Field Trip : Brazil

Brazil is a Federal State grouping 26 Provincial States (« Estados »), 1 federal territory and 1 federal district (the capital Brasilia), which have a certain amount of autonomy concerning economic and energy issues. The energy sector has been vastly modified. In 1990 a privatisation programme was put in place, followed in 1995 by a law on public services, softening the conditions for entry to the electricity market and guaranteeing free access to the distribution and transport networks, and in 1997 by a new law on the oil sector. The latter is aimed at defining the national energy policy concerning hydrocarbons and the means of regulation of a sector which was until then subject to no regulation.

The National Energy Policy Committee, under the supervision of the Ministry for Mines and Energy (MME) sets out energy policy

The National Electrical Agency (ANEEL) is responsible for the supervision of the electricity sector and its regulation.

The Coordinating Committee for Planning and Expansion of the Electricity Sector is in charge of its development.

The National Oil Agency (ANP) supervises the activities of the Hydrocarbons sector.

Topics

Proven Resources:

Gas: 229 Gm3
Oil: 1152 Mt
Coal: 12 Gt
Hydroelectric potential: 90 GW

Oil and gas:

The country's supply in oil and gas was, until 1996, ensured by Petrobras. Created in 1954 as a public monopoly of the Federal State, it is today the largest Brazilian company and the 16th largest oil company in the world.

From now on, prospection, production, external trade, refining and transport will be open to competition. The distribution of oil products is ensured by private, mainly foreign, companies (60%). In refining Petrobras continues to have a de facto monopoly as it holds 11 of the 13 refineries.

Class of 2003

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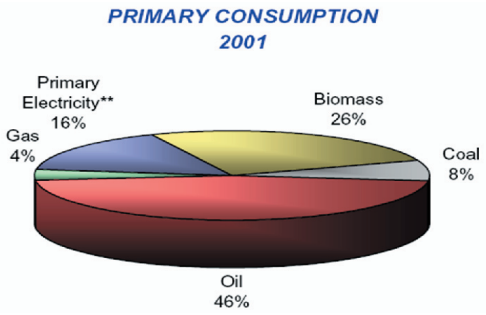
BRAZIL

Energy Sector (Source : ENERDATA)

Oil :

Until exploitation of its own reserves began in the 1980's, Brazil imported the majority of its oil (up to 90%). In order to combat this situation, the federal government put in place in the 1970's the «Pro Alcohol Plan» aimed at substituting conventional fuels with alcohol produced from sugar cane. Although very expensive in terms of government subsidies, this plan remains one of the means to ensure Brazil's energy independence.

The domestic oil production took off again in the 1980's. Oil imports now only account for 23% of the demand compared to 90% at the beginning of the 1980's. Brazil has 13 refineries with a total capacity of 1.9 million b/d, three of the refineries having a capacity of more than 200 000 b/d (2 in the Sao Paolo State and one in the Rio de Janeiro State).



Gas :

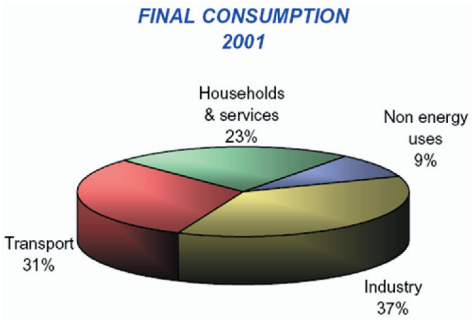
Gas production is increasing slowly but is still small; half of the gas produced is reinjected or flared, giving a marketed production of 5.3 Gm3.

Electricity :

The main electricity company in Brazil is Eletrobras, a Federal holding company created in 1962 and charged with the programming, financing and implementation of investments. Since being included in the national privatisation programme in 1995, the electricity sector has undergone, and is still undergoing, many changes. The 6 Federal and provincial companies (CESP, Furnas, Eletrosul, Eletronorte, Light, Escelsa) which make up Eletrobras will be privatised by the end of the programme. Eletrobras will continue to manage the transport network.

Distribution which was mainly the domain of the State companies is also in the process of being privatized.
In the generation sector, the public sector accounts for 78% of the production.

