Business Focus Series

Cogeneration In Brazil

Prepared by:

U.S. Agency for International Development

Office of Energy & Infrastructure

in Cooperation with:

Bureau for Latin America and the Caribbean

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This report is part of the Business Focus Series of the Office of Energy and Infrastructure of the U.S. Agency for International Development (USAID), and was prepared by the Washington International Energy Group and Harza Engineering. The opinions expressed are those of the authors and not necessarily those of USAID.

The Business Focus Series includes reports on promising energy and environmental markets and business opportunities in developing countries. The reports are of varying length and content, and may be regional, country-specific, or focused on a particular market segment.,

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FOREWORD

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Business Focus Series reports are a new publication from the U.S. Agency for International Development's Office of Energy and Infrastructure. The series includes reports on promising energy and environmental markets and business opportunities in developing countries. Reports are of varying length and content and may be regional, country-specific, or focused on a particular market segment. To obtain *Business Focus Series* reports, please contact the Office of Energy and Infrastructure at (703) 875-4052.

Note: Sources for figures and calculations in this document can be found in the following report: *Global Climate Change Mitigation Through Cogeneration: A Market Assessment of Cogeneration Project Opportunities in Key Developing Countries*, Office of Energy and Infrastructure, Bureau for Research and Development, U.S. Agency for International Development, June 1992. Since the completion of this study, Brazil has announced its decision to privatize ELETROBRAS. The capacity of the privatized assets will total 45,000 MW, and does not include the 13,000-MW Itaipu project. The Brazilian government is to select a consultant to advise the government on privatization models and to address such questions as whether or not generation and transmission should be privatized separately. The government wants to investigate alternative models so that a government commission may make an initial decision on foreign investment bids. Privatization will be conducted by auction and will be mostly in exchange for debt obligations of the Brazilian government or privatization vouchers issued by the government. Preliminary discussions indicate it is likely that ELETROBRAS subsidiaries Servicos de Eletricidade S.A. and Espirito Santo Centrais Eletricas S.A. may be the first entities to be privatized.

EXECUTIVE SUMMARY

Political power in Brazil was transferred from military control to a democratic regime in 1985. Economic performance in Brazil currently lags behind its potential, and economic growth has typically been erratic. In the past decade, Brazil's external debt has consistently been among the highest in the world. However, there are indications that the conservative economic reform program has had positive effects. Businesses have begun repatriating capital previously invested overseas and selling off inventories.

The Brazilian economy is philosophically one of free enterprise, but there is considerable state and semi-state participation in various strategic sectors, such as steel, transport, and public service utilities. The petroleum industry, for example, is a federal government monopoly on the production side, though some distribution functions are in private hands.

The Brazilian economy is philosophically one of free enterprise

Brazil's investment climate is marked by a fast-changing business environment, often including a large degree of uncertainty. Foreign direct investment, largely in manufacturing and finance, represents a relatively small but important part of Brazil's capital base. It is expected by the international community that the present administration's privatization program will affect long-term fiscal balances, fiscal debt, the financial and stock markets, and market reform.

Natural resources, especially vast mineral deposits, timber, and water and agriculture were the traditional mainstay of the Brazilian economy, bolstered by abundant human resources. Since the 1960s, however, there has been an increased emphasis on industrial development, financed largely by external borrowing. This has resulted in a more balanced mixture of commodity and manufactured exports, but has brought with it the accumulation of high foreign debt.

Many heavy and basic industries, including the energy industry in Brazil are government-owned. Serious efforts are now underway to privatize various sectors of the energy industry.

Electricity Sector

Brazil's electric power, transportation, and telecommunications systems generally have kept pace with development, but lack of investment and maintenance funds in recent years have made it difficult for these sectors to meet growing demand.

The central government is in the process of initiating private sector participation in the expansion of electric generating capacity, as well as privatization of many port, railroad, highway, and telecommunications facilities.

The central government is in the process of initiating private sector participation in the expansion of electric generating capacity

Brazil derives over 90% of its generating capacity from hydro power; however, the country is rich in other energy sources, including oil, natural gas, coal, uranium, charcoal, wood, bagasse and other biomass fuels.

The electric power sector was originally owned mainly by foreign private interests, most of which were transformed into public utilities during the 1960s and 1970s under the military regime.

Overall cogeneration potential in major industrial sectors in Brazil is 8,832 MWe. Estimates by an industry organization indicate that the sugar and alcohol industry offers one of the best and largest potentials for cogeneration in Brazil.

In 1990, self-generators including cogenerators provided about 140 GWh of the total 236,000 GWh of generation supplied to the grid. The amount of energy produced for captive load consumption by these self-generators, consisting mainly of industrial enterprises, is usually not included in the figures for total electricity market in Brazil, but represents up to 5%, or about 10,000 GWh, of total electric consumption.

At present, various industrial complexes produce electricity using cogeneration mainly to supply their own requirements and to have a secure supply of electric power. There has been no incentive to produce and supply electric power to the grid system due to a subsidized uniform price of electricity. Price subsidization programs, however, are being phased out and the selling price of electric power is expected to rise to a free-market level.

1. COUNTRY OVERVIEW

1.1 Political Background

Brazil was a Portuguese colony until 1815, then briefly became a kingdom of Portugal. Independence and the formation of an empire were declared in 1822. In 1889, a republic was proclaimed, introducing an era of constitutional democracy. The country was ruled until 1945 by military dictatorship, then by elected presidency until 1964, when it reverted to military rule. In 1985, the military returned the country to a democratic regime.

In 1986, a new Constitution, the seventh since 1822, was written by a special assembly of the National Congress, and was adopted on October 6, 1988. The Constitution democratized the government through requiring direct elections by secret ballot, calling for more political parties, seeking the abolition of censorship, recommending broader economic power for Congress, and eliminating presidential decrees. The 1988 Constitution also contains provisions for basic public health care, a 40-hour work week, and environmental protection measures.

The federal government consists of three branches: executive, legislative and judiciary. The President heads the executive branch, under which the civil service and Cabinet operate. The legislative branch is composed of two chambers: the Senate and the House of Representatives. Since two-party rule ended on November 22, 1979, Brazil has had a multi-party democracy, with 13 parties represented by current members of Congress. The 81 Senators are elected to 8-year terms, and the 495 House members serve 4-year terms.

In 1989, President Fernando Collor de Mello was elected to a five-year, non-renewable term. Collor's political party is relatively small, and there is little support for him in Congress. Although many members of Congress may agree with the necessity of the tough economic and fiscal course taken by the present administration, most do not publicly express any support for these policies for political reasons. Recent initiatives to ease pressure on state debt repayment to the federal government is expected to increase state-level support for the reforms if economic development proceeds. Since he is limited to one term, Collor is not facing any near-term electoral challenges, but the present administration's economic success or failure (as perceived from within Brazil) will be a key factor in the results of a plebiscite, scheduled for November 1992, which will determine whether Brazil will continue with its current presidential system or change to a parliamentary one.

Brazil has 26 states, three federal territories, and one federal district, Brasilia, which is the seat of the federal government. The federal government dictates to the states primarily when implementing national policies directed at achieving security, economic stability, energy development, self-sufficiency, and other goals which require central coordination.

However, states are granted considerable independent powers to enable them to administer the particular needs of their territory. Each state is headed by a directly-elected governor and has its own Constitution, elected legislature, and judiciary. States have the authority to divide or merge to create new states, promote local economic development plans, reorganize their political structures, set state budgets, and levy taxes.

1.2 Economic Background

Brazil's land area is 8.5 million square kilometers or about 6.4% of the entire land area of the Earth. In terms of land area, Brazil is the fifth largest country in the world. According to 1990 census data, Brazil is the sixth most populous country in the world, with 150 million inhabitants or about 2.9% of the world population. Approximately 63% of its inhabitants are less than 30 years old. Although the average population density of Brazil is relatively low per

square kilometer, 60% of the population is concentrated in the Southeastern and Southern regions, on 18% of the nations's territory.

The Brazilian economy is philosophically one of free enterprise, but there is considerable state and semi-state participation in various strategic sectors, such as steel, transport, and public service utilities. The petroleum industry, for example, is a federal government monopoly on the production side, though some distribution functions are in private hands.

Natural resources especially vast mineral deposits, timber and water and agriculture were the traditional mainstay of the economy, bolstered by abundant human resources. Since the 1960s, however, there has been an increased emphasis on industrial development, financed largely by external borrowing. This has resulted in a more balanced mixture of commodity and manufactured exports, but has brought with it the accumulation of high foreign debt. Brazil has been forced to renegotiate loans because it was unable to service them.

Economic performance in Brazil currently lags behind its potential

Economic performance in Brazil currently lags behind its potential, and economic growth has typically been erratic. In the past decade, Brazil's external debt has consistently been among the highest in the world. Inflation has been chronically high since the 1970s, and the country experienced hyperinflation in the late 1980s. It currently runs at about 21% per month. There have been frequent devaluations and revaluations of the Brazilian currency in the past ten years, as a tool to disguise or readjust for declining economic conditions. There are also persistent large income distribution disparities in the country.

1.3 Economic Changes and Privatization Initiatives

The current administration has committed itself to reforming the Brazilian economy

Despite considerable political opposition, the current administration has committed itself to reforming the Brazilian economy. In the spring of 1990, the government introduced an economic stabilization program founded on the principles of reducing inflation based on restructuring the highly inefficient state-owned industrial base, encouraging foreign investment, stabilizing the currency, and restructuring Brazil's international debt.

This economic stabilization plan includes the following initiatives:

- renegotiation of foreign and commercial debt repayment and credit agreements in 1991-92;
- balance of the federal budget through a fiscal austerity program;
- increased national revenue through the simplification and strengthening of the tax system;
- liberalization of trade by reducing tariffs and non-tariff barriers;
- adjustment of foreign currency rates to realistic levels that favor the export sector;
- integration of regional trade through the creation of Southern Cone Common Market (MERCOSUL); and,
- transformation and development of the financial system and capital markets.

Both private business and government analysts say that, for the first time, despite enormous political pressure, the government is facing its economic problems head-on, rejecting quick-fix solutions. There are indications that the conservative economic reform program has had positive effects. Businesses are repatriating capital previously invested abroad and selling off inventories. In 1991, the economic growth rate was 1.3%, up from -4.2% in 1990. Inflation

slowed to nearly zero within the first month of the program, gradually rising to about 10% per month by August 1991.

Table 1

Macroeconomic Indicators, 1990-2000

	1990	1995	2000
GDP per capita	2,300	2,500	3,200
GDP (billion 1988 US$)	343.8	428.5	573.4
GDP average annual growth	4.5% (1990-95)	6.0% (1995-2000)	

SOURCE: *Plano Decenal 1991-2000*, Grupo Coordenador de Planejamento dos Sistemas Electricos (GCPS), Ministry of Infrastructure, ELECTROBAS, Rio de Janeiro, 1991.

Many critical socio-economic problems continue to persist

Although Brazilian fiscal and monetary performance has been moderately positive to date, many critical socio-economic problems continue to persist which impact economic performance. Income distribution remains highly inequitable. The government's attempt to reduce this inequity, including initiatives to increase investment in education and public health programs, has been hampered by limited fiscal resources. In addition, the government is struggling with means to implement privatization schemes, foreign investment incentives, and energy conservation programs. Inflation levels reached about 10% in August 1991, and continued to ascend to levels of 20-30% per month later in the fall of 1991. Consumer sales have fallen, production levels are down (although there was a brief spurt in the second and third quarters of 1991), and unemployment has risen. Interest rates for commercial development loans are running at approximately 12% above the level of inflation.

There is some optimism that reforms will succeed and 1993 will see strong, across-the-board economic growth

Although it is still too early to gauge whether Brazil will succeed in promoting healthy economic growth and stability, there is some optimism that reforms will succeed and 1993 will see strong, across-the-board economic growth. In the short-term, some observers and economic forecasters expect the economy to begin a new cycle of growth in 1993, and this is generally the outlook presented by the government. Furthermore, when it begins to expand, the Brazilian economy is expected to experience explosive growth in all sectors simultaneously, which would lead to sustained growth rates in the range of 4.5-6% per year from the mid-1990s to 2000. This expectation is partly due to the anticipated improved climate for foreign investment, which may immediately precede domestic expansion and foster an economic boom, or immediately follow the initial expansion of the economy.

In the long-term, if the government is able to stabilize inflation, secure a realistic exchange rate, and open the economy to increased foreign investment, the economy can be expected to maintain healthy growth rates. Accordingly, many anticipate that electricity demand may increase significantly as the business climate improves and levels of investment rise. Furthermore, the electricity sector has a large growth potential since many rural communities have yet to attain full electrification, and many urban dwellers lack air conditioning and other basic electrical appliances common in developed countries.

