Sugarcane as an Energy Source in Brazil

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INTRODUCTION

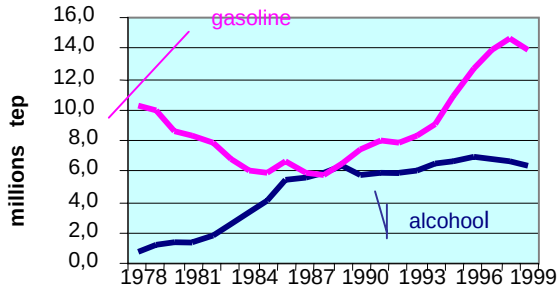
While industrialized countries are looking for ways to reduce greenhouse gas (GHG) emissions by substituting fossil fuels by renewable energy forms, in Brazil the only successful large scale program with that objective is running the risk of being dismantled in a few years. Paradoxically, it can be revived to play an important role in Brazil's power crisis, as well as to reduce balance of payment pressures, a critical economic issue for this country. This paper comments on this very unusual situation and suggests some measures in the right direction.

A BRIEF HISTORY OF BRAZIL´S ALCOHOL PROGRAM

The sugarcane industry has had, from its inception, strong ties to the very distorted and unstable international sugar market, in which temperate countries subsidize their domestic production of sugar. One of the mechanisms used to stabilize domestic production and to cope with the years when there was excess production was to convert part of the sugar into alcohol (ethanol) in special distilleries close to the sugar mill (*"destilaria anexa"*) that could be turned on and off. The anhydrous alcohol thus produced can be blended with gasoline in a proportion of up to 24%[1].

During the oil crises of the 70's in order to reduce the country's dependence on oil imports[2] and balance of payment deficits, the government created PROÁLCOOL, a program to increase sugar-cane alcohol production to use as a substitute of gasoline. It was initially addressed to increase the population of "destilarias anexas" in the existing mills.

When the second shock came in 1979, the government went for a more ambitious and comprehensive program, promoting the development of new plantations and the development of a fleet of hydrated alcohol- fueled vehicles.



For that purpose incentives were given to finance the creation of a great number of distilleries to meet the new demand for hydrated alcohol. Adaptations also had to be made in order to guarantee distribution of the new fuel to thousands of pump stations in a continental-sized country. A complex agro-industrial plan had to be put together, because sugarcane plantations have a long rotation period of five years, with 18 months before the first cut. Incentives to increase alcohol demand are commented further on.

The program induced a strong response. Alcohol production (anhydrous and hydrated) rose from 0.5 million m^3/yr in the late seventies to 15 million m^3/yr in 1987. Gasoline sales dropped sharply until 1990, when the energy content sold was less then that contained in alcohol.

The change in trend happened in 1989 when the program suffered a major setback due to an ethanol shortages in some of the main consuming centers. This shortage discredited PROALCOOL - which was about to be terminated when the Gulf War

[1] It substitutes fossil-origin MTBE to increase octane rate.
[2] At that time Brazil imported about 80% of the oil it consumed.

showed the government that this would not be a wise strategy. As a result, consumers lost confidence and sales of hydrated alcohol began a steady decline, reaching 5.1 million m^3 in 2000, from a peak of 10 million m^3 in 1992.

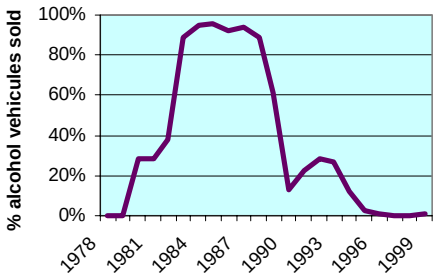
PROALCOOL was never formally terminated, but starting in 1998, subsidies were gradually extinguished and alcohol prices were set to fluctuate with market. It is important to observe that the main objectives of PROALCOOL were achieved, since over US$ 20 billion in oil imports were avoided, and over the last three years the retail price of alcohol has reached a point where it is competitive with gasoline[3].

CREATING A MARKET FOR ALCOHOL

To start the program, government made the use of alcohol vehicles mandatory in its official fleet. To attract new consumers and manufacturers, tax incentives were created. The price for alcohol was set as a fixed percentage of regular gasoline so that the fuel bill with alcohol would be less than that of a gasoline-powered car for a similar use.

