Brazil's Energy Story: Insights for US Energy Policy

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Brazil's energy story is in stark contrast to the US energy story which reflects the natural endowments of both countries and their level of development.

In the United States approximately 40% of all energy used comes from petroleum, 23% from coal, and 22% from gas, so fossil fuels represent 85% of energy consumption; the remaining comes from nuclear (8%) and renewables (7%).

In Brazil fossil fuels represent 53% (oil 37%, gas 10% and coal 6%) and nuclear 2%. Renewables represent 45% (sugarcane products 16%, hydroelectricity 14% and firewood and others 15%).

The fraction of energy consumption from oil is not very different in the two countries but there the similarity ends. Coal and gas are less important in Brazil, and hydro and biomass (sugarcane products and firewood) account for the balance. The US is highly dependent on oil, importing approximately 8 million barrels per day at a cost of approximately $300 billion per year from the Middle East. Brazil, in contrast, is self-sufficient, producing all the oil it consumes.

Brazil's energy story can be split in three different stories:

- the growth of hydroelectricity production
- oil findings in the continental shelf
- the use of sugarcane products as an energy source

The Story of Hydroelectricity

Production of electricity in hydroelectric generating stations started early in Brazil with small municipal and private companies that had strong links to English companies. However, in the last decades of the 19th century a group of Brazilians and Canadians established a new company in Toronto that was authorized in 1985 to operate in Brazil. Soon the company, named São Paulo Railway Light and Power Co. Ltd, obtained a concession for public transportation in São Paulo city using electrically-driven vehicles (street cars).

The new company immediately started building hydroelectric generating stations, the first of which started operation in 1901 with 2,000kW. A few years later the Tramway Light Power Co. Ltd was established in Rio de Janeiro. As a consequence, other hydroelectric stations were built in the Paraíba do Sul River; and in 1908 the Fontes hydroelectric plant station with 24,000 kW was inaugurated. At the time it was one of the largest hydroelectric stations in the world.

By 1940 LIGHT owned 44% of the installed electrical capacity in the country and the US company AMFORP another 14%.

The problem that soon developed was that electricity tariffs were administered by the government and were kept at low levels—for political reasons—and insufficient to finance expansion, which generated shortages and frequent interruptions of supply.

That situation led state governments and later on the federal government to establish state-owned companies, the largest of them in 1945 named CHESF (Hydroelectric Company of the San Francisco River), which built the large Paulo Afonso station.

In 1962 a federally-owned company, ELETROBRAS, was created that basically put the electrical sector in governmental hands expropriating foreign companies. What followed was a period of 30 years in which the sector expanded enormously and built many hydroelectric stations such as Itaipu. Today more than 80% of the installed capacity for electricity generation (most of it in the hands of the state) is hydroelectric with a small participation of thermal sources (coal, gas and nuclear).

After 1990 there was a wave of privatizations to promote competition in the sector, and most of the companies responsible for distribution were privatized. However, transmission and generation remained mostly in the hands of the state.

The partial privatization of the electricity system forced ELETROBRAS to reduce its planning and investment activities, which led ultimately to a serious crisis in electricity supply in 2001/2002 with shortages and blackouts that had serious political consequences. The new government elected in 2002 (Lula's government) froze plans for further privatization and introduced a system for expansion based on bidding by private and state-owned companies in which the winners offered the smallest cost of electricity to the public. Planning to rationalize expansion and an adequate mix of supply sources were practically abandoned.

The results of this strategy are dubious. Private companies (national and foreign) do not enter the bidding competition for new large hydro projects, such as Belo Monte, without the strong backing of the government through official banks.

Since most of hydroelectric sites in the southeast of Brazil were already built, expansion of the system is occurring in Amazonia where new hydro projects are opposed by environmental groups. As a consequence, other options such as coal and gas were favored while renewables such as small hydro and wind were less successful in the bidding process. The needed expansion of the system, estimated at 5% per year, is proving to be difficult to achieve.

