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Environmental aspects of energy market regulation in Brazil.

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ENVIRONMENTAL ASPECTS OF ENERGY MARKET REGULATION IN BRAZIL[1]

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Abstract

The privatization programme and the creation of regulatory agencies in the electric power and oil sectors were not independent decisions made by the government. They need to be looked at in their proper perspective. The need to increase the supply of energy and borrow external funds to this end led the government to accept the World Bank requirements. The World Bank's own view fits in a strategy for achieving sustainable development and is closely related to the implementation of the Kyoto Protocol.

Keywords

Regulation, environment, economic development, energy.

1. Introduction

Brazil is undergoing numerous significant transformations. The breaking point is the Real Plan put into operation in the first term of President Fernando Henrique Cardoso in mid-1994. We can divide the facts into two broad groups.

The first group concerns the way economic policy is defined and its objectives are pursued. Its most important attribute is an unyielding determination to lower inflation rates and make some fundamental adjustments in the fiscal sector. Obviously this can be a battle cry but it is not yet the time to claim victory. Politicians offer resistance because of their own interests. Nonetheless we can list some indisputable good results. The first point is that after decades of rampant inflation there is a period of stability. Inflation rates of up to 70% per month were lowered. Now it is even possible to experience months with deflation allied to an annual inflation rate lower than 10%. A period of stagnation before the plan was followed by a consistent increasing activity during the first four years of the Real Plan, a fact that can be shown by using more sophisticated econometric methods.[2] [3]

The second group of facts will be called structural reforms. The reform of the electric power sector is an example. One can interpret this behaviour as an independent action towards a preferred organisation of the sector. We argue,

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[2] Diniz (1999) demonstration of this fact draws heavily on the econometric literature of unit roots and smooth transition in trends.

[3] The economy is currently going through an adjustment period because of some external and internal factors that we will not detail in this paper.

however, that this is at most an incomplete appreciation of the facts. We state that the government chose this course of action mainly constrained by two facts: the necessity to cope with an increasing demand for energy and the lack of funds to invest in this sector. These forced the government to accept the commitments imposed by the World Bank in order to borrow funds from the Bank for this purpose. We are not judging the appropriateness of the decision but only expressing the perspective from which the government contemplated its actions. This link with the World Bank's positions can help us to foresee the policy of Brazil in some areas. This paper will be concerned solely with prospects for the environmental area.

In what follows we will restrict our analysis to the electric power sector. Some of the arguments can be valid for other sources of energy, especially the oil sector. Initially we shall present a set of basic facts on the Brazilian electric power sector. Then we shall summarize the position of the World Bank on this matter and examine the link between its position and the sustainability criterion. At that point we shall present the thrust of the argument. The environmental implications of the reforms are the focus of the following section, followed by some concluding remarks.

2. The Brazilian electric power sector: basic facts

Some selected data from the Brazilian Energy Balance 1999 are displayed in Tables 1-10 and Figure 1.[4] In what follows we shall stress the more relevant facts.

The first point to cover is a downward trend in real prices of the electric power sector. This is shown in Table 1 and Figure 1. The falling real price is particularly noticeable in the prices for the industrial sector. This is an important clue to the suspicion that the price of electricity may not cover the costs or generate a surplus to expand the supply. We can note in addition an upward trend in the real price of residential electricity for the period 1996-1998. There is no sufficient information to know with certainty if this is a persistent trend upwards.

Table 2 shows some selected data. We can stress that the generation of electricity is only a little bit higher than consumption. In the 1990s consumption was never below 95% of the generation. We can even state that all electricity is consumed. Other remarkable fact is that the bulk of the generation is supplied by hydro plants. Another point to stress is that the overall efficiency of thermal plants is around 32%. In the private sector (auto-generation) efficiency is never below 34% (typically around 38%), and the same figure for the public sector is never above 29% (typically around 26%). It follows that the public sector is less efficient than the private sector in thermal plants. We included two indexes reflecting the quality of electricity distribution. Both reflect two dimensions of power outages: mean number of hours per year and mean number of events per year. They present a similar behaviour: a deterioration of distribution services in 1996-1997 followed by quality better than ever happened before.

