BRAZILIAN COAL – ITS ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACT

Coal reserves are located in the south of Brazil, in the states of Rio Grande do Sul, Santa Catarina and Paraná.

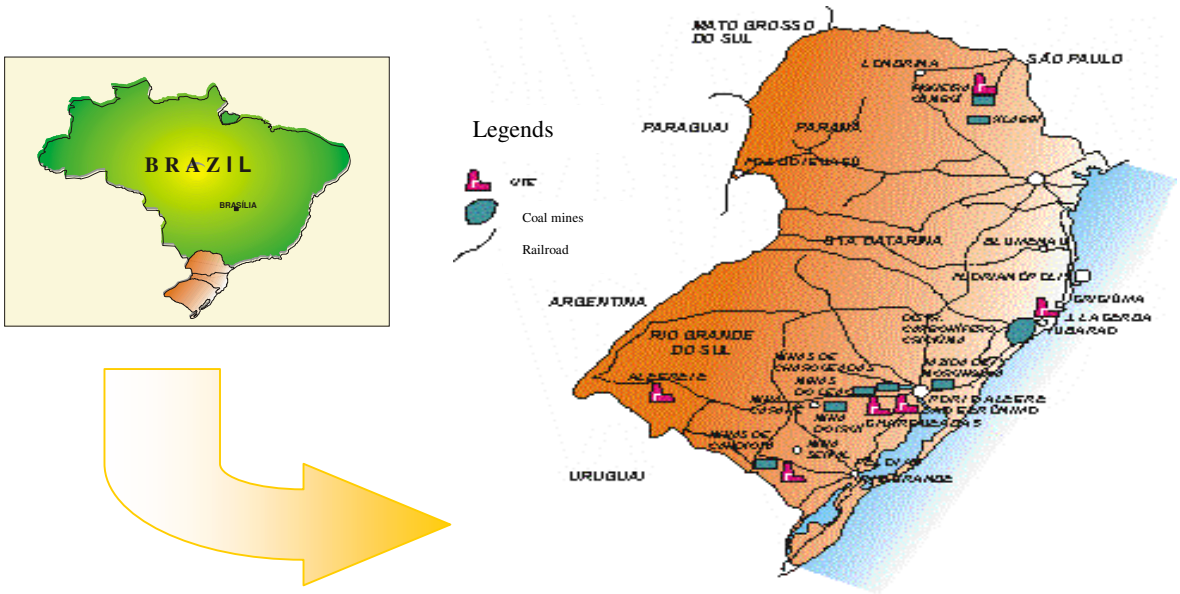


Figure 1 – Location of coalmines and of thermoelectric plants in Brazil

Brazilian mineral coal reserves are estimated at approximately 32 billion tons, as shown in Table 1; coal is the largest national non-renewable energy source, representing 46% of Brazilian fossil fuel reserves.