The new government has introduced special legislation to privatize many companies

The new government has introduced special legislation to privatize many companies where state participation is deemed unessential. The administration has put in place the necessary administrative machinery to implement an ambitious privatization program, as well as to open Brazil's markets to foreign goods. In 1991, four state enterprises were sold off, including the large Usiminas steel company, and a major railroad equipment manufacturer, Mafersa. The value of the four state-owned enterprises privatized in 1991 totalled US$ 1.7 billion, equal to 0.5% of Brazil's GNP.

It is generally expected by the international community that the present administration's privatization program will affect long-term fiscal balances, fiscal debt, the financial and stock markets, and market reform.

The greater acceptance of the move to privatize major state-owned industries by various political factions and interest groups encouraged the present administration to expand its privatization plan for 1992. Even the powerful labor unions are becoming more reconciled to privatization in some form.

The government was not satisfied with the level of foreign investor participation in the early privatizations. Subsequently, it has relaxed foreign investment rules regarding the privatization process in an attempt to attract more foreign investors in privatization auctions. For example, one such measure reduces the minimum period from twelve years to six required for capital to remain in the country when invested in the stock of privatized companies.

Over the past 30 years or so, a majority of the heavy and basic industries in Brazil including the energy industry became nationalized. Serious efforts are now underway to privatize various sectors of the energy industry.

In 1992, various state-owned companies are scheduled to be sold

In 1992, various state-owned companies (including steel, plastics, river transport, shipping, railroad, petrochemicals, aircraft manufacturing, and copper sectors) are scheduled to be sold. The National Privatization Commission and the Banco Nacional de Desenvolvimento Economico e Social (BNDES), a quasi-governmental development bank charged with coordination of the privatization process, pushed the privatization of ports and highway concessions because of the high construction and maintenance costs of these types of public works and the lack of efficient management.

The timetable for the sale of more than twenty-two state-owned companies in 1992 is proceeding as planned, except, when, in a few cases, the government perceived a lack of interest or adequate financial offers and subsequently delayed the bidding. Such entities include the fertilizer, iron and steel, river transportation, plastics, petrochemical, chemical and aircraft industries.

Brazil's electric power, transportation and telecommunications systems generally have kept pace with development, but lack of investment and maintenance funds in recent years have made it difficult for these sectors to meet their growing demand. This has become a primary motivation for the central government to initiate private sector participation in the expansion of electric generating capacity. However, the high debt level of many facilities in these sectors may impede their privatization in the near future.

Until recently, it appeared unlikely that the debt-ridden electric sector would offer any opportunities for sales to the private sector. However, in March 1992, the Brazilian government indicated that two of the state-owned utilities which it operated would be privatized in 1992. These utilities, LIGHT and ESCELSA, serve the Rio de Janeiro and Espirito Santo states.

It is not expected that the oil and natural gas production facilities (owned by the national company, PETROBRAS) will be sold off to private investors, although some of the subsidiary companies not involved in production or transport may be offered for bidding. However, a recent shift in federal policy now allows new concessions to foreign private entrepreneurs in the oil and natural gas exploration and development fields. The government, however, does not intend to give foreign bidders any preferential treatment for the development of the oil and gas fields.

2. INDUSTRY AND PRODUCTION STRUCTURE

2.1 Manufacturing

The country has a large and relatively sophisticated industrial base, which is currently the largest contributor to economic growth. There is vast potential for expansion in all areas if the current economic stagflation can be overcome. Major industries in Brazil include pulp and paper, sugar and alcohol, steel, aluminum, oil, petrochemicals, cement, textiles, shipbuilding, automobile manufacturing, mining, agro-industry, and food (including beef) processing. Of these industries, only shipbuilding is currently showing trends of decline.

There is vast potential for expansion in all areas if the current economic stagflation can be overcome

2.2 Energy Resources

According to ELETROBRAS, the national electric utility, the estimated generating potential of Brazilian hydropower sources is 225 GW, of which only about 50 GW is developed. The federal government intends to maximize the development of this energy to avoid the use of more costly fossil fuel-based generation and to reduce energy imports. However, there is growing opposition to hydropower in Brazil, focused mainly on the large population dislocations and major impacts on ecological systems. Problematically, most of the potential hydropower sources are located far from the largest and fastest-growing load centers, thus costly, long-distance, high-voltage transmission systems are needed to bring this cheap power source to consumers.

Brazil has an abundance of other energy sources, including oil, natural gas, coal, uranium, charcoal, wood, bagasse, and other biomass fuels. The potential of these energy sources is mostly untapped, as can be seen in the following figures showing energy reserves and primary energy production levels.

Table 2

Brazilian Energy Resources and Reserves

Type	Unit	Resources and Reserves			Energy Equivalent, 10^6 boe
		Measured/ Indicated	Measured/ Estimated	Total	
Oil	thousand m^3	438.779	-	438.779	2.759
Natural Gas	thousand m^3	116.008	-	116.008	770
Shale Oil	thousand m^3	445.100	9,402.00	9,847.10	27.866
Coal	million tons	10.187	22.206	32.393	28.258
Hydro-electricity	GW/yr	67.0	39.5	106.5	1,973/year
Nuclear Energy	tons U_3O_8	192.540	108.950	301.490	9.769
Peat	thousand tons	129.330	357.960	487.290	2.918

SOURCE: *Brazil 1991*, PETROBRAS, Rio de Janeiro, 1991.

Brazil has significant confirmed oil reserves. In 1990, oil reserves totalled around 450 million cubic meters. In 1990, Brazilian domestic crude production totalled 30.5 million metric tons, an increase of 1.2% over the 1989 production total, continuing a steadily upward production trend over the past 25 years. Meanwhile, imported crude totalled 28.7 million metric tons.

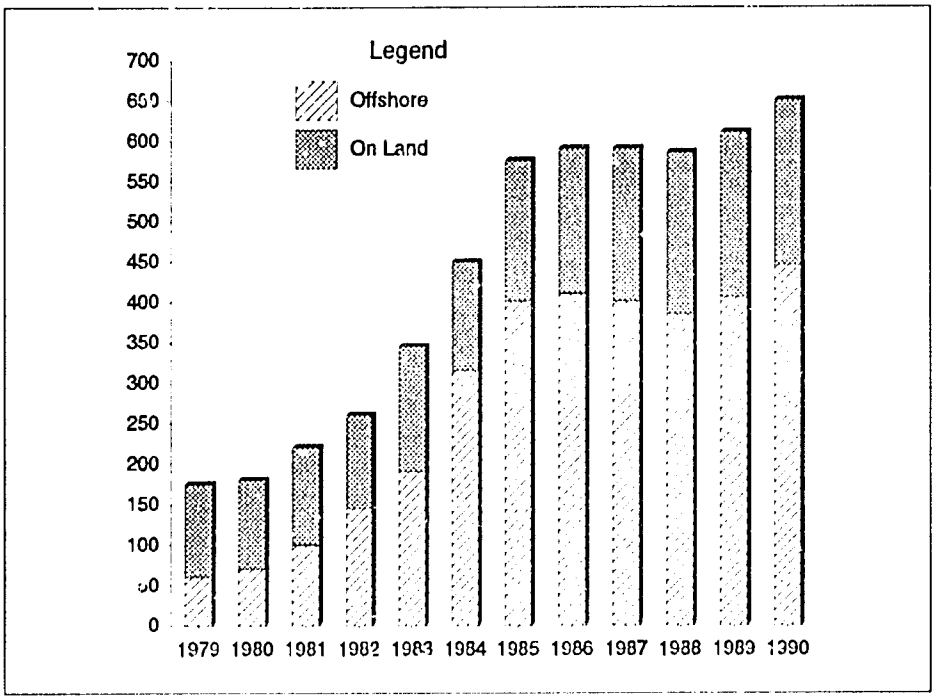
Brazil has significant confirmed oil reserves

Only 3.7% of Brazil's crude production is used as fuel for powering generating stations; the industrial sector consumes 13.6% of the total production.

Total domestic consumption for all petroleum products for 1990 totalled 58.3 million metric tons. Brazil's aim is to achieve self-sufficiency in crude oil by the year 2000. Prior to the 1973 oil crisis, Brazil imported about 70% of its oil requirements. Total energy imports today are about 23% of the consumption level. However, it is estimated that this goal would require about five to six times PETROBRAS' current US$ 2 billion annual level of investment in crude exploration and production functions.

Figure 1

Brazilian Oil Production, Including Natural Gas Liquids



SOURCE: *Brazil 1991*, PETROBRAS, Rio de Janeiro, 1991.

As shown in the previous graph, Brazilian oil and natural gas liquids production has almost levelled off since 1985, with modest increases in offshore production in both 1989 and 1990. These increases may be attributable to expanded offshore production of natural gas liquids. The natural gas market as a whole in Brazil, especially in the Rio de Janeiro and Sao Paulo areas, has grown with the increased availability of this fuel source in the past few years.

Confirmed natural gas reserves, as of December 1991, were calculated at 116 million cubic meters. In 1990, production of natural gas totalled 6.279 billion cubic meters, and total domestic consumption in the same year was 5.095 billion cubic meters. Almost one-fifth of the amount produced (19%) is flared off at the source, mainly because there is no available transportation for the gas at some sites. Of the consumed total, 3.344 billion cubic meters was used in energy production facilities, and 686 million cubic meters was used as a feedstock for petrochemical production.

Natural gas is not a traditional fuel in Brazil, and the expansion of this fuel source has just recently been given serious consideration

Natural gas is considered valuable in Brazil as a feedstock for other derivatives produced by the petrochemical industry, including methanol and ethanol, which are used extensively in the transportation sector. Natural gas is not a traditional fuel in Brazil, and the expansion of this fuel source, currently representing less than 2% of Brazil's total energy consumption, has just recently been given serious consideration.

Coal reserves, which have a confirmed level of 10.2 million tons, and estimated reserves of twice that level, are mainly located in the southern region of the country. However, due to the impact of the economic recession in Brazil, the level of mining was lower in 1990 and 1991 than in preceding years. For example, in 1991, coal mining production totalled 912,167 metric tons per month, which was 39% less than that mined in 1989, and the coal processing capacity was 228,833 tons per month.

The total amount of coal produced in Brazil in 1990 was 14.57 million metric tons, which includes 4.1 million metric tons of steam coal and 10.47 million metric tons of metallurgical coal. The quality of Brazil's coal is generally low in terms of energy value. The steel sector consumed 9.9 million metric tons of the total coal produced in 1990. Only about 2.7 million metric tons of coal were burned in thermoelectric plants. Other consumers used 1.1 million metric tons of coal. All of these figures were generally lower in 1990 than they were in 1989.

The quality of Brazil's coal is generally low, but its role as an energy source is expected to increase

The federal government's 10-year electricity plan *Plano Decenal* (1991-2000), promotes the development of coal power plants in Santa Catarina and Rio Grande do Sul states, and in general, the role of coal as an energy source is expected to increase. The coal industry is entirely in the hands of the private sector, which has been lobbying the federal government for many years for increased development support. The Ministry of Science and Technology is sponsoring research and demonstration projects for clean coal technologies. Coal's competitiveness with other fossil fuels in industrial applications is expected to grow.

Brazil has historically used various biomass sources for fuel purposes, including wood and wood by-products and the bagasse (waste material) from sugar cane crops. After the 1973 oil crisis, the *National Alcohol Programme* was initiated by the Brazilian government. This program promoted the indigenous production of alcohol from sugar cane crops as a transportation-fuel substitute for gasoline as a way to reduce Brazil's dependence on imported oil. Subsequently, sugar cane crops proliferated under the government-subsidized alcohol programs, and, concurrently, the use of bagasse as a fuel for cogeneration facilities at sugar and alcohol mills became widespread. As of 1991, the share of alcohol in Brazilian transportation fuel was 19%, and 42% of the total cars in use in Brazil used alcohol-based fuel.

The National Secretariat for Regional Development regulates the quantity, quality, pricing and export of Brazil's alcohol production. Major alcohol distilleries are located predominantly in the Northeastern and Southeastern regions of the country. PETROBRAS is responsible for the transportation of alcohol.

There are large confirmed uranium reserves in Brazil, measuring 301,490 tons, but Brazil's nuclear power program has been sharply curtailed after experiencing considerable problems with the availability of its one complete nuclear unit, Angra 1, which came on line in 1985. The current preliminary draft of the energy plan extending to 2015 outlines the completion of Angra 2 nuclear unit, but suspends further construction on the partially constructed Angra 3 unit.

Also, Brazil is instituting short- and long-term plans to promote solar, biogas, wood charcoal and other indigenous energy resources, including, technological developments to increase the value and utilization of these fuels.

The Secretariat of Science and Technology is responsible for technological innovations regarding the promotion of coal and alternative renewable energy sources. The Secretariat of Energy created the Division of Energy Development in 1991, which is responsible for coordinating and establishing policies and development plans for these non-traditional fuels.