Alcohol engines are essentially the same as gasoline engines (Otto cycle) with a higher compression rate. In the beginning of PROALCOOL, existing gasoline engines were retrofitted to run on alcohol. Besides increasing the compression rate, other technical problems had to be solved, such as the corrosion of some car components caused by the water in the fuel and the difficulty to "warm up" the engine on cold days.

The first alcohol vehicles were manufactured in 1979. As the main technical problems were solved, sales of these vehicles boomed. Market penetration averaged 92% between 1983/88. By 1990, over 5 million alcohol alcohol-fueled vehicles were in circulation, and represented an estimated 50% of the fleet.



The 1989 shortage reduced the confidence of consumers with a steep reduction of market penetration to an average of 30% until 1993. This would probably be a sustainable situation, but in 1994 market penetration dropped to 12% and from there on sales dwindled to less than 1%. By this time all the actors originally promoting PROALCOOL lost interest in it, as the economic policy to combat inflation overvalued local currency, strongly reducing alcohol's competitiveness vis-à-vis gasoline. Oil prices were also at one of their historical lows.

In 1999 the overvalued local currency was set to float and international oil prices tripled during the year, raising gasoline prices in local currency. Since alcohol prices were deregulated and less sensitive to currency changes, the fuel has become 25–50% cheaper than gasoline.

Irrespective of this fact, sales of hydrated alcohol have continued to fall, since 200-300 thousand alcohol vehicles are scrapped per year and only 10 thousand new ones were sold in year 2000. The automobile industry still has a few models but they are hard to find in the market and its sales are not promoted, regardless of the lower cost of the fuel. It acts as if it expects the extinction of this type of vehicle. At present, there are 3.7 million older vehicles in circulation and the distribution network is still in place. To keep the hydrated alcohol market alive, however, it is estimated that 200 thousand new vehicles will have to be sold yearly, a 10% market penetration - perfectly feasible in view of past experience.

This reduction has in part been compensated by increasing demand for anhydrous alcohol in the rapidly increasing new fleet of gasoline vehicles and by a policy to increase

[3] This can remain true at present if international oil prices are remain above 20 US$/bbl.

the percentage of alcohol in the blend with gasoline. The combination of these factors increased total alcohol consumption until 1997, but it then declined 20%, to less than 12 million m^3 in 2000.

In 1997 the government again made the use of alcohol vehicles mandatory in the Federal government (the "green fleet") and in vehicles sold with tax exemptions (mainly taxis), but this is restricted to luxury vehicles. The possibility of adding hydrated alcohol to diesel oil, a measure already adopted in Sweden, has been tested in the city of Curitiba with good results. Some advocate the use of flex-fuel vehicles, a solution used in the USA. These initiatives have been very timid and none so far has evolved into something practical.

SUGARCANE INDUSTRY

The sugarcane industry is formed by a complex of over 300 mills and distilleries that produce more or less half of their sugarcane and buy the rest from over 16,000 planters. The production is concentrated in the state of São Paulo, where more than half of production is located. The PROALCOOL program attracted new enterprises and plantations have also spread to other states. Of the total, approximately 50% of the sugarcane was used to produce alcohol fuel in the crop of 2001. In 2000, this industry sold US$ 4 billion of sugar and alcohol sales netted half that much[4].

The industry is controlled by private investors and is far from homogeneous. Many are family-controlled groups but many now have professional management, and some have associated in cooperatives. One of them (COPERSUCAR) became a major trader and also runs the most important research center, which has helped boost productivity throughout the years. It is important to note that the experience of the 1970s and 1980s shows that irrespective of its conservative views, this industry can respond very quickly if the opportunities are well understood.

The sugarcane industry has been traditionally owned by Brazilian entrepreneurs but very recently international groups bought the control of three major mills. Until recently, the sector was organized under many associations. Several competing leaderships were developed when the government controlled all alcohol activities. The transition to a market orientation is showing the importance of unifying efforts to seek common goals.

The monetary stabilization plan of 1994 that overvalued the local currency (R$) in relation to the US$ put the sugarcane industry under a prolonged financial strain, which was reflected in the reduction of the planted area. Major changes from 1999 on, however, inaugurated a new era for the sugarcane business. Change in the currency policy, the increase in international oil prices and relatively high international sugar prices have stimulated a renewed interest in the development of the sugarcane industry. In this period alcohol prices were also deregulated. At present, the industry is more capitalized and a growth of the crop area is expected in the years to come.