Tables 3-5 detail the profile of the electricity generation. Table 3 brings raw data expressed in PJ. Tables 4 and 5 show that more than 90% of all electricity generated in Brazil comes from hydro plants. Most of them are state-owned companies. The thermal plants' generation is divided into an equal proportion between the public and the private sector. Table 5 shows in detail the composition of thermal plants by source. Some types of plant are exclusively private (natural gas, firewood, sugar cane bagasse, black liquor, other wastes, gas coke and other

[4] All tables and figures are in the Appendix.

secondary sources), others are public (uranium) or almost public (steam coal and, to a lesser extent, diesel oil) and in one case the proportions of the two sectors are roughly equal (fuel oil).

The installed capacity is shown in Tables 6-7 by type of plant. They reinforce the results expressed in other tables. The single new fact is that the installed capacity in state-owned thermal plants is much higher than the corresponding in the private sector (auto-generation). But in previous tables we saw that generation is almost equal in the two sectors, with the private being more efficient. The facts seem to be consistent.

The profile of consumption is shown in Tables 8-10. Table 8 is the raw data in PJ. Table 9 shows that the consumption is proportionally higher in the industrial sector, followed by residential (half of the share of industrial consumption) and commercial (half of the share of residential consumption) sectors. Table 10 stresses that inside the industrial sector the highest shares come from pig-iron, steel, non-ferrous, other metals and chemical firms.

Summing up, we have ascertained seven stylized facts for the electric power sector:

- generation is mostly performed in state-owned hydro plants;
- auto-generation (private sector) thermal plants are more efficient;
- the private sector operates in potentially more polluting plants;
- deterioration of distribution services in 1996-1997 followed by unprecedented quality;
- real electricity prices show a decline over time with a partial reversion from 1996 on;
- generation is totally consumed;
- consumption takes place predominantly in the industrial sector.

A more accurate evaluation of the data can be performed when we look at the history of the power plant sector in the last decades. This sector had been considered as a strategic sector for the government of Brazil at least since the 1950s. There was a monopoly of electricity supply. The control of all phases of electricity production and distribution was shared between federal and state government and a tiny participation of the private sector in the following proportions:

- Generation: 65% federal government; 35% state government.
- Transmission: 70% federal government; 30% state government.
- Distribution: 19% federal government; 79% state government; 2% private.

It was argued by supporters of this type of organisation that the heavy investment needed in the sector could only be provided by the government, which had all the conditions to borrow, invest and cope with the increases in demand for electricity.

The 1980s revealed the financial fragility of the sector as a result of price controls (predominantly used as an instrument intended to redistribute income in favour of the poorest classes and some industrial sectors) and bad administration. As a result the World Bank stopped lending to the power sector in 1986 for non-compliance with pricing and financial covenants.[5] The interference of politicians in the administration of firms allied with the control of prices and the shortage of funds resulted in an amount of debt of the order of US$ 26 billion in 1993 which would make the firms bankrupt. In addition an insufficient expansion in the system capacity was detected. There was a deficit in capacity expansion of around 1,100 MW per year

[5] World Bank (1993b) p. 21.

and a necessity to expand 2,000 MW per year.[6] The system was operating beyond its nominal capacity. The government, by means of the Law 8631, assumed the debt, authorized an increase in prices of 70% and eliminated the uniform price regime. We can see in Figure 1 that this movement in prices was not sufficient to proportionate a real increase in prices. As a result the crisis in the sector reappeared in 1995 and debts of US$ 3 billion aroused the fears of bankruptcy.

It was clear then that the structure of the sector was not adequate to provide electricity services with quality, remunerate them according to their costs, increase the supply and improve the efficiency of the firms. From 1995 on a project to restructure the sector by means of privatization (essentially in distribution and generation), a new operator of the system - the Independent National Power System Operator (ONS) - and an independent regulator in the sector - the National Agency of Electrical Energy (ANEEL)[7] were implemented. Worthy of note is the increase in the real price of residential electricity in the period 1996-1998 as a result of the changes. The same is not true of the real price of industrial electricity real price. In the next section we will review the positions of the World Bank in this area so that we can more properly evaluate the reform of the electric power sector.