TABLE I – Chief Brazilian Coal Resources

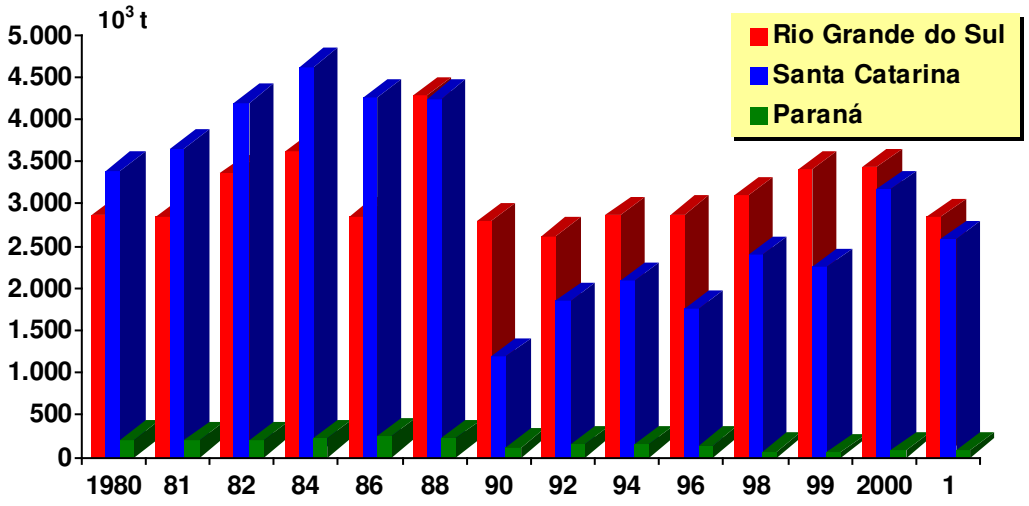
State	MINE	Resource (10^6 t)
Paraná	Cambuí	44
	Sapopema	45
	Outros	14
Santa Catarina	Barro Branco	1,045
	Bonito	1,601
	Pré-Bonito	414
	Others	289
Rio Grande do Sul	Candiota	12,275
	Leão	2,439
	Charqueadas	2,993
	Iruí / Capané	2,688
	Morungava	3,128
	Santa Terezinha / Torres	5,068
	Others	207
TOTAL		32,250

Source: Informativo Anual da Indústria Carbonífera – DNPM/99

Coal mined in Brazil was initially used in railroad and waterway transport, as well as in the production of gas for public illumination. Throughout the last decades and currently coal is also used in generating electric power, in the metalurgic industry, for producing metalurgic coke and for generating heat for various industries, the chemical, cement, paper, ceramic and metal industries in particular.

In Brazil, the main incentive to develop the coal industry, starting with the mines existing in the Southern Region, was that the state metalurgic industry used to be obliged to employ national mineral coal; this requirement is no longer in force.

GRAPH I – National Production of Saleable Coal



Current Brazilian gross coal production (ROM) stands at approximately 11.2 million tons and generates 4,560 direct jobs.

The generation of electric power provides the largest market for national coal, 87.6%. Economic coal mining for the purpose of energy started in Brazil upon the installation of the Charqueadas Plant and the Thermoelectric Plants of Candiota (RS); it was later consolidated when the Thermal Park of Jorge Lacerda (SC) was installed. Coal as an input for generating electric power began with the diversification of the electrical sector's energy matrix. It reduced the vulnerability of hydroelectric systems and contributed to optimizing energy supply.

TABLE II – Existing Coal Driven Thermal Plants

Plants in Operation	State	Installed Capacity (MW)
Jorge Lacerda A	SC	232
Jorge Lacerda B	SC	261
Jorge Lacerda IV	SC	363
Charqueadas	RS	72
Presidente Médici A	RS	126
Presidente Médici B	RS	320
São Jerônimo	RS	20
Figueira	PR	20
TOTAL		1,414

Plants under Construction	State	Installed Capacity (MW)
Jacuí	RS	350
Candiota III	RS	350
TOTAL		700

Source: Eletrobrás

HYDROTHERMAL OPERATION AND THE ROLE OF COAL

Production of electric power in Brazil – The Brazilian electrical system has its own special characteristics different from those of other large world systems in that it uses a high proportion of hydraulic energy (90%).

In hydroelectric plants, water reservoirs depend on meteorology which is ruled by annual and multi-annual cycles. Optimizing the use of hydroelectric power requires a confrontation of current with future values, especially in regard to water accumulation in reservoirs. In this context, thermoelectric plants play a major part in optimizing the use of hydraulic resources, despite their minor contribution to the total generation of power.

Every thermoelectric plant is differentiated by its greater or lesser flexibility in generating power to supplement hydraulic energy, according to its technology and conditions of fuel supply. In view of this, its capacity is divided into a flexible and an inflexible part.