3. BUSINESS INVESTMENT CLIMATE

The Brazilian rules for allowing foreign capital and repatriation of dividends were modified in 1991, leading to a more positive foreign investment climate

The Brazilian rules for allowing foreign capital and repatriation of dividends were modified in 1991, leading to a more positive foreign investment climate. Double taxation of multinational corporations was ended, many import barriers were reduced or removed altogether, and the informatics market was liberalized. Further, proposals to eliminate disincentives to foreign investment are pending in Congress.

3.1 Foreign Investment Issues

Brazil's investment climate is marked by a fast-changing business environment, often including a large degree of uncertainty. Economic policies and conditions tend to change erratically, making for instability in the market.

Several economic problems exist that make foreign investment difficult. Included in these are high inflation rates (with a history of spells of hyperinflation), little industrial investment and modernization during the last decade, and low levels of foreign exchange.

Brazil's investment climate is marked by a fast-changing business environment, often including a large degree of uncertainty

Despite economic problems, Brazil has several conditions that are conducive to investment, including an abundance of inexpensive semi-skilled and unskilled labor and many raw materials and foodstuffs.

Brazil's location makes it a favorable site for South American expansion programs, and a large potential consumer market exists within Brazil and within the region as a whole.

Import duties, which are currently high in order to encourage a positive trade balance, are expected to be reduced significantly by 1995 as Brazil becomes fully integrated into the MERCOSUL. According to a recent government proposal, tariff reduction is to be stepped up, so that the maximum is 35% instead of 40%.

Foreign investment is generally welcome

Foreign investment is generally welcome to the extent that it provides jobs and represents a long-term commitment to economic development. Specifically, foreign investment in agriculture, technology, labor-intensive industries, manufacture of currently-imported goods, and manufacture of exports are the areas favored. One example of the favorable treatment received by foreign investors in the export sector is a new proposal by the present administration to make loans available from domestic financial institutions, at internationally competitive interest rates, to foreign company subsidiaries in Brazil engaged in export activities. Also included in this incentive program are plans to increase financing options, to modify financing terms, to allow more products to be eligible for financing, and to lower taxes and/or tariffs on materials to be used in export products.

There are areas where foreign ownership is legally restricted, mainly for national security reasons. These areas include defense, communications, air transport, and petroleum exploration and refining. There are also some restrictions on the ownership of rural land, and participation in the financial sector and informatics (including computers, industrial automation, and electronics). However, because of Brazil's recent economic difficulties, several of these sectors are being opened up to foreign investment (see section on Privatization). For example, many barriers to foreign participation in the oil and gas sectors have been removed.

Brazil has greatly eased profit and capital repatriation rules

Brazil has greatly eased profit and capital repatriation rules. As of the end of 1991, foreign firms may register financial income as part of their formal capital base. This was not permitted before, but now has become law via a Central Bank initiative. This change in law increases the amount that is eventually allowed out of the country as repatriated capital. The exchange

rate that applies to this repatriation is the rate that prevails on the day of the formal reinvestment. This solves the problem of inflation eroding the amounts registered.

During the first two months of 1992, Brazil has seen a tremendous inflow of foreign capital. According to the Central Bank of Brazil, US$ 1.1 billion entered the country during January and February of 1992. Half of this capital took the form of portfolio investment, and the other half was direct investment. This total figure is almost as much as the total invested in Brazil during all of 1991. Total foreign investment in Brazil was US$ 1.4 billion in 1991.

In April 1992, however, the rate of foreign investment decreased. This is due more to the instability of the international financial situation, including the sharp drop in the Japanese equity market, than to domestic problems.

Foreign direct investment, largely in manufacturing and finance, represents a relatively small but important part of Brazil's capital base. The constitution contains provisions that restrict investment in petroleum and minerals exploration, health care, chemicals, biotechnology, and new materials.

As far as portfolio investment is concerned, the first quarter of 1992 has seen a high interest rate and an erratic stock market in Brazil, leading investors to shift a large volume of money into fixed-rate instruments.

Japanese businesses have expressed renewed interest, since withdrawing from the market in Brazil after 1986, in making new investments in Brazil because of the recent economic reforms and indications of possible economic improvement. Brazil is also attracting Japanese investment because of its position as a world leader in raw materials production, its membership in MERCOSUL, and the possibility of exporting Japanese-made products to Brazil.

3.2 Tax Issues

Brazil has a 30% federal income tax on taxable income, lowered to 25% for companies engaged only in agriculture. Income that is taxed by the federal government is also subject to state tax, which is calculated at rates up to 5% of the federal income tax due. There is also a value-added tax in Brazil, levied at various rates depending on the nature of the product.

Local and foreign investors are generally treated equally regarding investment incentives and tax concessions, and many state and local governments offer investment incentives

Local and foreign investors are generally treated equally regarding investment incentives and tax concessions. There are no special federal tax incentives to attract foreign investors, although many state and local governments offer investment incentives. For example, the Northeast and Amazon regions offer the following tax incentives:

- exemption from all or part of taxes and charges on imported equipment for new industries,
- exemption from income tax for a period of 10 to 15 years for all new industrial investments that are the first of their kind, and
- reduction of 50% in income tax for industries already operating or that are new to the region but do not qualify for the above exemption.

Generally, these regions grant low-cost loans or loan guarantees from the regional development banks as well.

In December 1991, the Brazilian Congress approved emergency tax measures which eliminated double taxation of foreign profit remittances.

As another tax incentive, Brazilian corporate taxpayers, including those that are foreign-owned, may invest part of their tax bill in government-approved projects, which are normally granted total or partial tax exemption.

3.3 Other Related Issues

The deregulation of business activities is a declared aim of the new government

The deregulation of business activities is a declared aim of the new government, although there is still considerable documentation and bureaucratic negotiation involved in day-to-day operations. Foreign exchange transactions have been under central government control, but, since late 1991, there has been some movement to provide more flexible flows of currency. The previously large differential between the official and *black market* currency value is now minimal. Stock markets are active and reasonably developed, but stock ownership is not widespread.

Price and wage controls, which can erode businesses' profit margins, have been imposed periodically to suppress inflation. However, these have shown themselves to be ineffective beyond the short-term, and the government is making an attempt to steer away from them.

4. INSTITUTIONAL CONDITIONS FOR COGENERATION DEVELOPMENT

4.1 Electric Power Regulation

The Ministry of Infrastructure's National Secretariat of Energy has traditionally had the regulatory authority for electric generation, transmission, distribution and related services in Brazil. The Secretariat is also responsible for regulation and planning of other energy resources, including the development of alternative fuels.

Centrais Eletricas Brasileiras (ELETROBRAS), a federal government utility holding company charged with the planning and coordination of Brazil's power system, works closely with the Departamento Nacional de Agua e Energia Eletrica (DNAEE) and the Secretariat of Energy as part of its system planning responsibilities.

DNAEE has been the primary agency for setting nationally uniform rates for electricity at the wholesale level. However, during the 1980s, the Ministry of the Economy had a major influence on electricity rates, using them as a macroeconomic adjustment tool to promote economic development and offset inflation. In 1991, the cost-based system for rate regulation was basically reaffirmed as the one that the present administration would follow. Subsidization of electric rates, though decreasing, will probably continue until the economy strengthens, and is likely to always be provided for poor and isolated areas.

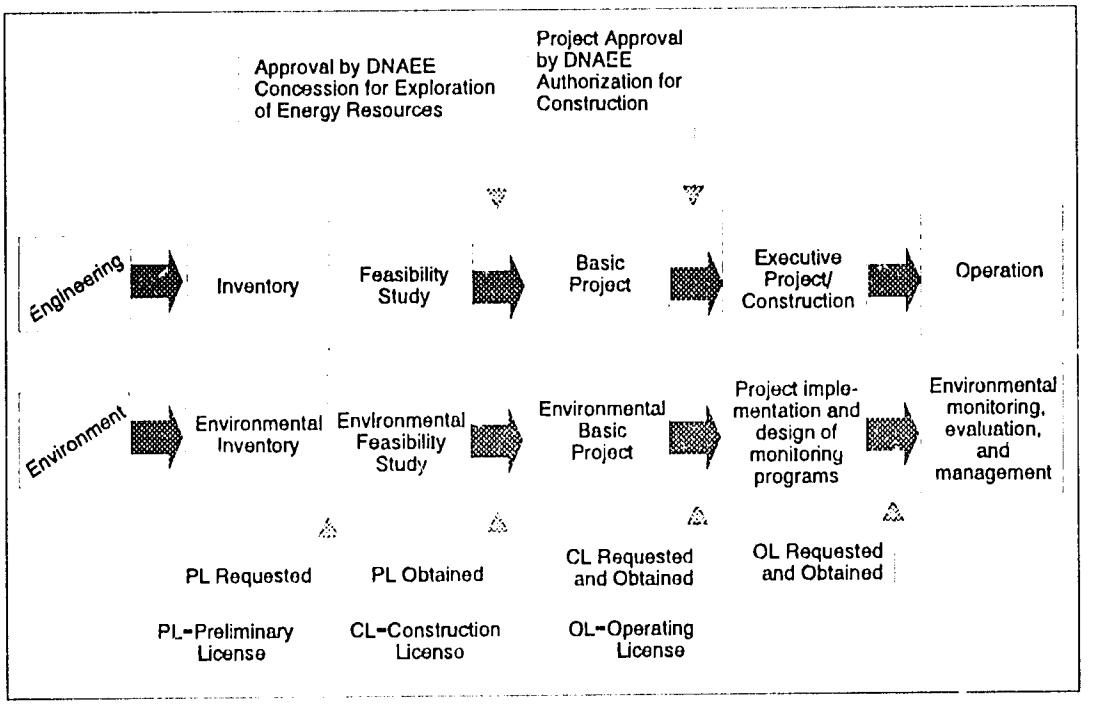
State owned utilities must follow national, as well as state, guidelines and regulations. At the state level, the oversight authority is mainly concerned with economic development, environmental quality, and local system and fuel planning issues. The relationship between the state and federal regulatory authorities is officially close, but there is little involvement of the state-level agencies in the formulation of national power strategies.

State-owned utilities must follow national, as well as state, guidelines and regulations

The licensing process for electric generating facilities in Brazil is primarily under DNAEE, with some environmental approvals required by the federal environmental protection agency, CONAMA. The typical licensing process is illustrated in the following chart:

Figure 2

Typical Plant Planning and Licensing Sequence in Brazil



SOURCE: *Estatistica Brasileira de Energia*, Brazil, 1990.

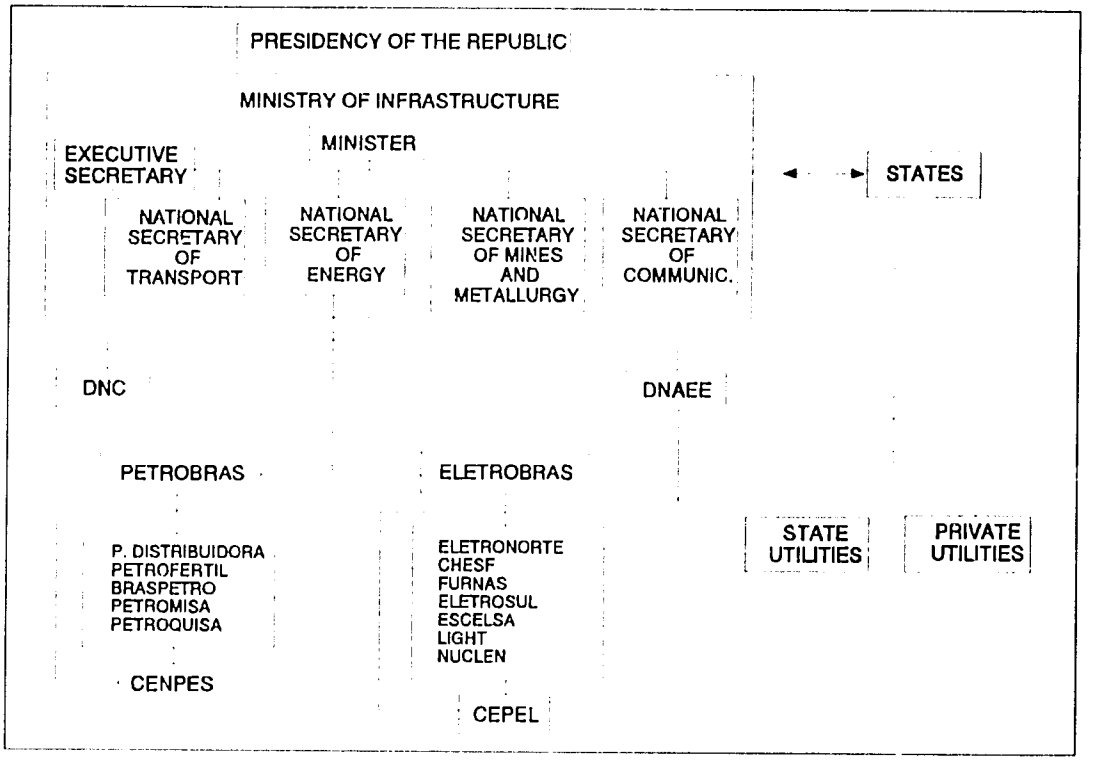
In addition to national and local entities, there are also regional planning councils, the members of which include representatives of the state utilities in that region, at least one representative of ELETROBRAS, and often one participant from one of the agencies under the National Secretariat of Energy. The regional councils function mainly to consider local strategies for fuel and power system development for their respective regions. New strategies for any of its local members must be approved by the council. State-owned utilities and regional councils derive political influence from their respective share of the electric market.