3. The World Bank approach

The core texts reflecting the World Bank's positions on energy (with emphasis on the electric power sector) and environment are World Bank (1992, 1993a, 1993b, 1999a). The Policy Papers in World Bank (1993a, 1993b) have been in the Operational Manual since May 1996,[8] so it is rewarding to spend some time examining them. Particularly important is World Bank (1993b), in which the staff reviews and analyzes the international restructuring experience in the electric power sector. [9]

The objectives of an electric power sector reform, according to the Bank's view, are the following:

- "increase economic and utility operations efficiency;
- "reduce the financial and administrative burdens they impose on government;
- "reduce the level of public sector debt imposed by the power sector;
- "reduce the cost of electricity by subjecting producers and distributors to competitive market forces." [10]

As for efficiency, we saw that available data shows the superior performance of auto-generation over state-owned thermal plants. The pursuit of efficiency brings the necessity to restructure or privatize the state-owned firms. Financial and administrative burdens occur in great part because of faulty administration and political interference. This generates a flow of financial problems and a huge stock of debt. The last objective would ideally be the transition from monopoly to perfect competition, that is, from an inefficient to an efficient level of energy consumption. In doing this, the electricity producer would not pursue his maximization of rent at the expenses of the consumer, but instead would be in what economists call Pareto optimum (a situation in which consumer and producer surpluses are maximized and

[6] See Ministry of Mines and Energy (1998b).
[7] Law 9427 (26 December 1996).
[8] World Bank (1999a) § 2.19.
[9] Estache & Rodriguez-Pardina (1999) is a more recent paper from the Bank that review exclusively the reforms of Argentina, Chile and Brazil.
[10] World Bank (1993b) p. 43.

no redistribution would produce better results than the chosen equilibrium). Obviously this is an ideal situation and we can expect some form of imperfect competition taking place. It is debatable whether the transition to competitive markets would have significant impacts on prices because the previous pricing policy emphasized redistributive aspects that put the prices to lower levels not sufficient to remunerate adequately the capital invested. An appropriate remuneration would create an expansion of capacity in accordance with the forecasted increase in demand plus some additional margin. This is not the typical case. It seems that prices would need to adjust upwards to a new level consistent with this requirement.

The same report of the World Bank stresses that the above objectives will be achieved by some generic approaches which can be adapted to each country. We shall see in what follows four generic approaches:

- "*Regulatory change*. To reduce the extent to which governments micro-manage utilities and thereby reduce management accountability by controlling prices, borrowing, budgets, investment plans, procurement, staffing levels, and employment conditions.
- "*Organizational changes*. To facilitate structural change within the utility from state monopoly and centralization to decentralization and exposure to competition.
- "*Commercialization and corporitization*. Increasing the utility's business orientation to operate more like a private corporation and less like a government department and subsequently to subject the utility to corporate legislation and require it to compete with other private companies in equal terms.
- "*Increased private sector participation*. Occuring in many forms, including the sale of some or all assets, stock exchange listing, franchising, leasing, contracting out, and nonutility power generation."[11]

These approaches set the tone for reducing the interference of the government in the electric power sector, inducing a mentality like a private firm in the employees and implementing some type of privatization (total or partial). In other words, a complete restructuring of the sector.

With this prospect in mind the World Bank clearly expresses five guiding principles that are valid today. They are:

- "Principle one: *Transparent Regulatory Process*. A requirement for all power lending will be explicit country movement toward the establishment of a legal framework and regulatory processes satisfactory to the Bank. To this end, in conjunction with other economy-wide initiatives, this requires countries to set up transparent regulatory processes that are clearly independent of power suppliers and that avoid government interference in day-to-day power company operations (whether the company is privately or publicly owned). The regulatory framework should establish a sound basis for open discussion of power-sector economic, financial, environmental, and service policies. The Bank must be satisfied that there is meaningful progress towards this objective.
- "Principle two: *Importation of Services*. In some of the last developed countries, where there are weak public and private sectors, a relative lack of market forces, and undeveloped capital markets, an early step in bringing about power-sector reform and increasing sector management efficiency will be to bring local, developed-country, or more advanced developing-country electric power services into the sector.