The coordination of Brazilian hydrothermal operation in line with present knowledge, was consolidated by the strengthening of the physical integration of the southern and southeastern electrical systems impelled by the construction of the hydroelectric plant of Itaipu – 14,600 MW. The 1973 Itaipu Law also led to the principle of “prorating onus and advantages resulting from the consumption of fossil fuels for generating electric power”.

In practice, supplementary thermal generation is programmed annually based on a methodology that involves a large quantity of information and is applied through a complex computer model. This program pinpoints expected fuel consumption and the respective prorating of its total cost. Thanks to thermoelectric supplementation, it is possible to optimize the system. As the

thermal input is flexible, when a region has abundant water the thermoelectric plants cease to be involved and cheap electric power is generated from the water that would have been wasted.

The mechanism for optimizing interconnected electrical systems resulted in significant gains and only moderate expenditures. A recent estimate shows that the benefit of the hydrothermal system's operation over the years 1985/1999 resulting from taking advantage of secondary hydroelectric power obtained through the flexible capacity of thermal plants and measured by the volume of avoided thermal generation was US$ 345 million per year. Over the same period average expenses for the purchase of fuel for thermal generation amounted to US$153 million. In relative terms, expenses due to the purchase of fuel through this mechanism amounted to about 2% of the distribution utilities' total invoicing which, in final terms, translates into lower rates for the final consumer.

Quantifying the operational system differently, that is from a cooperative point of view, the operation of the whole resulted in more power than the sum of the maximum of the parts. Consequently, Brazil was able to avoid over-equipping and over-investing in the amount of US$ 10 billion in two decades, and to supply a market 24% larger than it would have if the system had been operated with each plant endeavoring to maximize.

Despite the foreseen increase in installed capacity of gas-driven thermal generation for base operation, the need and convenience of the hydrothermal system is expected to continue until 2015; its importance will, however, decrease as from the time when the capacity of the thermal installations reach close to 20% of the total installed power.

The assessment of the economic consequences in the next ten years is made on the same bases as the estimate made for the experience of the above mentioned 15 years and on the premise that the market and the plants foreseen by the government will come into effect. The result points to an average annual saving of US$ 720 million, corresponding to the thermal generation avoided due to using secondary hydraulic power, against the corresponding expenditure for fuel in the amount of US$400 million.

Today Brazil appreciates more the problems and uncertainties arising during the radical transition underway which involves the actual operation of the energy market and the transfer of responsibility of investments to private enterprise, as in the assessment of the characteristics of the evolution of the generating park.

In the next 15 to 20 years it is expected that the benefits of hydrothermal optimization will continue, with emphasis on thermal efficiency gains. Transition should therefore be smooth for full operation of the market mechanisms in a competitive economy, During this interval, the best use of the abundant hydric resources Brazil has the fortune to dispose of is assured, and there is a chance that the coal mining industry in the south of the country will take a new lease on life. For reasons of environment and location, the new hydroelectric plants in Brazil will have a lower water storage capacity and that, in order to allow more energy sold, confirms the thesis of the need for flexible thermoelectric plants. The implementation of a coal-driven thermoelectric park will avoid that Brazil in future waste water and precious foreign exchange by burning natural gas according to high take-or-pay contracts, as it presently does. Due to the reduction of approximately 8% in electric power consumption as a result of the rationing implemented in 2001, projections of gas-driven thermal plants entering into operation are not met. However, since the gas pipeline exists, it is now necessary to create subsidies to make the artificial consumption of natural gas imported from Bolivia viable by means of thermoelectric plants.

ECONOMIC, SOCIAL AND ENVIRONMENTAL ASPECTS OF COAL-DRIVEN ELECTRIC POWER GENERATION IN BRAZIL:

⇒ Brazil has coal reserves of 32 billion tons, three times more than its oil reserves. They have a potential of 18,600 MW, sufficient for a hundred years of use;

⇒ provided there is large scale mining, prices of raw coal FOB mine are competitive with international prices;

⇒ for economic use of coal of low heating power and high ash and sulfur content – the characteristics of the Brazilian product – a run of mine operation and the adoption of clean combustion technologies (e,g, combustion in a fluidized bed) are indicated.