There is some uncertainty over how much autonomy the federal government's codes, regulations and laws governing the energy and electric sectors give to state utilities, although the federal government clearly retains the predominant authority over supply development. For example, the Secretariat of Energy for the state of Sao Paulo believes that it has considerable flexibility in improving its state-based electricity and gas distribution businesses. It is actually promoting various initiatives and energy schemes as a means of regional economic development and to reassure the reliability of its energy base.

Officials with various federal agencies have offered differing opinions over how much the federal government would assert its jurisdiction over state initiatives in the power sector. Regional electric councils must approve any individual state project affecting the electric system of that region.

Figure 3

Brazil's Regulatory Structure for the Electric Power Sector



SOURCE: *Energy in Brazil*, Brazilian National Committee World Energy Council, Rio de Janeiro, September 1990.

4.2 Structure of the Electricity Sector

Originally, the electric power sector was owned primarily by foreign private interests. Most of the sector was transformed into public utilities during the 1960s and 1970s under the military regime.

The main federal utilities were established in the period from 1948 to 1973. In 1962, Centrais Eletricas Brasileiras SA (ELETROBRAS) was formed to act as the primary national coordinator for Brazilian utilities. ELETROBRAS is the main federal agency charged with planning and implementing most of the federally-owned generation and transmission system capacity additions and upgrades. Although DNAEE, not ELETROBRAS, actually awards concessions for new plant and power system facilities, ELETROBRAS normally makes the expansion plans and must approve any state utility plan to undertake such projects. ELETROBRAS also arranges government and market financing of project loans on behalf of all the public Brazilian utilities.

There are several subsidiary operating companies under ELETROBRAS, including Centrais Eletricas do Norte do Brasil (ELETRONORTE), Centrais Eletricas do Sul do Brasil (ELETROSUL), and HidroEletricas do Sao Francisco (CHESF). ELETROBRAS has operated two state-owned utilities: Rio de Janeiro's Servicos Eletricidade S.A. (LIGHT) and Espirito Santo's Centrais Eletricas S.A. (ESCELSA).

Of the 53,900 MWe total installed generating capacity in Brazil in 1991, 49,200 MWe (about 92%) is hydroelectric, as can be seen in the following table:

Table 3

Electric Pcwer Generation in Brazil, 1990

	GWh	%	Installed Capacity (MW)	%
Hydro (*)	228,400	96.8	50,534	91.5
Thermal	7,460	3.2	4,669	8.5
Fuel Oil	848	-	-	-
Diesel	1,516	-	-	-
Nuclear	2,237	-	-	-
Coal	2,847	-	-	-
Natural Gas	12	-	-	-
Other (**)	140	-	-	-
Total Brazil	236,000	100.0	55,203	100.0

SOURCE: ELETROBRAS

(*) Including Itaipu
(**) Including Self-generation

Variations exist in estimates of Brazil's capacity, largely due to differences in the way reliability is factored in; for example, another estimate of capacity in 1989 was 55,237 MW.

The ELETROBRAS' *Plano Decenal 1991-2000* (Ten-Year Plan 1991-2000), the forecast calls for the addition of 40,000 MWe of generating capacity, broken down into 33,000 MWe from hydroelectric plants and 7,000 MWe from thermal plants.

Table 4

Total Installed Capacity in Brazil
Annual Variation in Recent Years

Year	Capacity (MW)	Variation from previous period (percent per annum)
1975	18,300	-
1980	30,600	10.8%
1985	41,900	6.5%
1990	55,200	5.7%
Future		
1995	*66,400*	*3.6% p.a.*
2000	*83,900*	*4.8% p.a.*

SOURCE: ELETROBRAS

Intentions for adding 7,000 MWe of thermal capacity and two nuclear units totalling 1,245 MWe are included in the plan. The only nuclear unit currently operating, Angra 1, provides 675 MWe (slightly more than 1%) of Brazil's total generating capacity. In addition, the plan includes 1,600 MWe from coal-fired power plants, a major increase from the current negligible contribution of coal-fired generation.

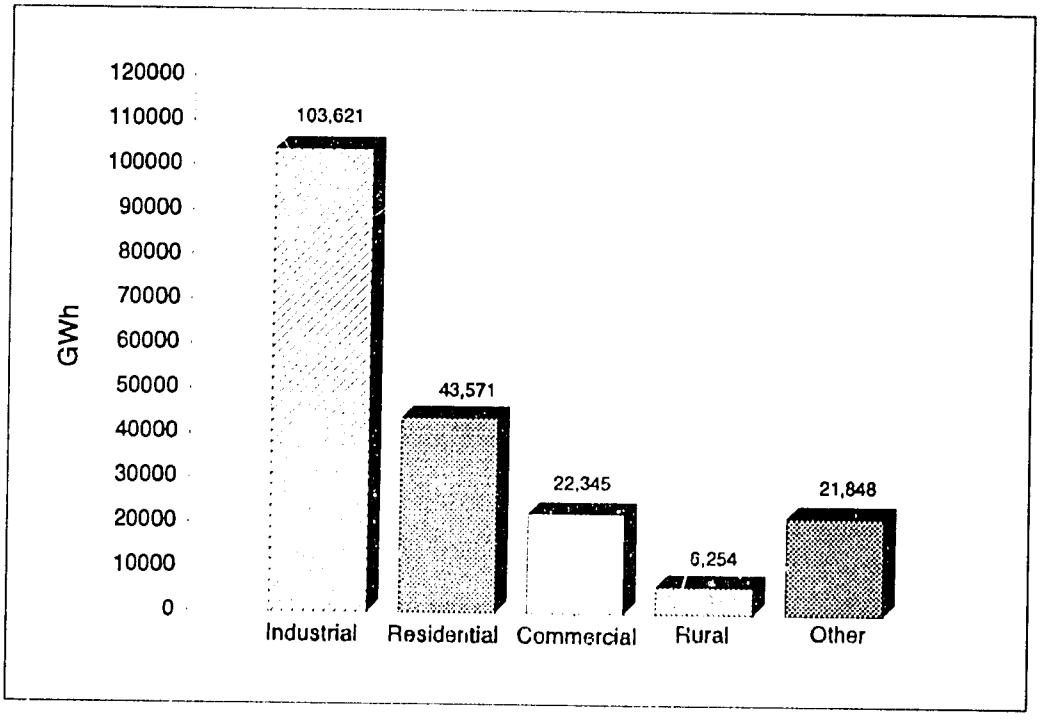
In 1990, self-generatorsincluding cogeneratorsprovided about 140 GWh of the total 236,000 GWh of generation supplied to the grid. In 1990, the amount of energy produced by these self-generators for captive load consumption (which is in addition to that supplied to the grid) was 10,000 GWh of total electric consumption. These self-generators, including some cogenerators, are predominantly in the electricity-intensive industries, such as aluminum smelting, steel, sugar and alcohol, petrochemicals, and chemicals.

In 1990, self-generators — including cogenerators — provided about 140 GWh of the total 236,000 GWh of generation supplied to the grid

According to *Plano Decenal 1991-2000*, Brazil's electricity demand grew an average of 9.4% per year during the period from 1970 to 1989. Annual growth rates in the 1970s were above 12%, and even when the economy slowed in the 1980s, electricity demand continued to grow more than 5% per year from 1980 to 1989. Total electricity consumption in 1990 was 245,000 GWh.

Figure 4

Consumption of Electricity in Brazil
1989 in GWh



SOURCE: *Energy in Brazil*, Brazilian National Committee and World Energy Council, 1990.

Table 5

Electric Power Consumption in Brazil, 1991

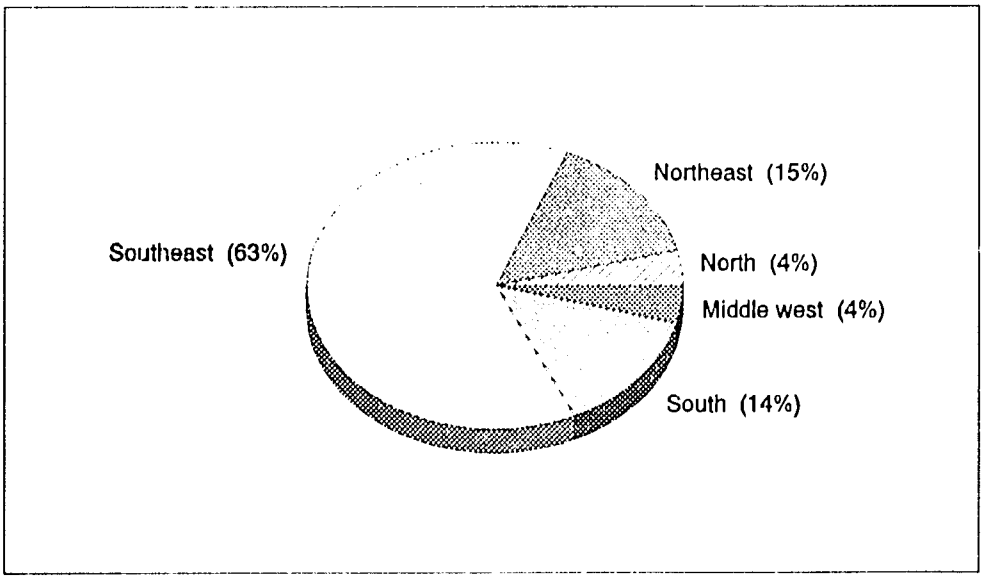
Region	GWh	%
North	10,500	5
Northeast	33,700	16
Southeast	126,500	61
South	29,800	14
Central-West	9,100	4
Total	209,600	100

SOURCE: ELETROBRAS

Brazil's total installed generating capacity is currently expected to reach approximately 66,400 MW in 1995, and 83,900 MW in 2000, representing an annual estimated electric demand growth of 5%. However, the federal government lacks the ability to provide the estimated US$ 6-8 billion per year in spending needed to meet new capacity requirements. An investment of roughly US$ 50 billion in the Brazilian electricity sector was made during the period from the mid-1970s to the mid-1980s, excluding interest. This expenditure, combined with the deficit from electricity revenues due to subsidized rates, brought the sector to the point of bankruptcy with an accumulated debt to the national treasury of US$ 9 billion. In addition, the foreign debt of ELETROBRAS and its controlled companies was over US$ 13 billion as of year-end 1990.

Figure 5

Energy Consumption in Brazil by Region, 1988



SOURCE: *Energy in Brazil*, Brazilian National Committee and World Energy Council, 1990.

The Southeast region alone consumes over one-half (126,500 GWh) of Brazil's total electric generation, and the utilities in this area are very actively promoting energy conservation and resource development programs that will enable them to meet the fast-growing demand within their respective service territories.

Generation

Together with ELETROBRAS, the nationally-controlled power entities control about 90% of the generation and transmission capacity in Brazil. Only a relatively small share of the generating capacity in Brazil is controlled by state-owned utilities, and only about 1% of the total capacity is controlled by privately-owned generators.

The nationally-controlled power entities control about 90% of the generation and transmission capacity in Brazil

Isolated electric systems in Brazil are served primarily by industrial generators. These generators were granted concessions to build generating units to serve their own industrial needs in regions that lacked full electric service through any of the government-owned utility systems. Thus, such individual private entities were allowed to act as utility concessionaires in order to develop local power resources and meet the electric service needs of a particular area.

Overall, the Brazilian government has promoted and continues to support the maximum possible development of hydropower projects for its energy base. Recently, however, there have been some federal initiatives to extend its support to the development of other energy resources in order to foster regional economic development, fulfill particular regional energy needs, or reserve its domestic oil production for other industrial and transportation uses. More attention is being placed on potential development areas such as natural gas, coal and nuclear resources for the energy-short southern region of the country, which has coal and recoverable natural gas reserves, and the country's only nuclear reactor site are receiving greater.

There is also some concern that Brazil's electric system is highly dependent on rainfall, thus some effort is being made to provide insurance against drought conditions by developing pumped storage options and by diversifying its electricity base. Furthermore, environmental activists and native Brazilian Indian groups are becoming more vocal in their opposition to new hydropower projects, due to concerns about massive population relocations, and destruction of natural wildlife habitats.

