	1.152	90,117
1977	5.011	17.677	1.660	92,879
1978	5.641	19.429	2.213	98,656
1979	5.935	20.448	2.587	101,421
1980	6.108	21.069	2.573	101,963
1981	6.112	21.107	3.265	103,485
1982	6.182	21.051	4.896	97,983
1983	6.186	21.063	5.834	92,725
1984	6.151	20.930	6.857	93,838
1985	6.195	21.093	10.300	97,826

Source: adapted from CONSIDER, Ministerio de Indústria e Comercio charcoal, its national consumption, its production based on reforestation program as well as an estimate of plantation necessary to give support to the National Steel Program.

An analysis of this Table reveals that presently an enormous amount of charcoal produced in the country is obtained from native forests, which represents a big risk to our ecology.

In relation to the technology for production of charcoal, one notes that there is dominance of traditional processes. However, the present and future situations demand the development of modern technologies based on continuous processes, with utilization of volatile materials and with larger charcoal yield per ton of material employed.

Presently, the Foundation of Technological Center of Minas Gerais — CETEC located in Belo Horizonte — Minas Gerais, the largest gusa producing State based on charcoal is involved in an excellent program for development of this technology.

We believe that the development of this area will depend very much on corresponding improvement of wood hydrolysis (acid or enzymatic) presently in the phase of development in the country. This route would allow the integral use of wood, to the benefits of the steel industry (lignin), the energy sector or more specifically liquid fuels (ethanol) and finally the food sector (SCP).

These programs have been implanted as an action of some isolated industrial sectors due to the steep rise in the price of petroleum and increasing dependence of Brazil on foreign energy sources (petroleum and coal) of the order of 80%. These programs are a part of the Brazilian Energetic plan, whose projects envisage a reduction of our present external petroleum dependence from 80% to about 30% in 1985, respectively.

Table 3 represents the main objectives of this model.

Considering the fact that there is an urgent necessity to search for options for substitution of diesel oil, the Brazilian Government is presently involved in a program of alternative fuels starting from vegetal oils — PRODIESEL.

With the progress in gasoline substitution by ethanol, diesel by vegetal oils, and industrial oils by coal, the country can largely reduce its petroleum imports.

Table 3. Brazilian energetic model

Projections (1985)	Energy (barrels equivalent petroleum/day) (10^3)
Demand	1,700
Conservation	200
Petroleum (imported)	500
Petroleum (national)	500
Coal	170
Charcoal	120
Shale	25
Other sources	15
Alcohol	170

Source: Ministerio das Minas e Energia: Modelo Energetico Brasileiro. Brasilia, Novembro 1979

In technological terms, two processes represent potentialities, which can transform vegetal oils, generally triglyceroids, as alternative fuels to diesel oil [10]. These processes are transesterification and therm-catalytic cracking, both being developed in the country [14,17].

There exists a big potential for production of biogas and biofertilizers through anaerobic fermentation of animal residues, considering the fact that there are more than 120 million cattles in the country: Specifically for the rural areas where about 40% of the population lives, and where more than 90% of rural farms are not yet electrified, anaerobic degradation of animal residues could be a very pragmatic approach for energization of rural areas. It is only within the last few years that Federal and State Governments are stimulating installation of biodigestors of mainly Indian and Chinese types. This technology is propagated through demonstration units and provision of low interest credits. Success of these programs is leading to the definition and establishment of a Government policy for rural energization.

For better utilization of agricultural residues, the traditional gasogene technology has been developed at the industrial level and is expanding throughout the country. Actually, a number of units are functioning in farms and industries for power generation.

Recently, the Ministry of Mines and Energy and the Ministry of Agriculture have established a joint program mapping the zones destined to the production of energy and food in the country. This study will also provide the acquisition of information on the real potentiality of primary materials for food and energy.

Studies conducted by various groups in Brazil have demonstrated the importance of decentralized integrated systems which make adequate use of subproducts and residues from energy producing systems for improvement of energetic and economic balance. Such systems would allow the development of agriculture and of agroindusstries for the production of food, feed and fuels.

Regarding substitution of petrochemicals the country is developing appropriate routes to produce chemicals such as ethylene, butadiene and acetyldehyde etc, from ethanol. It should be noted that out of 10.7 billion l of alcohol projected to be produced in 1985, about 15% would be utilized for alcoholchemicals.

3 Socio-Economic and Environmental Aspects

The biomass conversion program has helped to increase the gross national product. For example, in 1980, GNP of the country increased by 8.5%, highest among all the non-oil exporting countries. However, the increase in GNP and high per capita income are not necessarily best indicators of development of a country. In fact, the expansion of the economy must be accompanied by better distribution of income. However, the PROALCOOL is leading to the accumulation of wealth in the hands of a few agro-industrialists due to the low interest credit scheme.