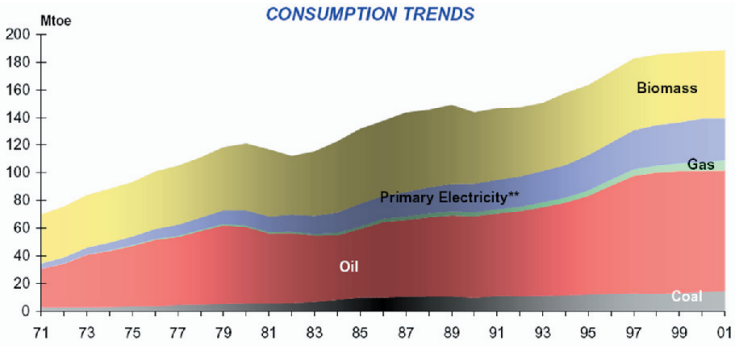
Hydroelectricity dominates public and private production with 86% of the installed power (65 GW of a total electricity capacity of 79 GW, 2002) and around 83% of the electricity production (269 TWh of a total of 324 TWh in 2001). Hydroelectric plants of 1000 MW or more account for 2/3 of the installed capacity. The rest of the electricity production comes mainly from diesel or coal fired thermal power plants. With the commissioning of Angra II in 2000, the country has now 2 nuclear reactors (Angra I and II). Autoproducers account for 6% of the electricity generated.
Electricity imports have increased sharply since 1985 mainly due to the buying of the Paraguyan share of the electricity produced jointly by the two countries at the Itaipu dam (12 600 MW). In 2001 imports represented 41 TWh.



Balance :

Oil is the main source of energy with 46% of the total country needs. Hydroelectricity is in second position with 16%, followed by coal with 8% and gas with 4%. The supply structure has remained relatively stable since the middle of the 80's. Non-commercial energies (wood, peat, bagasse) also have an important role contributing 26% of the primary consumption in 2001. A non-conventional energy source aside, the Brazil's energy independence has grown strongly since the end of the 1970's (when it fell to 30% in 1978) to reach 79% in 2001.

With a consumption per capita of 1.1 toe, Brazil is within the average for the semi industrialized countries but well below the European average of 3.7 toe.



LIGHT

Electricity Producer

Rio de Janeiro, March 8th 2004

The Light generation facilities produce, on average, 15% of the energy distributed by the company to its 3 million customers, located in the 30 municipalities that make up its concession area in Rio de Janeiro State. The Light generation system comprises eight power plants of which 6 are generation stations and two elevated pumping stations. The whole constitutes the Paraiba do Sul/Pirai/Ribeirão das Lajes hydroelectric complex.
The first dam construction began in 1904 and the Fontes power plant was, in 1908, the largest hydroelectric station in Brazil with 30MW of nominal power.

In 1942, after finishing the elevation of the Lajes Dam from 404 m to 416 m, the Fontes Nova power plant could already deliver 132 MW of electric power.
In order to follow the growing demand in electricity, part of the Paraiba do Sul River was detoured, leading to the creation of a new power plant in 1953 : the Nilo Peçanha power station.

This power station, with 6 generating units corresponding to a a global installed capacity of 360 MW, has the particularity to be linked upstream to the Lajes reservoir by an underground straight line.
The water flowing through this power station powers a last hydro plant, called Pereira Passos. The purity of this water is accurately tested and controlled because part of the Rio inhabitants use it for their drinking consumption.
Completing our visit of Nilo Peçanha Hydro plant, we boarded small motorboats, to cross the Lajes reservoir. This watershed of 305 km^2 is located inside a genuine wooded hills area. The Lajes reservoir remains an integral part of the Brazilian Atlantic Rain Forest Biosphere Reservation, a part of the UNESCO's "Man and Biosphere" program. Light, which is responsible for this ecological sanctuary for 100 years, maintains cooperative agreements with research institutions and universities for the protection and improvement of the environmental quality of the region.
The visits and landscapes were exceptional. This first day was a good introduction for this stay in Brazil.

M.A.E

Electricity

Sao Paulo, March 9th 2004

MAE
MERCADO ATACADISTA DE ENERGIA ELÉTRICA

During the 90's, the Brazilian electrical sector's knew an important crisis, mainly because of the depletion of the capacity to generate energy from the existing hydro power plants, the increase of the demand due to the «Plano Real»
- a Brazilian economical plan - and the shortage of the government budget to fulfill these needs in face of other priorities. A new electrical energy market model was then created in 1996. Three institutions were created : the ANEEL, MAE and ONS.