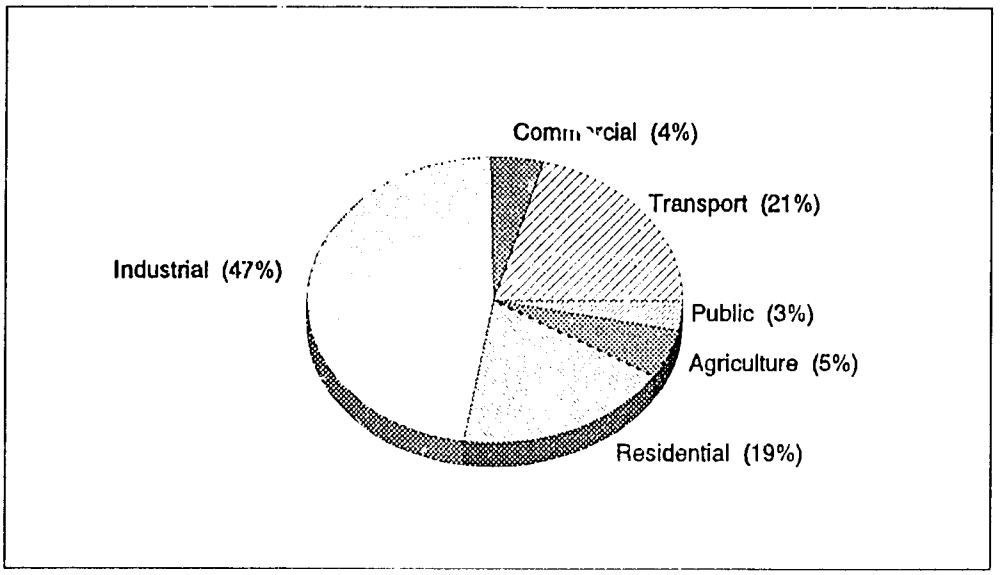
Electric generating capacity was added to the national system in increments of 3,000 to 12,000 MW per year during the 1970s and much of the 1980s. Now, however, the recent and continuing period of slow economic growth has led to the delay of many plant construction projects, and the national strategy for meeting energy needs is being re-examined. In light of Brazil's difficult economic and financial condition, and the major capital requirements for developing new generating and transmission capacity, the electric sector's traditional style of large, centralized power schemes is being framed by a more measured approach, centered around growing nation-wide energy and ecology conservation programs, smaller dispersed generation strategies by the private sector, and new fuel resource development.

The Brazilian government has introduced and is expanding nation-wide energy conservation programs, mainly through ELETROBRAS and PETROBRAS, extending to all customer classes. For the industrial and commercial sectors, Brazil is trying to encourage rational use of fuels and electricity, and is promoting a wide array of conservation technologies, including cogeneration and district heating and cooling (DHC) systems. On the residential level, natural gas is being promoted for residential water heating and cooking, as a substitute for electricity. The rising electric ratesunder the government's plan to greatly reduce its subsidization program in the energy sectorare also regarded as a means of slowing the rapid expansion of electricity demand in Brazil and encouraging conservation.

Recently, World Bank officials have asked the Brazilian government to bring electricity prices up from their subsidized prices to the real marginal cost level (about 67 mils per kWh, or $67 per MWh) by December 1992.

Figure 6

Energy Consumption in Brazil by Class, 1988



SOURCE: *Energy in Brazil*, Brazilian National Committee and World Energy Council, 1990.

The federal government is trying to enhance the attractiveness of, and expand the opportunity for, private power development initiatives, not only for captive load purposes, but for sales of excess power to the grid

One of more obvious solutions being pursued by the federal government in light of all these considerations is enhancing the attractiveness of and expanding the opportunity for private power development initiatives. *Plano Decenal 1991-2000* provides for the completion of various units under construction, encouragement of industry self-generation and cogenerationnot only for captive load purposes, but for sales of excess power to the gridand investment by private developers in the construction of new generating units through a bidding forum under DNAEE.

Transmission

The cost of providing redundancy of the transmission network is simply too prohibitive

One geographic inconvenience which is a characteristic of the Brazilian electric supply system is that some of the largest and most plentiful generating sources are located at great distances from the major load centers, requiring long distance transportation over expensive, high voltage transmission lines. For example, the Brazilian share of the power from Itaipu 10,500 MWe hydroelectric plant jointly owned by Paraguay and Brazil is basically dedicated to serve Brazil's largest city, Sao Paulo, which is located about 900 kilometers away. The power is relayed mainly over an ultra-high voltage 750-kV transmission system. The cost of providing redundancy of the transmission network to ensure reliability is simply too prohibitive. Construction of Brazil's major transmission network required large amounts of scarce financing capital, and this has contributed to the overall public and foreign debt of Brazil's electricity sector. Line losses for the transmission system are about 12-13% of the capacity. Another important problem for system efficiency is the unauthorized use of electricity (stealing).

Two distinct power systems have developed in the north and in the south-southeast region. The two systems are being interconnected through long-distance, high-voltage transmission facilities. A commission established in 1990 by ELETROBRAS is studying how to develop

transmission systems that can carry the vast hydropower potential of the Amazon region economicallywith minimal environmental impactto the far-distant north and southeastern regions of the country.

In 1990, Brazil had 14,783 kilometers of 500-kV, 1,612 kilometers of 600-kV (direct current), and 1,782 kilometers of 750-kV transmission line capacity. This is in addition to the 26,996 kilometers of 230-kV, 7,434 kilometers of 345-kV, and 5,652 kilometers of 440-kV transmission lines. ELETROBRAS, in its *1990 Annual Report*, indicated that, within a few years, the focus on expanding the generating capacity base is expected to shift to expansion of transmission and distribution systems.

Distribution

In Brazil, there are 25 state-owned utilities and 35 other power entities, including municipals, rural cooperatives, and approximately 10 small private utilities. Their main function is to provide distribution services to electric customers. Some of these distributors also own generating capacity, but on the whole, this capacity is a minor portion of their overall requirements, and most power is purchased from the federal power entities.

The influence of the state-owned utilities amongst each other and with the federal utilities varies widely from state to state. ELETROPAULO is the largest state-owned utility in terms of number of customers and peak demand, with a yearly peak demand of 8,576 MW in 1991. ELETROPAULO has some generating capacity, but mainly serves as a distribution system in the metropolitan Sao Paulo area. ELETROPAULO serves in the Southeast region, which has the largest electric consumption level. However, like the other state-owned utilities, it must concede to federal power dictates set by ELETROBRAS and DNAEE, and have any major system plans approved by the other members of the regional utility planning pool to which it belongs. Furthermore, the role of the state utilities in planning functions for the national power system is practically non-existent, which is a sore point with the state governments.

4.3 Current Policy Directions

Private Sector Participation: Existing and New Asset Ownership

The Brazilian government's privatization plan currently includes only modest efforts in the electricity sector

The Brazilian government's privatization plan currently includes only modest efforts in the electricity sector. In March, the electric utilities serving the Rio de Janeiro and Espirito Santo regionsthe Rio Electric Power Company and Espirito Santo Centrais Eletricas (ESCELSA)became the first electric utility enterprises to be put on the list of pending privatizations. This development contradicted the government's earlier insistence that, due to the large-scale debt that the electric sector carries, it would be difficult to privatize any of the public utilities.

Despite the plan to privatize these two relatively small electric power companies, it remains doubtful that any of the larger generating and transmission concessions controlled by ELETROBRAS will be soon privatized, with the possible exception of ELETROSUL, which has less debt and a better annual operating performance than LIGHT. Although there has been no indication that other state governments will sell their utility concessions in the near future, some of the provincial governments such as that of Sao Paulo are basically supportive of privatization. Some states may find it desirable to privatize their utilities in light of the debt, operating losses and inefficiencies these businesses have incurred until now, and of the further investment required to maintain and expand the electric system.

Recent moves to allow electricity tariffs to rise to the marginal cost level of 67 mils/kWh a policy promoted strongly by the World Bank may enable all of the electric operating entities to regain enough of a return to improve their financial condition and reinvest in the system.

Of the utilities that used to be owned by foreign private interests, only about ten small, isolated supply systems have remained in private hands. Today these are generally thriving enterprises for the most part, partly because they were excluded from some purchase requirements and tariff subsidization which characterized the larger federally- or state-owned counterparts.

Most of the private systems are owned and operated by industrial entities, built in areas where no other provider of electric service was available

Most of the private systems are owned and operated by industrial entities, built in areas where no other provider of electric service was available. Based partly on the success of these systems, and partly on the need for outside financing sources, the Brazilian government is now seeking to open project-based concessions, through competitive bidding, for hydropower sites to be developed by other such industrial or private developers. The government hopes to attract foreign concerns in particular which are viewed to have the investment capital to bid for concessions to build many of the new capacity additions. It is also working to find ways to mobilize the industrial and commercial sector to invest in their own generating systems. An electric sector institutional reform is currently being considered by Congress to allow this option to be fully developed. DNAEE has already given a private consortium a concession to develop a hydropower site in the Northern Amazon region, lending credence to the government's intention.

There are existing cogeneration plants operated at various industrial sites, including those belonging to both the private and the public sectors

There are existing cogeneration plants operated at various industrial sites, including those belonging to both the private and the public sectors. The sugar and alcohol industry has traditionally operated cogenerating units at their mills. These cogenerators do not always produce the total electricity requirement for the site, and some portion of their electric need is usually purchased from the grid.

PETROBRAS owns and operates many cogeneration plants at its petroleum refinery and petrochemical complexes and actually sells excess power to the grid, although not at a fair market value since it is also a federally-owned enterprise.

Brazil is still working out how it will implement policies that will achieve the stated goals of moving toward more private-sector economic ownership of assets and opening the country to foreign corporations. Further complications exacerbate this situation because many of the federally-owned corporations are currently being investigated. The major setbacks to private industry initiatives will be sector-specific shortages of the capital necessary to invest in generating and cogenerating systems, and the current unavailability of suitable fuels, such as natural gas, for such industrial plants.

Regulatory Issues of Concern to the Private Sector

There are various decrees, laws, and policies based on the basic *Codigo de Aguas* (1934), which sets the parameters for the development of energy resources (mainly hydropower) and the structure of the electricity sector in Brazil. This basis in law demonstrates that private power developers have historically played a small, but critical role in the power sector in Brazil.

The following laws and decrees relate to various issues concerning both actual and prospective private power development in Brazil:

- *Decreto-lei No. 1,513 (December 29, 1976)* introduced a compulsory loan (based on electricity requirement) to be made to ELETROBRAS by all self-generators with greater than 500 kW installed capacity using any kind of petroleum-derived fuel. This compulsory loan will terminate in 1993, and was used to help ELETROBRAS finance its large investment in electric power systems during a period of major expansion.

- *Decreto-lei No. 1,634 (August 31, 1978)*, exempts self-generators from compulsory loan to ELETROBRAS if they use extraction turbines without condensing capability, and the steam is used entirely in the industrial process.

- *Decreto-lei No. 1,872 (May 21, 1981)*, treats the purchase of self-generators' excess capacity by local utility concessionaires, setting up the process to be followed by the utility when purchasing excess power from private generators.

- *Portaria DNAEE No. 084 (October 22, 1981)*, regulates the purchase, by local public utility concessionaires, of excess electricity produced by self-generators, unless supplied to consumers in an isolated electric system or an area only serviceable by means of this type of electric system.

- *Portaria DNAEE No. 283 (December 31, 1985)*, allows self-generators the right to contract for back-up reserves from the grid if their own power systems are non-functioning.

- *Portaria MME No. 661 (May 19, 1987)*, set up a Working Group to define the details for technical interconnection requirements between self-generators and utilities.

- *Decreto Lei No. 1,872, Titulo VII, Planilha 1: "Autoprodutores" (May 21, 1987)*, allows public service utilities to purchase excess power from self-generators, and to require, under certain circumstances, self-generators to produce power for the grid.

- *DNAEE Portaria No. 246 (December 1988)*, regulates the negotiation process for self-generators selling excess power to the local utility, broken down into 3 main categories: Sales; Transport; and Power Exchanges.

In *DNAEE Portaria 246*, pertaining to the negotiation process for self-generators selling excess power to the local utility, the issues are broken down into three main categories: sales, transport, and power exchanges. The sale section provides that the local utility distributor has the first right to the excess electricity available from a self-generating entity. If the local utility is not interested in purchasing this energy, then it may become available to other local suppliers. The purchase price may not exceed the interconnected system tariff set by DNAEE. The transport section provides for local utility wheeling services from the self-generator to another facility of the same company located on a different site, at a price negotiated by the two parties. The power exchange section is premised on the concept that, for some technical reason, power cannot be transmitted, the self-generator may swap a quantity of power produced for the system for an equivalent value of electricity provided by the utility to a related facility on a different site.