This development is both good and bad news. In the short term it can mean more net revenue for the sector. In the medium term the flexibility to switch production from alcohol to sugar increases the risk of producing an alcohol shortage similar to that observed in 1990, as there is no regulation for alcohol. This could in turn precipitate the end of the use of this fuel.

Since blending with gasoline is close to its technical maximum, the reduction of domestic market for pure alcohol will increase exposure to the export market. Demand for ethanol should increase in the international market, as many countries plan to switch from MTBE. Chances are, however, that this will also be a protected and volatile market as

[4] US$ 1 = R$ 2 at the time

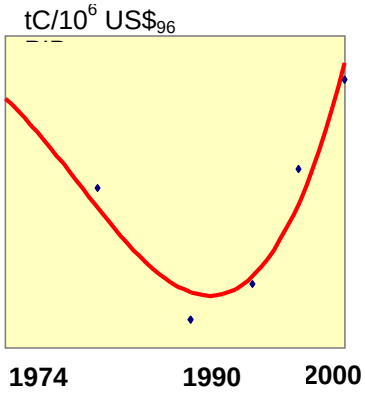
importers will subsidize domestically produced feedstocks - sugar beet in Europe and corn in the USA.

ENVIRONMENTAL ISSUES

When PROALCOOL was established, critics pointed to the elevated costs of negative regional environmental externalities. Among other issues were: the exacerbation of historical labor problems; water contamination by the stillage[5]; air pollution from the traditional burning of field residues ("queimadas"); and competition with other food and agricultural products.

Many of these problems have been overcome with technological advances. The main remaining problem is the burning of field residues, which pollutes the air with ashes. Federal law requires this practice to end in the near future. This is being achieved through mechanization. The huge quantities of biomass saved can be incorporated to the soil, as well as used to generate additional power.

The choice of this renewable option was motivated at the time solely by strategic and balance of payment considerations. Using this program to reduce GHG emissions was a non-issue in the late 1970s. Nevertheless, on a global scale, it was the largest man-made intervention to substitute a fossil fuel by a renewable fuel, thus reducing GHG emissions. Presently this reduction is estimated to be 9 million tC/yr[6]. The positive effect as well as the relative slow-down of the program from the 90's are visible in a curve of the CO2 emissions compared with Brazil's economy as measured by its GDP.



Other unsought environmental benefits were the considerable reduction of air pollution in the city of São Paulo and the avoided use of MTBE as an octane enhancer - considered today a major environmental problem throughout the world.

SUBSIDIES AND INCENTIVES

The incentives and subsidies for PROALCOOL in the beginning were meant to be transitory because high oil prices would make the ethanol competitive in the long run. Decreasing marginal costs for the renewable fuel were also expected and in fact happened. However, when international oil prices fell in 1986 to levels lower then before the "oil crisis"[7], the program became a major headache for successive governments[8] as a discontinuation of the subsidies could have a great impact on the economy.

By this time, over US$ 20 billion had been invested in hundreds of distilleries, over 5 million vehicles and a complex of associated sectors. It was also the most labor-intensive energy form, with a significant positive effect on the balance of payments[9].

The subsidy to cover the difference between alcohol costs and prices was kept with declining proportions until the end of 1998, when major changes in fuel pricing policy

[5] With the then existing technology, for each liter of alcohol, 13 liters of an environmentally very aggressive stillage was produced!

[6] Macedo, I.: "GHG Avoided Emissions in the Production and Utilization of Sugarcane & Ethanol in Brazil", MCT/ 1997.

[7] It should be noted that this was by no means a Brazilian problem. This price drop was not expected by any of the energy analysts of that time.

[8] Proálcool was almost extinguished in 1990 and this did not happen basically because the unexpected Gulf War reminded the prudence of not exposing Brazil to the risks of fuel shortage.

[9] Even when oil prices were very low this was never under US$ 1 bil /yr. At present, the equivalent to 200.000 bbl/day of gasoline reduces imports on approximately US$2.2 bil /yr.

took place. Gasoline prices, until then regulated, were freed to be set by the market. Alcohol subsidies were also gradually extinguished and alcohol prices were also allowed to fluctuate with the market.

Since gasoline and alcohol prices were set to float with market, alcohol pump prices have fallen to levels that make it 25-50% cheaper for the same distance than gasoline. Alcohol is now sold competitively because the sugar-cane industry has been able to increase its productivity steadily from its beginning.