- Getulio Vargas Foundation - GVF studies show that, considering the impact in 22 years for each additional national coal-driven 1,000 MW installed, the implementation of these projects will have the following effects on Brazil:

<u>on tax collection</u>

⇒ an increase in annual income from direct and indirect federal and state taxes in the range of US$125 million in the current value of the tax inflow resulting from coal mining and the production of electric power.

<u>on regional development</u>

⇒ the implementation of thermoelectric plants driven by Brazilian coal results in an increase in national production amounting to US$ 0,7 million (NPV) impacting directly on the economy of the states of Rio Grande do Sul, Paraná and Santa Catarina in the south of Brazil;

⇒ the installation of thermoelectric plants will attract industries that use by-products as inputs for the production of cement, fertilizers, steam, etc., leading to the development of integrated projects of major social-economic impact;

⇒ the possibility of supplying approximately 60% of the national ammonium sulphate market, 85% of which is currently supplied by an imported product.

<u>on job offers</u>

⇒ according to a GVF study, there are 8.32 multipliers for each direct job generated in the coal industry and 2.88 in national thermal generation; therefore, coal can promote the generation of about 14,000 new direct and indirect jobs;

⇒ during the construction period of each plant, estimated at 36 months, there will be 1,500 direct job opportunities;

on the balance of payments

⇒ current net value of the exchange flow (22 years) of a thermoelectric coal-driven program is 6.27 times less than that of a gas-driven program,

on the environment

⇒ The new coal-driven-electric power technologies it is intended to introduce in Brazil – Clean Coal Technologies, greatly reduce environmental emissions that are therefore perfectly compatible with the strict standards of Brazil's environmental legislation;

⇒ furthermore, the use of these technologies will also allow burn coal rejects produced over decades when aiming at obtaining metallurgic coal in Santa Catarina, and provide the environmental recovery of coal basin in the south of Santa Catarina;;

⇒ coal projects being developed in Brazil are designed to use the ECOPLEX concept, i,e, projects integrated with an industrial symbiosis where by-products are used as raw material for other industries. Consequently, less funds are required for production, less energy is consumed, and several industries are integrated with the plant, the mine and the neighboring communities with a resulting lesser environmental impact.

AN ANALYSIS OF EMISSIONS BASED ON THE BRAZILIAN HYDROTHERMAL SYSTEM

The hydrothermal character of the Brazilian Interconnected Electrical System is somewhat flexible as to the amount of fossil fuel it consumes. This is due to the fact that its energy matrix is predominantly hydroelectric, an dvantage Brazil enjoys in its electric power generation. In other words, thermoelectric generation is supplementary to hydroelectric

generation, substituting it only when the reservoirs are short of water. Due to the cost of thermal generation, it is only made use of when demand cannot be met solely by hydroelectric power.

Such substitution is simple in coal-driven thermal plants since coal is technically and economically easy to store, following the rhythm of mine production. Moreover, in Brazil, natural gas supply contracts are based on the take-or-pay system which stipulates a minimum supply with compulsory payment even if there is no demand for it. As a result, the operation of natural gas driven plants is not as flexible as that of coal-driven plants.

It is in this context that the operation of thermal plants in Brazil should be analyzed. Although coal-driven plants emit more gases per unit of generated power, such emission can be monitored due to the operation's flexibility.

Whereas gas-driven plants are currently operating on a base system (90% of their installed capacity), coal-driven plants are more flexible, operating in complementation to hydroelectric plants and/or according to a peak system. Table 7 shows the emissions of four plants, each with a nominal 500 MW capacity, operating wherever reservoirs cannot provide sufficient water. It is estimated that in this case thermoelectric plants, both coal and gas driven, would operate at 90% of their total capacity.