The local utility distributor has the first right to the excess electricity available from a self-generating entity

In an important development in 1989, DNAEE published a manual for self-generators, *Manual do Autoprodutor*, prepared by ELETROBRAS and BNDES. The manual was prepared to stimulate private participation in the electricity supply system, in particular by promoting electric self-sufficiency in industrial park areas, and offering more competitive electric prices to industries in order to help secure their business viability.

The manual identifies the pertinent legislation related to electric energy generation, issues for the selling of excess power, and guidelines for financial credit lines that may be available for investment in the electricity sector.

Also, on June 13, 1989, *DNAEE Portaria No. 95* set forth the primary basis for the purchase of excess cogenerated electricity from industrial producers to the grid, which remains in effect. Article 1 of this initiative requires that the cogenerator not use oil-based fuels, and that the electrical output is a secondary product to the primary production of steam for an industrial application. The production of electricity is viewed as being a means of enhancing the energy efficiency of the overall system. *Article 6* provides that the purchase price of excess power is to be negotiated between the purchasing utility and the cogenerator, but may not exceed the marginal cost of the generated power of the national interconnected system.

The purchase price of excess power is to be negotiated between the purchasing utility and the cogenerator, but may not exceed the marginal cost of the generated power of the national interconnected system

Wheeling of excess power from private industrial generators and cogenerators to other affiliated company sites within the same federal state is provided for by law. The provision also allows the wheeling of power through the local grid to another adjacent utility wishing to purchase the power if the local utility does not need the capacity through the local utility grid. The charge for this service is to be based on the amount of line capacity utilized for the transaction(s), and negotiations between the parties.

Independent power generators must request DNAEE's approval of their projects, with only a slight variation based on whether the application is for hydroelectric or thermal-based plants. DNAEE has outlined the procedure for thermal plants, divided into three size classifications, in *Norma DNAEE No. 13* described below:

- For units larger than 10 MW, the applicant must obtain approvals for the project viability study and the basic project outline from DNAEE; furthermore, the Ministry of Infrastructure must issue an authorization allowing the power plant to be established;
- For those units smaller than 10 MW but larger than 500 kW, the applicant must obtain approval of the basic project from DNAEE, and permission from the Ministry of Infrastructure to establish the power plant; and
- For units smaller than 500 kW, the self-generator is only required to register its thermal power plant with DNAEE for statistical record-keeping.

BNDES and its subsidiary, FINAME, offer financing for private sector power projects

The government development bank in charge of privatization schemes, BNDES and its subsidiary, FINAME, also offer financing for private sector power projects, including conservation, efficiency and new construction programs. BNDES revises its conditions for private sector loans annually. Loans for self-generators are established under BNDES' *Energy Program* and its energy efficiency program *PROEN*, which is the most relevant financial program for cogeneration facilities at existing industrial sites.

Table 6

BNDES Lending Terms

Program	Minimum Finance Rate (%)	Term (Years)*	Maximum Participation (%)
Energy Program			
BNDES	8%	12	55%
FINAME	9.5-12%	8	70% (south)** 80% (north)***
PROEN			
BNDES	6%	5	60%
FINAME	7%	5	70% (south)** 80% (north)***

* includes a grace period of 6 months from the beginning of commercial operation
** "south" includes the southern and southeastern regions
*** "north" includes the northern, northeastern, and central-western regions

SOURCE: Manual do Autoprodutor, DNAEE, Brasilia, 1989.

Wholesale Power Market. There is no change in how the Brazilian wholesale power market system will accommodate purchases from an increasing number of private generating sources. According to the nationally-defined procedures and requirements, the local utility concessionaires are the key point of contact for negotiating with private power generators on the terms for sales. However, power will be purchased on a firm, non-firm, contractual and spot market basis, with an energy price to be set at or below the marginal cost of the interconnected system's generating cost. First preference will go to the least-cost producers, who will likely fulfill some of the nation's fuel and environmental criteria, since the cheapest fuel is likely to be bagasse or natural gas.

There is no change in how the Brazilian wholesale power market system will accommodate purchases from an increasing number of private generating sources

There is a provision for wheeling of private power which is not needed by the local utility to a distant third party over the grid, whether to another utility or to an affiliated industrial user.

Pricing. Although electric rates used to be set according to the economic cost of providing the various services, during the 1970s and 1980s there were major and growing discrepancies between the actual cost of power, the rates charged to the various ratepayer classesindustrial, commercial, and residentialand the costs allocated to different regions of the country. Rates to various customer classes are subsidized as much as 85%. The following table shows the tariffs and taxes in effect for electricity as of December 1991.

Table 7

Electricity Tariffs and Taxes
December 1991, US$ per MWh

TARIFFS	
Average Brazil	43.1
High Voltage	
230 kV	21.1
88-138 kV	23.2
34-69 kV	30.0
2.3-13.8 kV	45.2
Average High Voltage	32.3
Residential	57.5
TAXES	
High Voltage	
Compulsory Loan (ELETROBRAS)	14.0
ICMS (State Tax)	6.8
Total	20.8
Residential: ICMS (State Tax)	12.0

SOURCE: ELETROBRAS, Brazil, 1991.

There are various rate schedules available to customers: 1) rates based on the voltage level and quality (or interruptibility) of the supply; and 2) rates based on time of use (peak and off-peak rates) and time of year (rainy and dry seasons). In December 1991, the average rate for high voltage customers (230 kV) was 21.1 mils/kWh; the average residential customer electricity rate was 57.5 mils/kWh. High voltage customers must pay a 14 mil/kWh *compulsory loan* fee to ELETROBRAS in addition to the regular tariff, and all end-users must pay a state tax (ICMS) ranging from 6.8 mils/kWh for high voltage customers to 12 mils/kWh for residential customers.

In 1991, the *average base electricity rate* which is the average of the national interconnected system and is applied uniformly across the country was 43.1 mils/kWh. This rate was subsequently raised to 45 mils/kWh in late January 1992. The rate increase was part of a DNAEE initiative fostered by the World Bank to bring electricity prices up to the real marginal cost level by December 1992. The initiative is intended to: 1) bring electricity prices more in line with the actual cost of electricity service, thus reducing subsidization; 2) stabilize prices at the true cost level for a longer period of time, with adjustments only for inflation every month or so; and 3) decouple electricity prices from the international currency value of the Cruzeiro.

Since the rate increase became effective, industrial, commercial and residential customers have been hard-hit by the average 2.5% rise in their electric bill on top of current monthly inflation levels of around 23%, and concurrent price increases in water, gas and other basic services. There are, however, serious doubts that DNAEE will be able to achieve its targeted *average base rate* of 67 mil/kWh before March 1993 or later, due to the social and economic upheaval the rising prices will cause.

DNAEE has approved the purchase of excess electricity from self-generating entities, at a price capped at the official wholesale interconnected-system tariff.

The price of power sold to the grid is a key factor in determining the degree of expansion of self-generation and cogeneration capacity in Brazil. DNAEE has approved the purchase of excess electricity from self-generating entities, at a price capped at the official wholesale interconnected- system tariff. However, at the current price of electricity, which is still partially subsidized, it is not economic for most industrial customers to invest in electric generating equipment for their own production purposes or for selling to the grid. If steam or other thermal energy forms are required in the production process, it makes more economic sense for the industry to simply use boiler equipment to produce the thermal energy, and to purchase the electricity from the local utility system.

At the 67 mils/kWh base rate that is the goal of the ongoing rate increases, many private interests would actively seek to expand their self-generating and cogenerating capacity

At the current rate levels, private developers and industries would not get a reasonable profit from selling power to the grid from self-generating or cogenerating units. However, at the 67 mils/kWh base rate that is the goal of the ongoing rate increases, many private interests would actively seek to expand their self-generating and cogenerating capacity on industrial and commercial sites. With the assurance of 67 mils/kWh as a base price, and with the promotion of capital investment by foreign entrepreneurs, these developers believe they will get a profitable return on power investments.

The World Bank has been working with Brazil to achieve its target rate, but this has proven to be a difficult issue. Observers foresee that, in a political sense, it will continue to be difficult for the Brazilian administration and congress to reach agreement on policy measures such as raising electric rates that will have an initial negative socio-economic impact.

Fuel Promotion

New gas pipelines have recently been completed which will, for the first time, bring large supplies of natural gas from the offshore production fields near the Rio de Janeiro and Santos areas to the Rio de Janeiro and Sao Paulo metropolitan areas. In addition, plans are being implemented to import natural gas in the next few years from Bolivia to Brazil's southern states (especially Sao Paulo, but also including Parana, Santa Catarina, Rio Grande do Sul, and Minais Gerais) and within about five years from Argentina. Some portion of the Bolivian gas

may be directed for use in the transportation sector or as feedstock for petrochemical and chemical plants.

New gas pipelines have recently been completed, and plans are being implemented to import natural gas in the next few years

Anticipating the greater supply base, the state of Sao Paulo is promoting the use of natural gas for home heating, cooking, and DHC systems. Industrial and commercial concerns in Sao Paulo and other southern states are looking at the potential for natural gas applications in energy productionincluding cogeneration-based lighting, air cooling, and hot water systems in commercial buildings and shopping malls. At the federal level, the use of natural gas for transportation fleet vehicles is currently being promoted as a means to improve the air quality in large cities.

The federal government's *Plano Decenal* is promoting the development of coal-fired thermoelectric plants in the Santa Catarina and Rio Grande do Sul states. The role of coal is also discussed in the *Reexame da Matriz Energetica Nacional*, which promotes coal-fired power plants in the southern region, as well as the establishment of minimum annual mining production capacity for the sake of stabilizing the supply. *Reexame* also proposes that a long-term coal use policy be formulated, financial credit lines for coal development projects be made available, and that coal be able to compete with other fossil fuels as an industrial fuel under market conditions, unless this produces distortions which impede national energy goals. Independent of federal initiatives, the southern states of Sao Paulo, Rio Grande do Sul, and Santa Catarina are currently promoting the development of coal for new powerplants, which would use new generation technologies to improve the coal's fuel efficiency and mitigate environmental emissions.

Brazil also has various biomass sources of fuel, including wood and wood byproducts and the bagasse (waste) from sugar cane crops. Sugar cane crop production for the support of the government's alcohol program and the use of bagasse as a fuel for the cogeneration facilities at the sugar and alcohol mills has become widespread.

Environmental Issues

Industrial and densely-populated residential centers have experienced significant pollution problems related to air and water emissions, and inadequate sanitation systems. The latter is especially prevalent in the poorer areas which are often clustered around industrial plants and are undesirable property.

Brazil has a vast quantity of natural resources, including large mineral deposits, which have been exploited without regard to the environment or ecological balance. In recent years, however, a considerable amount of international attention has been focused on Brazil's lack of environmental protection policies, especially in regard to the destruction of the Amazon region's tropical rain forest by cattle ranchers and miners. The destruction of the rain forest is removing a natural *sink*, or carbon dioxide (CO_2) absorber, which has become more important in light of growing concern about greenhouse gas emissions and their contribution to global climate change. Other nations would like Brazil to take stronger actions to preserve the rain forest as an inheritance of mankind. It was significant, however, that Brazil hosted the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in June 1992.

Although DNAEE issues the licenses needed to build electric power projects and makes recommendations to the Ministry of Infrastructure to grant concessions for power projects, CONAMA is the main regulatory authority responsible for the environmental permitting of power facilities. CONAMA oversight of environmental areas is based on provisions in the *Water Code (Codigo de Aguas)*, the *Wildlife Protection Code* and other general environmental licensing laws which lay parameters for economic development of natural resources. CONAMA has also issued *Resolutions 001/86 and 006/87* as a basis for its environmental permitting process.

Three environmental permits are required for power projects in Brazil: a preliminary license, which is for the basic proposed design; a construction license before initiating any site building activities; and an operating license before the plant, transmission or distribution facility begins commercial operation. Both an environmental impact statement (EIS) and an environmental impact report (EIR) are required before the preliminary license can be issued for any generating facility 10 MW or more, and for transmission lines above 230 kV. There is an opportunity for a public hearing before issuance of the preliminary license.

Both an environmental impact statement and an environmental impact report are required

Environmental issues gained much greater prominence in Brazilian electric sector planning during the late 1980s with the establishment of several environmental advisory committees and the various utilities'including ELETROBRAS'own Environmental Department, as well as the over-arching COMASE (Environmental Activities Coordination Committee), consisting of representatives from DNAEE, ELETROBRAS and 25 utilities. The environmental objectives for the power sector are:

- population resettlement (to minimize and control impacts, so as to assure the same or improved quality of life standard);
- maintaining positive relations with the native Brazilian Indian population (as protected under the Brazilian constitution);
- maintaining conservation and preservation of flora and fauna; and
- providing for the careful utilization of coal in all stages of its development (mining, processing, storage and burning). Enhanced licensing and communication efforts are being promoted by private and government agencies on all levels, and enhancement of utility environmental personnel and the monitoring coal emissions are viewed as critical priorities.