SUGARCANE AS AN ENERGY RESOURCE AND GOVERNMENT

Primary energy in Brazil in 1999 totaled 233 million toe (tons of oil equivalent). Of that total, 34 million toe was supplied by that year's sugarcane crop, equivalent to more than half of the oil and gas production[10]. Of this total, about 11 million toe were burnt in the field. The sugar component of this feedstock was transformed into 7 million toe of alcohol. The 16 million toe in the bagasse was used to produce 6 TWh in 1,000 MW of co-generation facilities in distilleries and sugar mills, as well as process steam needs. Eletrobrás estimates that up to 60TWh can be produced cost-effectively using higher pressure boilers and other conservation practices. New technologies under development could double or triple this output[11].

Despite being one of the major primary energy sources in Brazil, the sugar-cane industry was never fully accepted as an energy source. This is probably because of its agricultural roots, and the fact that it was privately owned in a government-controlled energy sector.

Petrobrás, the state-owned oil monopoly, which suffered direct competition that affected its refining structure, never accepted the sugarcane industry. Charged by the government with distributing alcohol, Petrobrás imposed the structure of the gasoline distribution system, although gasoline was produced on the coast and alcohol inland. Petrobrás even built MTBE plants (which is being abandoned throughout the world for environmental reasons), although its sale was formally forbidden in Brazil and anhydrous alcohol was cheaper than this additive.

The government agency (IAA) created to stabilize domestic production and international trade was extinguished in 1990. Its termination coincided with very high international sugar prices, when a significant part of alcohol production was diverted to sugar. It came as no surprise that when a government agency was established in 1998 to regulate the fuels sector in Brazil, it was named the "National Petroleum Agency"[12]. Several topics of the 1997 Energy Policy law address the continuation of alcohol as a fuel and requires the National Council of Energy to guarantee its supply to consumers and to keep strategic stocks of fuels but the agency restricted its attention to fossil fuels[13]. The non-existence of any kind of regulation that can prevent a shortage from happening is at the root of the lack of consumer confidence in alcohol.

Another example of lack of coordination is that Brazil decided to develop a program to use natural gas (NG) to power vehicles. These vehicles run on NG and a second fuel. The natural choice would be to adapt the existing alcohol vehicles because NG requires high compression rate vehicles. The conversion, however, is being done mainly with low

[10] Brazil produces 85% of its oil needs and is expected to be self-sufficiency by 2005. NG imports from neighbor countries (Bolivia and Argentina) are expected to increase.

[11] Instead of burning the biomass to produce steam, it is gasified and the gas used in a turbine.

[12] Agência Nacional do Petróleo – ANP.

[13] Pg. 89 – 90; Setor Energético Brasileiro – Situação Atual e Perspectivas; CNPE; December 2000.

compression gasoline vehicles that operate with a bad performance and with greater emissions even though NG is a “clean” fuel.

The impressive power generation capability (see below) was discarded because, at the time when PROALCOOL was launched, Brazil had a large hydroelectric program. The state-owned power monopoly Eletrobrás did not consider this resource, even though, in many regions, the sugarcane crop coincides with the dry season. A striking illustration of this posture is that very recently, after the opening of the power market, the official plan prepared by Eletrobrás estimated sugarcane to be the most cost-effective source of generation available and at the same time estimated its potential to be substantial. Yet, although problems of power shortage were already well mapped, the myopic point of view of ignoring this potential was kept in the suggested plan, severely reducing the possibility of the sugarcane industry selling power to the grid.

Government affairs with sugarcane industry are categorized basically considering its agricultural characteristics, and are thus treated through the Ministry of Agriculture.

POWER FROM SUGARCANE RESIDUES

To enable the sugarcane industry to maintain and expand production, it is important for it to keep on increasing its industrial productivity. Technological advances will happen step-by-step as new species and better handling are incorporated - driven by the new stimulus of competition between producers. A quantum jump in overall energy efficiency, however, is feasible in the medium term if the potential do produce and sell power to the grid is fully developed.

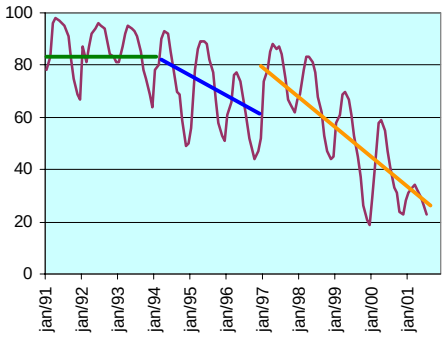
The chance for this occurred in 1998, when legislation opened the electricity market, in principle. In practice, the market remains incipient as the new actors are still defining their roles and strategies. A few factors, however, reinforce the power-from-cane strategy as a potentially very effective option. The overall economics are based on the fact that these are thermal plants with a near zero cost fuel, paid in local currency, located near important loads and with capacity to generate in the dry season.