Table III: Thermoelectric plants operating at 90% of their total capacity

Technology	Efficiency (%)	PCS (kg/kcal)	SOx (t/yr)	NOx (t/yr)	M.P. (t/yr)	CO (t/yr)	CO_2 (t/yr)
Pulverized Coal - PC	34-40	2,500	2,400	6,100	760	1,000	3,800,000
Fluid. Bed - CFBC	34-40	2,500	6,400	3,800	800	2,800	4,650,000
Simple Cycle	30-35	11,000	450	2,300	6700	1,600	2,400,000
Comb. Cycle	50-57	11,000	30	470	Negligible	110	1,500,000

Source:: COPPE/UFRJ

In order to appraise the coal emissions based in the Brazilian hydrothermal system, simulating the system by means of hydrological periods over 2002 to 2011, the graph below shows that the capacity factor of the largest thermal complex of Brazil will have an average of 41.5 %

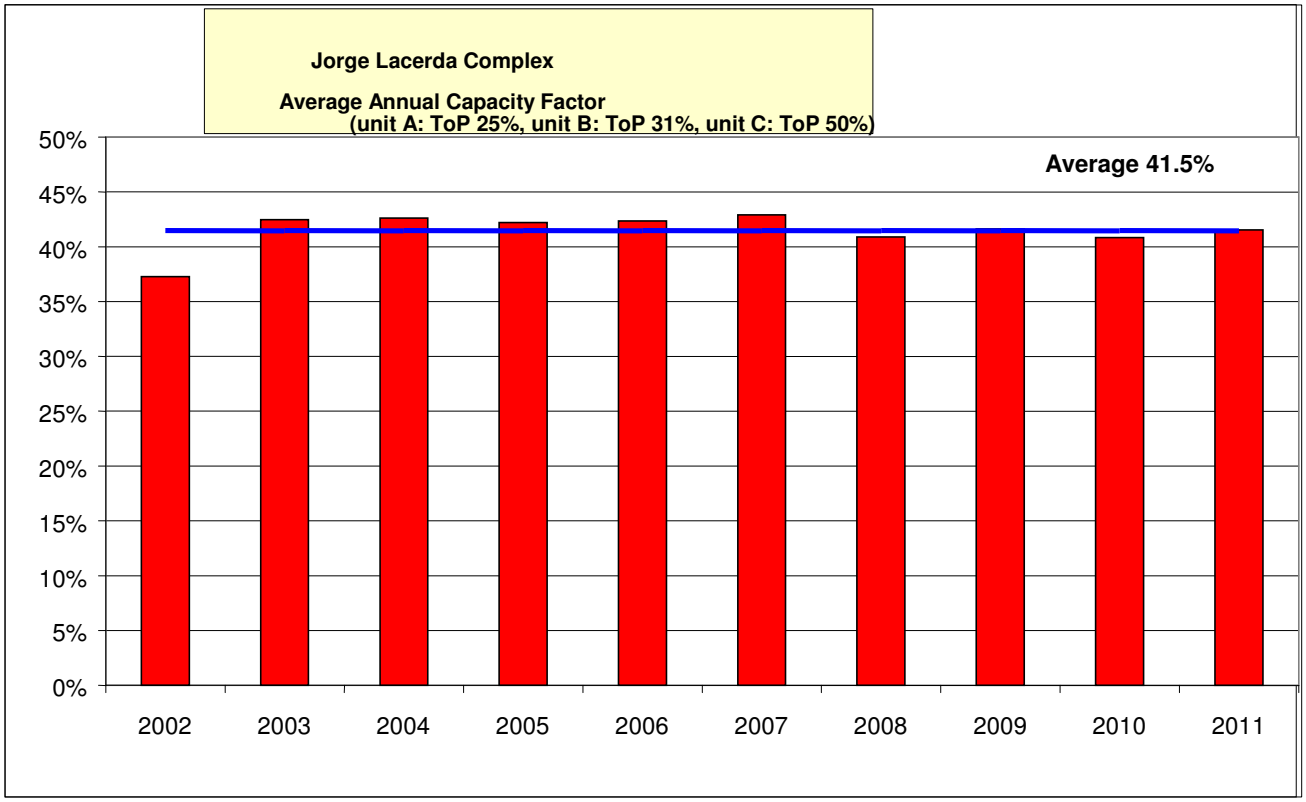


Table IV – Thermoelectric plants using 41.5%of their capacity to supplement hydroelectric plants