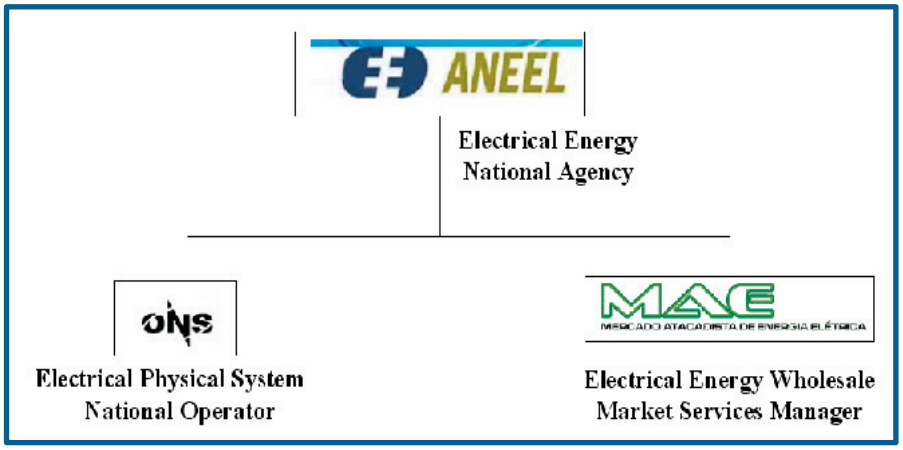
The MAE, located in the city of Sao Paulo, is the Electrical Energy Wholesale Market Services Manager. With the ANEEL (Electrical energy National Agency) they play approximately the same role in Brazil as the CRE (Commission de Régulation de l'Energie) in France. The ANEEL is responsible for captive consumers whereas the MAE has only to deal with eligible consumers.

The MAE, considered as an impartial regulator, is only under the authority of the ANEEL, from which it gathers a large part of its information (an other large part of its data come from the ONS). MAE is in charge of buying and selling the bilaterally not contracted energy from the interconnected system are processed. It is also responsible for all the activities required to administrate this market, including financial, accounting and operational activities.

The main tasks of the MAE are :

• **Operating and managing the wholesale electricity market**
It means that the MAE is responsible for all operations occurring on the electricity market. The MAE manages the market system by implementing the prices, the rules and the procedures.

• **Registering agents and bilateral contracts**
Some companies are compelled to enter the market and it could be optional for others to enter it depending on the level of their production or consumption of electricity.



• **Managing the commercial metering**
The MAE has to adjust the generation and consumption data.

• **Establishing the MAE energy price**
The MAE price is established to the energy negotiated in the Short Term Market which is not ruled by any contract. To establish it, MAE counts the total energy consumed minus the energy exchanged by bilateral contracts. The result is equal to the volume of energy exchanged on the spot market. These calculations are operated weekly but the MAE wishs be quickly able to offer a hourly price.

• **Implementing and monitoring the market rules, defining the market procedures**
The MAE applies the penalties imposed by the ANEEL and managing the System Service Charges (which regulates the 'adjustment market').

The MAE is also in charge of the Energy Reallocation Mechanism (MRE), which is a financial mechanism though which the hydrological risk of a centralized dispatch, related to the optimization of the hydrothermal system, is shared among its participants.
The MAE has to allocate the financial surplus. This surplus is the difference between the total of payments and receipts and the money collected thanks to MRE.

• **Promoting legal follow-up of the MAE operations**

• **Providing training to the agents**
MAE is responsible for providing to companies participating in the market the information necessary to understand the rules and the procedures. It teaches them how to deal with the market.

• **Implementing services tools for the agents**
These tools aim to help the agents manage their operations on the market.

ITAIPU

Hydroelectric production

Foz de Iguaçu, March 10th 2004

One of the seven wonders of the modern world!!

Since 1995, Itaipu has been included in the list of the seven wonders of the modern world by the «Popular Mechanics» magazine and the American Society of Civil Engineers (ASCE). Why? A rapid glimpse at some numbers on Itaipu will give an idea of the scale of its grandeur:

- The total volume of concrete used in the construction of Itaipu would be sufficient to build 210 football stadiums like the Maracanã, in Rio de Janeiro.
- The iron and steel employed would permit building 380 Eiffel Towers.
- The maximum flow over the

Itaipu spillway (62.2 thousand cubic meters per second) corresponds to 40 times the average flow over the Iguaçu Falls.