Since PROALCOOL is about 20 years old and many distilleries are close to the end of their life-cycle, the investments to modernize these plants can synergize with the investments needed for power production, thus reducing marginal costs. The new business would need investments of US$ 6 - 8 billion but would bring this industry a new and more stable revenue stream in the range of US$ 2 to 3 billion per year, thus contributing to a new financial equilibrium.

A PROBLEMATIC TRANSITION FROM MONOPOLY TO POWER MARKET

The transition from government-owned monopoly into a privately-owned market-driven sector has been shown to be very problematic, with few additions of new electricity generation capacity after many years of reduced investments. Until recently, no power shortages were observed because the evolution demand during much of the 1980s and 1990s was considerably lower than initially projected. After 1994, with monetary stabilization, however, economy started to grow again incorporating a large portion of low-income residential consumers.

Hydro systems supply 90% of Brazil’s power needs. To cope with annual and multiyear seasonalities, the reservoirs of the most important basin (Southeast) can store 100 TWh of energy (about three months of demand). This large storage capacity tempted the system operators to treat these reservoirs, even after privatization, in a political rather than technical way. To compensate for the lack of new power additions, the reservoirs



were depleted starting in the mid 1990's, thus increasing the risk of a power shortage, as occurred in the beginning of 2001.

After 1998, as the reservoirs reduced their accumulated storage, it was very clear that some intervention in the market would be necessary, both to reduce growth in consumption and to increase supply. Working to promote conservation has been a sort of taboo in the power sector, and although officially accepted through an official program (PROCEL) it was never undertaken seriously.

Only at the end of April 2001, as the rainy season ended, was the government alerted to the criticality of the situation. By this time the only solutions left were either to impose massive blackouts or to order drastic rationing measures. Due to the great risk of serious economic and social disorganization from blackouts on such a scale, the government opted for rationing, targeting a 20% reduction. The response has been good and has shown that conservation measures are feasible.

Although the development of power from sugarcane biomass would seem to be an obvious choice to address the current power shortage, the government has given it little attention, probably because this sector is not organized. It has insisted on the traditional central planning approach of developing large gas-fired power stations and to facilitate the importation of barges and mobile generators. For that purpose, the government, which has been aggressively pushing privatization, had to create a new government enterprise that will act as an energy broker for an emergency period of five years.

CONCLUSION

If a revival of alcohol vehicle sales does not take place soon, a crisis of availability of alcohol will emerge in an abrupt way as the population of alcohol vehicles drops below a certain threshold level where alcohol distribution costs become unbearable. When this happens, millions of alcohol vehicle owners – mostly lower income – will blame the government for their losses, since it is responsible, by law, to guarantee the availability of fuels. This outcome will also exacerbate balance of payment problems, since the switch to gasoline will increase fossil fuel imports by US$ 500 million per year. Reducing the exposure to oil imports is also desirable for strategic reasons as recent events in the World have shown.

A new PROALCOOL is not needed, to avoid this outcome as the situation today is very different from that observed in early 1980s: Brazil is almost self-sufficient in oil, alcohol is competitive at present international oil prices, and has the prospect of further cost reductions, especially if its electric power potentials are developed.

Nevertheless, a political initiative the from government working together with the principal stakeholders, such as the sugarcane industry and car manufacturers, is necessary to change the declining trend of hydrated alcohol use. For that purpose government role would be to identify and remove barriers that make the market vulnerable to fluctuations and use its fiscal potential to develop the demand for alcohol vehicles. .

As for power production, sugarcane can play a major role - including in the short term. Going from conventional 21 atmosphere boilers to higher pressures would be a key step. However, for this to happen the industry has to feel comfortable that the market rules will not be changed against them and that the government's short term measures to address the energy crisis will not undermine competition - as they have so far appeared to do.

To move this market, heavy intervention is not necessary. The government's role should be a policy of neutrality and showing confidence in this resource. Many of the

mechanisms created to deal with the short-time emergency can be used to boost the market with no additional costs.

Expanding sugarcane's role in electricity generation can help the country recover from the current energy crisis. Sustaining alcohol vehicle technology can help avoid the next energy crisis. Both efforts contribute to a strategy of "no regrets".