Technology	Efficiency (%)	PCS (kg/kcal)	SOx (t/yr)	NOx (t/yr)	M.P. (t/yr)	CO (t/yr)	CO_2 (t/yr)
PC	34-40	2,500	1,091	2,799	400	454	1,834,059
CFBC	34-40	2,500	2,908	1,745	414	1,318	2,132,162

Source: COPPE/UFRJ/SIECESC

It is thus possible to arrive at the approximate quantity of gases that would fail to be emitted into the air if there were less need to supplement hydroelectric generation with thermoelectric coal-driven generation.

If we analyze in this context the data shown in Tables III and IV, we realize that for the same amount of energy commercialized, the volume of gases emitted through the operation performed by coal-driven plants can be diminished when the flexibility of the operation of these plants is incorporated in the analysis. In Brazil, coal-driven plants could emit similar volumes of gases as natural gas-driven plants. It is however important to point out that future changes in natural gas supply are expected, although intensive negotiations between Brazil and Bolivia would be necessary. We should stress that, as the Brazilian energy matrix is environmental is clean, burning coal with clean coal technologies will not affect the Brazil global emissions.

Relevant Aspects

- The use of coal in the energy matrix is considered important since it allows a greater diversification of sources and provides less exchange risks and less risk of price changes in commodities such as oil, gas, etc.
- Additionally, the nationalization index of equipment for coal-driven plants is larger than that of gas-driven plants, providing more benefits in terms of income and job opportunities in the Brazilian industry.
- Coal is a domestic macroeconomic input with no weight in the balance of payments, permitting Brazil's foreign resources to be used in the acquisition of goods that improve the competitivity of Brazilian products in international trade.
- Guarantee of Supply – A Strategic Question. Aside from the potential domestic importance, the use of coal contributes to reduce dependence on external sources for energy which is growing due to electrical interconnections and imported natural gas.
- Long-term stability since coal reserves are known and available.
- As a result of the publication of Law 10,438 of April 29, 2002, which creates incentives for a program of diversification of Brazil's energy matrix, including

national mineral coal provided it is based on a clean technology, the discussion of a program for new coal-driven thermoelectric plants with a minimum capacity of 2000 MW to be implemented with private capital is now in its final stage.

Social Impact

Because mining is a temporary activity, a major concern of mining communities is to ensure that, once coal reserves are exhausted, they will still be able to have economic conditions for survival. In Brazil, the mining industry pays a royalty amounting to 2% of their invoices to government and city administrations for investment in new economic activities and improvement of the life style of their populations. Moreover, in the State of Santa Catarina, the coal industry, concerned with improving the standard of life of the region, created in 1959 a Society for Assistance to Coal Workers (Portuguese acronym SATC). Its objective is to offer children of miners and the low-income community social mobility through good professional instruction.

In 2002, SATC matriculated 5,000 students in lower and higher institutions of learning and already graduated over 3000 technicians in the economy's secondary sector. These qualified professionals further the region's economy by founding small and medium-sized companies. For instance, in the metal/mechanic sector 35% of the region's companies were founded by former SATC students. The Coal Mining Industry Union of the State of Santa Catarina administers the project funded by the coal industry which contributes one million US dollars per year for SATC' upkeep.

This social commitment of the coal industry allows the economic diversification of the region and has a strong impact on the suppression of poverty.

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