There are no strict environmental emissions standards relevant for Brazil's private power facilities at industrial sites

Along with the electric sector's ten-year plan, the second version of an *Environmental Master Plan* (EMP) is being completed by ELETROBRAS. The main environmental considerations in the electricity sector are related to the development of hydroelectric projects and the construction of long-distance transmission lines. There are no strict environmental emissions standards relevant for Brazil's private power facilities at industrial sites. In the future, private power projects will be mostly based on hydropower, natural gas, or bagasse fuels, which have fewer environmental impacts. Any coal-fired generation that is undertaken will probably utilize clean coal technologies which are being promoted by state governments in the south, and by the Ministry of Science and Technology at the national level.

5. MARKET CONDITIONS FOR COGENERATION DEVELOPMENT

5.1 Brief Overview

New laws and regulations are currently being drafted regarding electricity generation in the private sector. However, it is doubtful that any of the existing utility plants controlled by ELETROBRAS, or oil and natural gas production facilities controlled by PETROBRAS, will be privatized.

The Brazilian government is encouraging the industrial and commercial sectors to undertake independent energy-efficiency, conservation, and investment programs

In general, the government is determined to either privatize or deregulate its various business enterprises, forcing them to compete and function in a free-market environment more effectively. To this end, and due to the considerable investment foreseen as necessary in the electric sector in the coming decade, the Brazilian government is encouraging the industrial and commercial sectors to undertake independent energy-efficiency, conservation, and investment programs.

In recent years, government-owned industries have lacked the investment ability to ensure that production facilities were sufficiently upgraded, and technical management lacked the incentives to review overall production techniques to ensure the highest degree of cost-effectiveness. Therefore, any attempt to increase efficiency was not easily attainable.

Many industrial facilities in Brazil, including the highly regarded steel sector's plants, tend to be energy-inefficient. According to a recent study, Brazilian steel plants consume on average 30% more electricity than their Western European counterparts. Despite this energy inefficiency, Brazilian steel makers are judged to be the most efficient and competitive among the countries of the future MERCOSUL. It is likely, however, that energy efficiency will be promoted in this and other basic industries as existing price subsidies are removed and as conservation programs are promoted by the federal government.

Other major industries (including iron mills, port facilities, telecommunications, transportation, and PETROBRAS) are considerably less efficient overall than those in developed nations. Consequently, they cost the economy an estimated US$ 38 billion, or 10.4% of GNP, per year. Recent initiatives that encourage efficiency will not only improve the economy, but will also increase international competitiveness.

Historically, Brazil has promoted self-sufficiency in engineering, construction and equipment concerns. Today, Brazil is considered self-sufficient in most technical areas. Exports of equipment that is manufactured in Brazil have traditionally faced stiff import requirements and prohibitive tariff barriers. Currently, however, native manufacturers do not have the capability to produce some types of power-generation equipment (including steam turbines), so trade barriers are being administratively phased out by the federal government.

These conditions should provide more opportunities for foreign vendors of electrical equipment to enter the formerly protected Brazilian market. There is also a marked redirection away from the historically large Brazilian electricity schemes (such as the 10,500 MWe Itaipu hydroelectric plant, which is the world's largest hydroelectric facility) to smaller, dispersed generating strategies located closer to the load centers. This shift could call for foreign investment capital.

5.2 Market Aspects

The official thrust of the national government's plan for the utilization of more gas-fired generation in the electric sector is expected to open many market opportunities for various

types of foreign firms. This provides for a tremendous new market opportunity for foreign capital investors, equipment makers, technology and service firms.

Bagasse-fired generation at sugar and alcohol mills in Brazil can offer a potential of 3,000 to 10,000 MWe of excess sales to the utility grid if the electricity tariff level rises to 67 mil/kWh

Furthermore, studies undertaken by the National Secretariat of Energy have estimated that bagasse-fired generation at sugar and alcohol mills in Brazil can offer a potential of 3,000 to 10,000 MWe of excess sales to the utility grid if the electricity tariff level rises to 67 mil/kWh, as is scheduled by DNAEE by December 1992. This level of tariff ensures a return for private investors, and would stimulate sugar and alcohol mills to optimize their generating capacity potential. Representatives of the sugar and alcohol industry confirm the potential growth of their generating capacity, but are looking to foreign investors to provide the capital needed for the expansion.

Another industry that has installed generating units on its industrial sites is the aluminum smelting industry, located in the northeastern coastal region, which currently provides about 8% of its own generating needs. This electricity-intensive industry sees a major opportunity for private interests to build new generating capacity to sell power to the grid. It is expected that increased competition in generation will lower the overall costs of the electric system, even though prices will initially rise with the removal of electric subsidies.

There are also current planning activities for private development of cogeneration plants related to major shopping malls in the cities of Rio de Janeiro and Sao Paulo. In total, the Secretariat of Energy is aware of 49 major shopping malls in Brazil currently in the planning stage, a number of which are considering cogeneration applications. With some encouragement from the federal government, or after some experience with this type of model has been gained, it is expected that many more of these malls could become potential cogenerators. Most of the industrial or project developers considering such projects are very open to foreign participation in project financing, technological and operating service support, and equipment supply areas.

5.3 Key Industries for Cogeneration

At present, various industrial complexes produce electricity using cogeneration mainly to supply their own requirements and to have secure supply of electric power. There was no incentive to produce and supply electric power to the grid system due to subsidized uniform price of electricity. However, this is changing as the subsidization programs are phased out and the selling price of electric power is expected to rise to a free-market level.

Overall cogeneration potential in major industrial sectors in Brazil is 8,832 MWe

Overall cogeneration potential in major industrial sectors in Brazil is 8,832 MWe.

Table 8

Brazil: Overall Cogeneration Potential

Industry	Cogeneration Potential MWe
Pulp and Paper	263
Petrochemical & Refineries	496
Sugar & Alcohol	7,700
Textiles	N/A
Cement	N/A
Metallurgical	230
Commercial	143
Total	8,832

SOURCE: *Global Climate Change Mitigation Through Cogeneration: A Market Assessment of Cogeneration Project Opportunities in Key Developing Countries*, Office of Energy and Infrastructure, Bureau for Research and Development, U.S. Agency for International Development, June 1992.

The sugar and alcohol industry, using sugar cane bagasse as a fuel, can provide about 7,700 MWe or 18,000 GWh as a generating source. Of this, 11,000 GWh of the potential is located in the state of Sao Paulo.

In the state of Minas Gerais, the estimated cogeneration potential is about 500 MWe, of which approximately 60% is from the sugar and alcohol industry and the rest from metallurgical industries.

Table 9

Cogeneration Potential

- **No Evaluation of country's total potential made thus far**

- **Sugar cane bagasse is largest possible fuel source**
  - — In Sao Paulo, Sugar/Alcohol industry estimate is 11,000 GWh
  - — In Brazil, figure is estimated at 18,000 GWh (approximately 7,700 MW)

- **CEMIC (Minas Gerais Sate)**
  - — Preliminary estimates indicate 500 MW potential
  - — Largest share of above potential comes from:

Steel/Metallurgy:	22%
Sugar/Alcohol:	60%

- **Aluminum Industry (*)**

— Today's cogeneration:	0 MW
— Potential from present Alumina refineries:	80 MW
— Including new planned refineries for '90s:	150 MW

(*) Due to process steam/power requirements for Alumina refineries

SOURCES: ABAL, CPFL, CEMIG, ELECTROBRAS
Provided by Sr. Pires de Mello, ALCOA-Brazil, March 9, 1992

Estimates of electric power production through cogeneration for other industrial sectors are based on production capacities for each industry as a whole, and, if available, on other utility consumption data (steam and electric power). Using these data and commercially available turbine information, electric power production through cogeneration for various plants is calculated.

Pulp and Paper

The estimated technical potential for cogeneration in the pulp and paper industry, including the current installed capacity, is about 500 MW

The estimated technical potential for cogeneration in the pulp and paper industry, including the current installed capacity, is about 500 MW. But because of the type of fuel available and the subsidized rates for electricity, the pulp and paper industry in Brazil does not presently appear to offer attractive private-sector opportunities for developing cogeneration power plants. Specific capital costs for installing utility-scale cogeneration plants compared to captive cogeneration systems would normally be prohibitive, and a detailed technical and economic study would be necessary to identify any cost-effective projects.

Pulp and paper plants use large amounts of steam and electricity in their processing operations and have large amounts of useful waste material (like bark, wood chips, bagasse, and paper liquor), though not in sufficient quantity to support a utility-scale cogeneration plant. Most pulp and paper plants have installed back-pressure turbines to generate electricity only for internal use.

Fuel used for steam production will be one of the biggest impediments to attracting private-sector cogeneration plant developers in this industry. In contrast to other South American countries like Argentina or Mexico, the majority of the Brazilian pulp and paper industry depends more on burning biomass or coal instead of natural gas in generating steam or electricity. A potential for change to natural gas in this sector exists with the planned expansion of the domestically produced natural gas distribution network including imports of gas from Argentina and Bolivia. Increased availability of natural gas would facilitate development of larger-scale cogeneration facilities in the pulp and paper industry.

The pulp and paper industry in Brazil does not presently appear to offer attractive private-sector opportunities for developing cogeneration power plants

Approximately 3% of the world's pulp and paper mills are located in Brazil. The majority of pulp and paper mills are located in Sao Paulo. Cellulose production in Brazil climbed from 664 tons in 1970 to 3,945 thousand tons in 1990. In terms of paper and board producers in the world, Brazil is listed on 11th position in 1989.

Information concerning some of these pulp and paper plants is presented in the following table:

Table 10

Brazil
Energy Data for Pulp and Paper Mills

Company Electricity	Total (mT/y)	Power Capacity (tons/h)	Boilers (MW)	Steam Fuel (MWh/day)	Purchased Turbines
Aracrus Celulose	500,000	90	Wood (?)	64	
Bahia	66,000	100	Oil+Coal+Other Max	8	100
Bonet SA	22			70	
Cambara SA	36,000	95	Wood+Oil	5	
Celupa-CIA	30,000	20		1	67
Cenibra	350,000	400	Wood	40	68
Champion	620,000	85	Wood (?)	22	755
Cocelpa	110.000	100	Oil	16	150
Cibrap	15,000	22	Oil+Other		
Florestal Monte	300,000	140	Wood+Oil	55	
Inpa	36,000	15	Oil+Other		
Itapage SA	98,000	100	Wood	5	70
Kimberly-Clark	23,700	9	Oil		
Klabin					
- Correia	230,000	70	Bark	12	4
- Sao Paulo	50,000	35	Oil		
- Telemaco	1,080,000	370	Coal+Bark	65	660
- Estrada	25,000	30	Oil		150
Lwarcel	36,000	25	Wood	8	39
Manville	465,000	110	Oil+Wood	3	384
Matarazzo	42,600		Wood		90
MD Nicolaus	40,000	25	Oil+Other		
Nossa Senhora	66,600		Oil+Wood		
Papelok SA	93,000	40	Wood		
Papirus	170,000	50	Wood		
Portela, CIA	150,000	100	Wood+Other	3	200
Rigesa					
- Tres Barrases Barras	230,000	64	Wood	7	125
- Valinhos	301,500	54	Wood+Oil	0	150
Rioceli SA	311,000	200	Coal	50	
Ripasa SA	33,000	20	Oil+Other		69
Safelca SA	26,000	8	Oil		730
Santa Therezinha	36,000	27	Wood+Oil		200
Penha Mill	30,000	22	Oil+Other		200
Governador	18,000	2	Wood		200
Santo Amaro	127,000	55	Oil+Bark		
Simao-Piracicabaacicaba	113,000	90	Oil+Coal		
Suzano	822,000	280	Oil+Gas+Other	25	780
Zorzi De Papeis	75,000	65	Wood+Oil		148
Total	6,755,400			461	5,340

SOURCE: *Global Climate Change Mitigation Through Cogeneration: A Market Assessment of Cogeneration Project Opportunities in Key Developing Countries*, Office of Energy and Infrastructure, Bureau for Research and Development, U.S. Agency for International Development, June 1992.

Note: Many plants presented in the above reference did not supply sufficient information concerning steam or electricity production or demand, or information on a fuel used as an energy source. These plants, and the small plants which do not represent a market potential for cogeneration, have been omitted.

As the pulp and paper industry requires large quantities of process steam, each facility could be a potential candidate for a cogeneration project, should sufficient quantities of fuel become available. Based on steam generation rate, the estimated cogeneration potential expressed in MW is presented in the following table, based on these assumptions:

Each facility could be a potential candidate for a cogeneration project, should sufficient quantities of fuel become availabie

1. Wherever oil only is used for generating steam, the STAG system with a gas turbine, an unfired heat recovery steam generator, and a non-condensing steam turbine are anticipated as a potential for cogeneration.