- The flow through two Itaipu turbines (700 cubic meters of water per second each) corresponds to the total average flow of the Iguaçu Falls (1500 cubic meters per second).
- The height of the main dam (196 meters) is equivalent to the height of a 65 storey building.
- Brazil would have to burn 434 thousand barrels of petroleum a day to obtain from thermoelectric plants the same energy production as Itaipu.

In April of 2001, the power station surpassed the mark of 11 million visitors!

A new world record...

The Itaipu Hydroelectric Power Plant, the largest in operation in the world, is a binational enterprise jointly developed by Brazil and Paraguay in the Paraná River. The installed power of the Plant is 12,600 MW (megawatts), with 18 generating units of 700 MW each.

The production record of the year 2000 amounted to 93.4 billion kilowatt-hours (kWh) was 3% superior to the 75,000 GWh/year forecast in the project design!! It was responsible for the supply of 95% of the electric power consumed in Paraguay and 24% of the total demand in the Brazilian market.

The installed capacity of the plant will be enlarged to 14,000 MW by the middle of 2004, when two new generator units will be operating.

Thanks to the increase in production that, 10 years from now, Itaipu will still generate the equivalent of 16% of the entire Brazilian consumption!

The green of the lake shores

Since the preliminary project phase, Itaipu Binacional has always shown a special concern for the environment guaranteeing the water quality in the reservoir and preserving the fauna and the flora of the region, the forest and the health of the resident populations neighbouring the Itaipu Lake.

Itaipu versus Three Gorges

In spite of the grandeur of the Three Gorges hydroelectric power plant, at present under construction, Itaipu will continue for many years to be the greatest hydro plant in the world: the forecast for the Three Gorges is "only" 84 billion kWh/year with its 26 machines of 680 MW each compared to the 93 billion kWh/year of Itaipu.

What's more, the flow of the Paraná River, regulated by dozens of power plants located upstream form Itaipu, is more stable than that of the Yang-tse, where the Three Gorges is being built.

CEPEL

Electric Energy Research Center

Rio de Janeiro,March 11th 2004

The CEPEL (Centro de Pesquisas de Energia Electrica : research center of power energy) was founded in 1974 as a non profit institution attached to the industry minister in order to follow the trend of the Brazilian power sector and to develop a Brazilian research capability.

Since its foundation, the investments amount to 150 millions US dollars, with an annual budget of 27 millions US dollars.

The CEPEL is based in the University City of UFRJ, Fundão Island. It gathers the directorate of the research center and more than 20 laboratories covering different specialties like dielectric material or isolating materials. On the whole, 32 laboratories are linked to the center centre and employ 400 persons.

The center is organized according to a matrix project management and is composed of different branches:

- DAS : System Automatization
- DCA : Energy optimization and environment
- DIE : Transmission and distribution equipment
- DES : Electrical power system
- DTE : Special technology

We were guided by M. Hamilton Moss se Souza, coordinator of the Cresesb (Centro de Referência para Energia Solar e Eólica Sérgio de Salvo Brito), a center that promote management and distribution of power in isolated areas.

We visited a show room of the center that presents more precisely the research undertaken in this center: energy audit in buildings, development of label indicating the consumption of domestic machine, better insulation and glasses, energy optimization, etc.

This visit was also the occasion to present our work on the transport and sustainable development theme.

CenDoTec

Sao Paulo, March 9th 2004

The CenDoTec (French-Brazilian scientific and technical documentation center) is both french and brazilian. It is linked to the French foreign office and aimed at developing scientific cooperation between Brazil and France.

We were given a very warm welcome by Luc Quoniam, the director, who in his office in the university of São Paolo (USP) present us the CenDoTec activities, which are organized around four topics.

- Cooperation between France and Brazil : with number of institutions and organisms, it consists in facilitating foreign exchanges between students and technicians, organizing visits, seminars and information exchange, publication of information papers…
- Scientific and technical support : organization of events, publications, discussion and mailing lists
- Technical and educational support : linguistic support, french library at disposal, newspapers…
- Welcoming researcher passing through São Paolo

In short, the CenDoTec is a team, which has for many years tried to present France to Brazilians and Brazil to French people !