Despite that, some social programs of the government were successful such as "Luz para Todos," expanding electricity lines to small and isolated communities that were not connected to the grid. In the last 10 years, some 10 million people were connected to the grid at a cost of approximately $8 billion.

The Story of Petroleum and Gas

Until 1930 there was very little activity in Amazonia, and all of the petroleum used in the country was imported. The efforts made in prospection gave disappointing results. Foreign companies were not allowed to operate in the country and all kinds of conspiratorial theories were circulating at the time to justify the failure of finding oil. This led to a strong wave of nationalism and the establishment of a state owned company, PETROBRAS, in 1952 to prospect for oil.

Initially PETROBRAS had a strong technical department under the direction of Walter Link, a US citizen, which made extensive mapping of possible oil deposits, recommending studies and exploration offshore. Until the early 1970s his advice was not followed, and the country remained heavily dependent on oil imports until the cost suddenly went from $2.90 per barrel to $11.65 per barrel during the 1973 oil crisis.

The import bill for oil—80% of which was imported—skyrocketed from $600 million in 1973 to $2.5 billion in 1974, approximately 32% of all Brazilian imports and 50% of all the hard currency that the country received from exports.

The response of the government to the crisis was to start offshore drilling, which immediately resulted in an increase in production, and to accelerate ethanol production. The idea was to reduce gasoline consumption and therefore decrease oil imports. Production goals were set

at 3 billion liters of ethanol in 1980 and 10.7 billion liters in 1985.

The success of offshore drilling led to the expansion of PETROBRAS and changes in the law that permitted the participation of foreign companies (up to 49%). It was not an outright "privatization" of the company but rather an opening to attract the capital needed for investments. The discovery of the large PRÉ-SAL oil fields at more than 5 kilometers below sea level and under a 2-kilometer layer of salt led to further drilling at the technological frontier in this area, offering new risks and challenges but also new opportunities.

If successful, the PRÉ-SAL activities could convert Brazil into a major oil exporter in 5-10 years. Present production is approximately 2 million barrels per day and could grow to 5 million barrels per day.

The Story of the Ethanol Program

Sugarcane has been cultivated in Brazil since the 16th century and more recently the country became the largest producer of sugar, accounting for approximately 25% of the world's production. Ethanol production has been small but, starting in 1931, the government decided that all the gasoline used in the country (mostly imported) should contain 5% of ethanol from sugarcane. This was done to benefit sugar-producing units faced by declining prices of sugar in the international market that notoriously fluctuate over the years.

Around 1970 the sugar industry in Brazil stagnated, processing only 70 to 80 million tons of sugarcane per year, mainly due to government policies of guaranteed prices to producers. When the international price of sugar was low, the government purchased the sugar at prices that satisfied the producers. Competition and modernization were thus discouraged; each producer had a quota and therefore few concerns about losing money. Sugar producers didn't plan for the long run and usually produced strictly what they considered financially attractive in a given year. Since the price of sugar in the international markets varies significantly over time, such lack of planning frequently left the producers out of the market when prices suffered strong fluctuations.

Decree 76,593 of November 14, 1975 which is really the birth certificate of the Brazilian "Alcohol Program" determined that very generous financing terms were to be offered to entrepreneurs to produce ethanol and that the price of ethanol should be on a parity with sugar, 35% higher than the price of 1 kg of sugar.

The decree made the production of ethanol and sugar an opportunity for entrepreneurs. It opened the way for the increase in the production of ethanol, which indeed happened.

In principle, the problem of increasing ethanol production was solved. The remaining problem was to make sure that the ethanol produced was consumed.

The government solved the problem using two instruments:

- Adopting mandates for mixing ethanol to gasoline. Up to 1979, the mixture of ethanol in the gasoline increased gradually to approximately 10%, which required small changes in the existing motors. In 1981, ethanol consumption reached 2.5 billion liters.