2. In all other cases, a boiler and a non-condensing steam turbine are assumed to represent the cogeneration system of the plant.

3. There is no credit taken for any existing turbine generators (least reliable information in table). Steam turbine throttle conditions are assumed to be: (a) pressure equal to 1250 psig, and (b) temperature equal to 900 F. It is assumed in the above estimate that the process steam, in all cases presented, is at 150 psig, average temperature of returned process condensate and make-up is at 165 F, and the steam turbine total efficiency is 75%.

Table 11

Brazil

Pulp and Paper Mills Estimated Cogeneration Potential

Company	Power Boilers (tons/h)	Fuel	Purchased Electricity (MWh/day)	Estimated Cogeneration Potential (MW)
Aracruz Celulose	90	Wood (?)		10
Bahia	100	Oil+Coal+Other Max	100	11
Bonet SA	22			2
Cambara SA	95	Wood+Oil		10
Celpa-CIA	20		67	2
Cenibra	400	Wood	68	44
Champion	85	Wood (?)	755	31
Cocelpa	100	Oil	150	65
Cibrap	22	Oil+Other		2
Florestal Monte	140	Wood+Oil		15
Inpa	15	Oil+Other		1
Itapage SA	100	Wood	70	11
Kimberly-Clark	9	Oil		1
Klabin-Correia	70	Bark	4	7
- Sao Paulo	35	Oil		30
- Telemaco	370	Coal+Bark	660	40
- Estrada	30	Oil	150	23
Lwarcel	25	Wood	09	2
Manville	110	Oil+Wood	384	12
Matarazzo		Wood	90	3
MD Nicolaus	25	Oil+Other		2
Nossa Senhora		Oil+Wood		
Papelok SA	40	Wood		4
Papirus	50	Wood		5
Portela, CIA	100	Wood+Other	200	11
Rigesa				
- Tres Barrases	64	Wood	125	7
- Valinhos	54	Wood+Oil	150	6
Riocell SA	200	Coal		22
Ripasa SA	20	Oil+Other	69	2
Safelca SA	8	Oil	730	30
Santa Therezinha	27	Wood+Oil	200	8
Penha Mill	22	Oil+Other	200	8
Governador	28	Wood	200	8
Santo Amaro	55	Oil+Bark		6
Simao-Piracicabaacicaba	90	Oil+Coal		9
Suzano	280	Oil+Gas+Other	780	32
Zorzi De Papeis	65	Wood+Oil	148	7
			Total	501

SOURCE: *Global Climate Change Mitigation Through Cogeneration: A Market Assessment of Cogeneration Project Opportunities in Key Developing Countries*, Office of Energy and Infrastructure, Bureau for Research and Development, U.S. Agency for International Development, June 1992.

Sugar and Alcohol

The sugar and alcohol industries offer one of the best and largest potentials for cogeneration in Brazil, with an estimated 7,700 MW of electric power that can be generated in these industries

Estimates by an industry organization indicate that the sugar and alcohol industries offer one of the best and largest potentials for cogeneration in Brazil. It is estimated that nearly 7,700 MW of electric power can be generated in these industries. The corresponding net annual generation is 18,000 GWh. It is not clear whether this reported capacity and generation is from combustion of excess bagasse in stand-alone power plants or from cogeneration plants which also produce process steam for the manufacture of sugar and alcohol. If this reported capacity is annualized consistent with the reported generation, the estimated total plants' capacity is about 2,740 MWe. Detailed individual assessment of each facility is necessary to estimate cogeneration potential more reliably.

Brazil is the largest sugar producer in the world, with about 26% of total production. The *National Alcohol Program* (Proalcool) was set up in 1975 to expand alcohol production for use as an automotive fuel to replace gasoline. In 1990, hydrated alcohol consumption was 11.3 million cubic meters, substituting for about 115 thousand barrels of gasoline equivalent per day, compared to gasoline consumption of 163 thousand barrels per day.

The majority of sugar and alcohol plants are located in the state of Sao Paulo, which produces 75% of Brazil's sugar and alcohol. The sugar and alcohol production in this region during the years of 1985-1987 was 2.8 million and 3.8 million tons respectively for sugar and 4.4 million liters and 5.3 million liters respectively for alcohol. The total installed electric generation capacity in the state of Sao Paulo in this sector is 367 MWe.

Bagasse produced in the sugar industry as a byproduct or waste material is used either as fuel to produce steam, as a good source of raw material for the pulp and paper industry, or as fuel for electric power production. However, the sugar and alcohol industry is seasonal, and operates during crop season. In the off-season, production of electric power cannot be fueled by bagasse, and power must come from condensing turbines.

The estimated potential for cogeneration in the oil refining an l petrochemicals sector is 496 MW

The petrochemical and refinery industries produce gas-turbine quality fuel gas and also use large amounts of process steam throughout the year. The estimated potential for cogeneration in this sector is 496 MW, as can be seen in the following table:

Table 12

Brazil
Petrochemicals and Refineries Estimated Cogeneration Potential

Enterprise and Facility	Product Description	Capacity MT/Y	Estimated Steam Use KG/HR	Estimated Cogeneration Potential KW (1)
Companhia Brasileira de Estireno				
Sao Paulo Plant	Ethylene	4,800	830	
Copene-Petroquimica do Nordeste S.A.	Ethylene	460,000	79,621	121,011
Oxiteno S.A. Indistria E Comercio				
Oxiteno Nordeste S.A.				
Industria E Comercio				
Maua Plant	Ethylene Glycol	25,000	13,708	22,449
	Acetate	9,000	4,165	516
			17,874	22,965
Camacari Plant	Ethylene Glycol	122,130	66,970	98,723
Itaguai Plant	Ethylene Glycol	80,000	43,868	62,837
Petroquimica Uniao S.A.	Ethylene	360,000	62,312	91,488
Polialden Petroquimica S.A.	HDPE	92,000	11,453	18,755
Politeno Industria E Comercio S.A.	LD Polyethylene & Eva	130,000	16,183	26,302
	LLD Polyethylene	130,000	16,183	26,302
			32,367	52,605
Prosint-Produtos Sinteticos S.A.	Methanol	191,600	5,946	736
Ultrafertil S.A.				
Industria E Comercio de Fertilizantes				
Arucaria Plant	Methanol	7,920	245	30
Union Carbide do Brasil, S.A.				
Cubatato Plant	Ethylene	40,000		
	LD Polyethylene	128,000		
			22,858	26,952
Total Cogen Capacity (KW)				496,211

(1) Based on gas turbine with heat recovery boiler and condensing turbine.

* In the absence of any direct input from the operating companies, it is assumed that the fuel type is natural gas.

SOURCE: ***Global Climate Change Mitigation Through Cogeneration: A Market Assessment of Cogeneration Project Opportunities in Key Developing Countries*****, Office of Energy and Infrastructure, Bureau for Research and Development, U.S. Agency for International Development, June 1992.**

Individual detailed assessments need to be made for each facility. This sector can use several off-the-shelf technologies for such applications.

The refining and petrochemical plants are located in the northeast part of Brazil. While this sector was being aggressively pursued in many other countries, Brazil did not develop this sector until recently. In the 1940s, some exploration and production started, but full-scale production stared only after the creation of PETROBRAS in 1953 as a state-owned company to control all of Brazil's petroleum and natural gas reserves and all aspects of exploration, production, imports/exports, and transportation activities through its various subsidiaries.

PETROBRAS owns ten refineries and one asphalt plant, with effective refining capacity in 1990 of 237.9 cubic meters per day. This corresponds to 99% of the total refining capacity in Brazil. In 1990, PETROBRAS produced 1,166 thousand bpd of oil products, of which 16.5% corresponded to gasoline, 35% to diesel and 18.9% to fuel oil.

There are three petrochemical complexes in Brazil, located in the northeastern, southern and southeastern regions, which, in 1990, had an ethylene production capacity of 1.5 million tons per year.

Some plants already have cogeneration facilities. However, modern technology offers a way to expand this cogeneration capacity or add new cogeneration plants. In the production of ethylene alone, the estimated cogeneration potential is over 100 MWe.

In the production of ethylene alone, the estimated cogeneration potential is over 100 MWe

Textile Industry

The textile industry in Brazil is very significant. This industry uses steam as well as electric power and, as a result, there should be great incentive for cogeneration. Overall potential and potential cogeneration opportunities need to be identified by detailed case studies.

Steel and Metal Industry

In 1990, Brazilian steel production was 21 million tons, making Brazil the eighth largest producer of steel in the world. Availability of electric power and deposits of bauxite has promoted the development of the aluminum industry in the northern region. In 1989, production of primary aluminum was 888 thousand tons, making Brazil the fifth largest producer in the world.

Overall cogeneration potential in the steel and metal industries is about 110 MWe. At present there is no cogeneration in this sector. Potential cogeneration in the from existing aluminum industry is 80 MWe and 70 MWe for new planned facilities.

Overall cogeneration potential in the steel and metal industries is about 110 MWe

Total cogeneration potential is 142 MWe in commercial and residential real estate applications

Shopping malls, convention centers, large hotels, and apartment complexes need air conditioning and electricity. COMGAS has identified 25 projects ranging from 3 MWe to 20 MWe capacity, with total cogeneration potential of 142 MWe in this sector, as can be seen in the following table. COMGAS, a major supplier of natural gas, is extremely interested in the success of these projects.

Table 13

Brazil
Commercial Cogeneration Potential (1)

Expected Cogeneration Capacity (KW)		Consumption of Natural Gas (M3)
	Super Market Centers	
10,146		51,324
3,754		17,477
11,111		32,363
3,750		27,975
3,750		27,975
32,511		157,114
	Office Buildings	
4,075		23,374
3,240		23,532
1,720		21,864
4,495		21,556
3,254		15,580
3,082		14,732
3,324		15,934
2,958		14,286
1,649		17,492
11,268		52,990
1,858		8,919
1,386		8,800
5,850		28,013
3,750		11,973
51,909		279,045
	Hotels, Shopping Centers, and Others	
4,123		11,766
8,800		31,437
4,265		29,443
11,721		54,280
21,474		98,193
7,455		16,399
57,838		241,518
142,258	**Total**	677,677

(1) Estimates are from COMGAS of Sao Paulo

SOURCE: ***Global Climate Change Mitigation Through Cogeneration: A Market Assessment of Cogeneration Project Opportunities in Key Developing Countries*****, Office of Energy and Infrastructure, Bureau for Research and Development, U.S. Agency for International Development, June 1992.**

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ACRONYMS

ABAL	Subsidiary of ELETROBRAS
AEA	Advanced Engineering Associates
bbl	Barrels
BLT	Build-lease-transfer
BNDES	Banco Nacional de Desenvolvimento Economico e Social
boe	Barrels of oil equivalent
BOO	Build-own-operate
Btu	British thermal unit
CEMIG	Subsidiary of ELETROBRAS
CHESF	Companhia Hidro Eletrica do Sao Francisco
COMASE	Environmental Activities Coordinating Committee
CONAMA	Brazilian Council on the Environment
CPFL	Subsidiary of ELETROBRAS
DHC	District heating and cooling
DNAEE	Departamento Nacional de Agua e Energia Eletrica
EIR	Environmental impact report
EIS	Environmental impact statement
ELETROBRAS	Centrais Eletricas Brasileiras SA
ELETRONORTE	Centrais Eletricas do Norte do Brasil
ELETROSUL	Centrais Eletricas do Sul do Brasil
EMP	Environmental Master Plan
EPA	Environmental Protection Agency
ESCELSA	Espirito Santo's Centrais Eletricas SA
EX-IM Bank	U.S. Export-Import Bank
FINAME	Subsidiary of BNDES
FURNAS	Centrais Eletricas S.A.

GDP	Gross domestic product
GNP	Gross national product
GT	Gas turbine
GW	Gigawatt
GWh	Gigawatt hours
HRSG	Heat recovery steam generator
IBRD	International Bank for Reconstruction and Development
ICMS	State tax
IDB	Inter-American Development Bank
IFC	International Finance Company
IMF	International Monetary Fund
kV	Kilovolt
kWh	Kilowatt hours
LIGHT	Rio de Janeiro's Servicos Eletricidade SA
MERCOSUL	Southern Cone Common Market
mm Hg Abs	Milligrams of mercury (pressure)
mm tons	Million metric tons
MMcf	Million cubic feet
MME	Ministry of Mines and Energy
MW	Megawatt
MWe	Megawatt electricity
NUCLEN	Engenharia SA (Nuclear operating subsidiary of ELETROBRAS)
PROEN	BNDES energy efficiency program
psig	Pounds per square inch
ST	Steam turbine
STAG	General Electric acronym for steam and gas turbine
TPA	Tonnes per annum
UNCED	United Nations Conference on Environment and Development

UNDP	United Nations Development Programme
U.S. AID	United States Agency for International Development
VAT	Value-added tax
WIEG	Washington International Energy Group

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