The PROALCOOL is helping to reduce country's vulnerability caused by the uncertainty associated with foreign petroleum supply. For example, in 1980, it brought a reduction of about 10,000 $m^3\ d^{-1}$ in imported oil.

It is also estimated that only PROALCOOL will require an investment of $ 5 billion for installation of new distilleries up to 1985 and generate savings of much higher value in hard currencies, consequently reducing the pressure on National Balance of Payment.

The Biomass Conversion Program has raised public awareness of the important role that biomass can play for the future development of the country. It has also provided an opportunity to scientists and technologists to develop new and appropriate national technologies to reduce country's dependence on imported ones. It should be remarked here that Brazil is already spending a substantial amount of foreign exchange for importing technologies for various sectors of the economy.

In fact all forms of biomass suitable for energy can have non-energy uses as well, and bioenergy production will compete with other uses for the same land base. In most of the developing countries like Brazil, agriculture provides food in form of corn, rice, wheat, beans etc. for local population and earns foreign exchange through export of cash crops such as coffee, cotton, soyabeans etc. It is expected that, in 1985, 3 million ha of fertile land will be needed for sugar cane cultivation to reach the target of 10.7 billion l of ethanol production. It is estimated that these 3 million ha can produce 5.1 million t of corn or 1.5 million t of beans or 4.5 million t of rice or various combinations of these crops. It may be remarked here that if the Government also decides to substitute 2.5 million l of diesel oil by vegetable oils, then additional 4 to 5 million ha of fertile land will be needed. The transfer of land from food crops to biomass for energy production will further aggravate the existing deficit food situation of the country [5].

Furthermore, the expansion of a big agriculture program would necessitate an extensive use of fertilizers, which is a serious problem to be tackled since at present the country imports large quantity of fertilizers.

The program for production of alcohol and diesel substitutes based on biomass will create about one million jobs during 1980–85 which is very important for a country having a high population growth rate. Unfortunately, 80–85% of these jobs will be available in the South and Central South regions of the country which are already rich in agriculture and also have most of the industry of the country. This situation will further stimulate the existing migratory trend from North and Northeast to these regions and thereby create social problems.

Out of the 228 distilleries projects approved by the end of 1979, with the exception of one, all are based on sugar cane as feedstock. The increased commercialized farming of sugar cane necessary for fermentation alcohol, particularly in the State of São Paulo, is leading to dislocation of small land owners and rural workers to cities, augmenting urban employment problems.

Biomass feedstocks (sugar cane, soyabeans, nuts, babassu etc.) may be diverted for nonenergy uses (e.g., sugar, vegetable oils for human consumption) that may, at times, have a greater economic value. Recent big increase in the price of sugar in the international market is bound to influence the supply of sugar cane for ethanol production. Adverse weather conditions also can interrupt harvesting or reduce biomass productivity and thus create imbalance between the biomass quantities produced and consumption needs. Moreover, if any of these factors should cause biomass supply problems, high transportation costs for supply of primary feedstock from other regions may make such problems difficult to solve. It may be mentioned here that some of the capital intensive high capacity distilleries in the country are already running below full capacity. These aspects stress the need for installation of small and medium sized systems based on diversified primary feedstocks.

Biomass in Brazil although has the potential of an energy source may create serious environmental problems. The feedstocks have to be harvested properly and the conversion technologies adequately chosen. For example, the production of 10.7 billion l of alcohol, in 1985, will be producing 130–155 billion l of stillage creating a pollution potential about twice that of the present population. Stillage is being released in the rivers and fields creating air and water pollution. There is an urgent need to establish a national program for the development of efficient biogas, biofertilizers or animal feed bioprocesses.

4 Present Status and Future Trends

The program of substitution of petroleum derivatives by biofuels is in a fairly advanced stage in Brazil. The National Alcohol Program has quite successfully met its present target. To reach the goal of 1985 for production of 10.7 billion l of alcohol, more than two million ha of additional fertile land must be brought under sugar cane cultivation. The competition with food and feed crops and necessity of large quantities of fertilizers represent serious problems. The diversification of primary feedstocks by cultivation of amilaceous (cassava, babassu, etc.) and cellulosic (wood) materials using marginal lands is very essential.

The technology for conversion of vegetal oils to diesel oil substitute is in an advanced stage of development and offers good future prospects.

The conversion of wood into ethanol, charcoal and single cell proteins, through the processes of wood hydrolysis, is being seriously studied.

The program for production of gaseous fuels from animal and biomass residues has been recently undertaken and is being gradually expanded in rural areas.

The formulation of a broad-based policy for development of agriculture and agroindustries compatible with food, feed, fuel and chemicals production, integrated with adequate use of subproducts and residues is being seriously considered to serve as a guideline for future developments.

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