- Setting the price of ethanol paid to producers at 59% of the selling price of gasoline (which was more than twice the cost of imported gasoline). The high price of gasoline had been used for a long time by the government as a method of collecting resources to subsidize diesel oil. Part of those resources was then used to subsidize ethanol.

Subsidies of approximately $1 billion per year, on average, over the 30 years were needed to sustain the program. These subsidies were removed gradually and in 2004 the price paid to ethanol producers was similar to the cost of gasoline in the international market.

In the 1980s two fleets of automobiles were circulating in the country: some running on

gasoline, using a blend of up to 20 percent anhydrous ethanol and 80 percent gasoline, and others running on hydrated ethanol. In 1985, the scenario changed dramatically as petroleum prices fell and sugar prices recovered on the international market. Subsidies were reduced and ethanol production could not keep up with demand. The production of ethanol leveled off, but the total amount being used remained more or less constant because the blend was increased to 25 percent and more cars were using the blend. Thus, by 1990 a serious supply crisis occurred due to a shortage of the appropriate fuel. The government tried to mitigate the shortage by importing ethanol and methanol. Methanol was blended with gasoline and ethanol yielding another fuel that could be used in gasoline cars, freeing more ethanol for the neat ethanol-powered ones. But the shortage crisis, lasting one year, scared consumers; and the sales of neat ethanol cars dropped rapidly. By the year 2000 it was lower than 1% of total new cars sold.

Then, after 2003, ethanol consumption rose again, as flexible-fuel engines were introduced in the cars produced in Brazil. These cars are built to use pure ethanol with a high compression ratio (approximately 12:1) but can run with any proportion of ethanol and gasoline, from zero to 100 percent, as they have sensors that can detect the proportion and adjust the ignition electronically. Flex-fuel cars were an immediate hit; today they represent more than 95 percent of all new cars sold because they allow drivers to choose the cheapest blend on any given day. Approximately 50% of the gasoline that would otherwise be used in Brazil today was replaced by ethanol. The production of pure ethanol-driven cars is being discontinued because of the success with flexible-fuel engines.

In the 30 years since 1976, ethanol substituted 1.51 billion barrels of gasoline which corresponds to savings of $75 billion (in 2006 dollars), taking into account the amount of gasoline saved each year at the world market price.

An additional benefit of the ethanol program was electricity cogenerated with the burning of bagasse—the fiber remaining after the extraction of juice from sugarcane—in ethanol distilleries. One estimates that this source of renewable electricity could contribute more than 10% to the whole production of electricity in the country by 2020.

In relation to the participation of other sources (thermo and nuclear) these were modest until 2008. However, in the auctions which occurred in 2008/2009, there was a significant increase in the forecast of thermo and coal source energy, since there were few hydroelectric plants able to participate in the auctions. This tendency was reversed in the EPE (Brazil's federal energy planning company) plans in 2010, and there was a significant increase in the participation of wind energy until 2020.

The contribution of nuclear energy indicates an increase until 2020 due to the conclusion, expected for 2015, of the Angra III nuclear reactor. By 2030, the National Energy Plan forecasts the installation of four more nuclear reactors. However, the 2011 disaster of Fukushima, Japan, is causing a reassessment of nuclear expansion plans around the world and the same should occur in Brazil. One inevitable consequence of the disaster is that nuclear energy costs should increase due to the need for additional safety measures, which will probably make this type of energy source less competitive.

In relation to the participation of biomass in the generation of electricity, the forecasts of EPE for 2020 significantly underestimate this potential. Recent surveys conducted by the National Supply Company (CONAB) indicate the possibility of the co-generation with sugarcane bagasse to be much higher than the numbers estimated by EPE.

Energy efficiency so far has had a small role in the energy planning of Brazil, despite the existence of the Energy Efficiency Law # 10.295 of October 17, 2001, which authorized the executive branch to establish maximum levels of specific energy consumption or minimum levels of energy efficiency of machines and equipment manufactured or commercialized in the country.