COGEN - SP

Cogeneration

Suburbs of Rio de Janeiro, March 12th 2004

COGEN - SP
Associação Paulista de Cogeração de Energia

Cogeneration installations at the Carioca Shopping Center provide heat, cold and electricity for the commercial center.
These installations include 2 natural gas motors (engine power :1.6 MW), 2 absorption machines, 2 heat recovery boilers and a hot water system for the process. These installations are controlled by automatic supervision which checks electric production of the engines, steam and hot water.

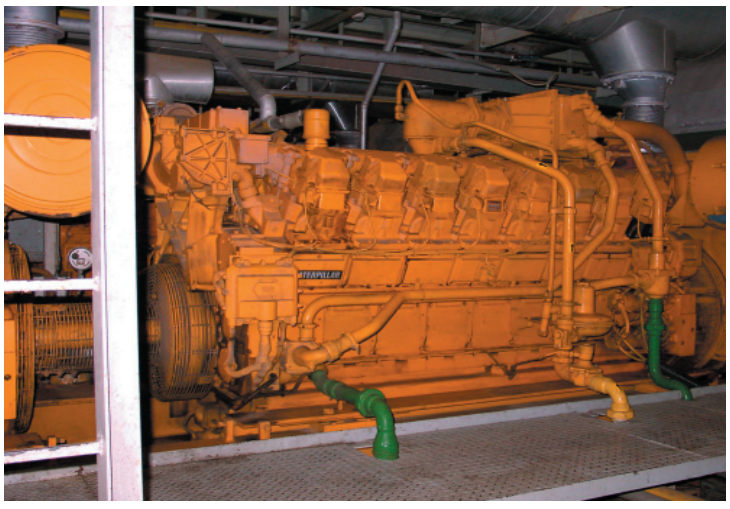
Under normal conditions one gas motor is used to provide cold and part electricity. At peak time the second motor is switched on to reach 100% of the charge in 2 minutes. The commercial center is connected to the local networkofthe distribution operator Light.

Dalkia arbitrates between complete electricity production with cogeneration and electricity consumption from the network in function of the gas and electricity prices given by Light. Gas prices are fixed every three months and Dalkia is able to plan its production.

In case of high gas price the Carioca center relies less on its cogeneration installations and more on electricity from the network. Incaseofelectricity overproduction the excess is injected on the Light network.
No sale agreement is defined between Dalkia and the distribution operator and as a consequence Dalkia is not paid for its production.

In case of network breakdown the system is able to work alone in a special mode.

At the other extreme network connexion is automatic in case of trigeneration installations breakdown.



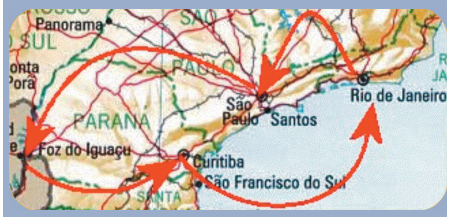
The Route

As Brazil is a big country, this trip was the opprtunity to use local air transport. This was organized as follows :

- Arrival at Rio de Janeiro Saturday March 6th at night.

- Light facilities visit Monday all day, then departure to Sao Paulo at night.

- On Tuesday morning in Sao Paulo, visit of the Wholesale electricity market (MAE), then in the afternoon, visit of the CenDoTec Center before leaving for Foz de iguacu.



- Wednesday morning, visit of the hydroelectric production dam, then in the afternoon, visit of the Iguacu falls.

- At night, leaving Fos de Iguacu for Rio de Janeiro with a technical stop at Curitiba.

- Arrival at Rio de Janeiro for the last two visits. On Thursday the Electric energy research center (CEPEL) then Friday the COGEN SP cogeneration facility at the Carioca shopping center in the Rio de Janeiro suburbs.

Finally return to Nice via Paris.

CONTACTS

Acknowledgements

The Mastère OSE wishes to express its most sincere gratitude to all those having contributed to the organization of this trip.

Most particulaly to the speakers and organizers of the visits and conferences during this week. We have received the warmest and most admirable welcome everywhere.

We have been very impressed with the high level of the presentations and the speakers who have been most competent and made themselves availble.

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