[11] World Bank (1993b) p. 43-51.

- "Principle three: *Commercialization and Corporatization*. The Bank will aggressively pursue the commercialization and corporatization of, and private sector participation in, developing-country power sectors.
- "Principle four: *Commitment Lending*. The Bank will focus lending for electric power on those countries with a clear commitment to improving sector performance in line with the above principles.
- "Principle five: *Private Investment*. To encourage private investment in the power sector, the Bank will use some of its financial resources to support programs that facilitate the involvement of private investors."[12]

The principles above stress that the World Bank is bent on regulation reforms that give a professional character to state-owned firms and a warm welcome to private participation in the elctric power sector.

When we have in mind the above panorama of the World Bank's view and look at the power sector reform in Brazil it is possible to trace many interrelationships between them. In fact reading the documents supplied by the Ministry of Mines and Energy[13] we can see the necessity of financial support to increase the supply of electricity. We know that the World Bank had not been lending money to the electric power sector in Brazil since 1986. The situation got worse with two crises in the sector in 1993 and 1995. The need for larger increases in electricity supply allied with the absence of funds led to the acceptance of the World Bank principles. They explicitly state that the lending will occur if and only if the reform in the sector is on the way.

The reform looked at in its proper perspective is more an act dictated by necessity than an independent action towards a preferred organisation of the sector. There was no alternative. Indeed if we contemplate the Brazilian projects proposed to the World Bank in the energy area we can conclude that reality is not too far.[14]

We need to understand two basic things: goals and means to achieve these goals.[15] Restructuring, privatization, deregulation and competition in any reform are not goals, but means. The goals in our case can be two: to obtain the necessary financial resources to eliminate any gap between supply and demand; and to obtain greater efficiency in the sector. Our discussion can be viewed as an assesment of the weights that the two objectives had in the decisions towards implementing the reform. The justification based on the second factor is more palatable to the government. We argue that the first factor was an effective constraint that determined the type of reform adopted.

A careful study of a recent paper that will dictate the future policies in the energy area in general (World Bank (1999a)) reveals that nowadays the same principles discussed above for the electric power sector are being applied to operations of the World Bank in the oil, gas and coal sectors.[16] This is the reason for our statement that the same considerations could be applied for instance to the reform in the oil sector that created its regulator (ANP). The reform in the oil sector was a

[12] World Bank (1993b) p. 59-77.
[13] For instance Ministry of Mines and Energy (1998a, b).
[14] There are some projects proposed and one project on energy efficiency that is under implementation. See for instance World Bank (1999a) § 2.32 and World Bank (1999 c, d, 1998, 1997).
[15] See the discussion in Joskow (1998).
[16] World Bank (1999a) § 2.16-2.19.

step towards an efficient exploration of new and old wells with the participation of the private sector.[17] It also opened the doors to new funds provided by the World Bank.[18]

4. Environmental implications

The reforms in the energy sector have something to do with the environment. Efficiency is only halfway to solve the problem. We need to achieve sustainability as well.

4.1. Concepts of sustainability

There are many concepts of sustainability to choose from and no consensus about which one is the best. One example is given by the World Commission on Environment and Development:

"*Sustainable* development is development that *meets the needs of the present without compromising the ability of future generations to meet their own needs*."[19]

This concept stresses the role of intergenerational equity in the sustainability debate. But the term "needs" is too vast to turn this definition into an operational one.

One possibility is to narrow down the definition and consider sustainable development as the situation in which future growth is not compromised by that of the present. This is an operational definition but eliminates from the discussion many problems related to development. It preserves, however, the link between sustainable resource use and growth.

With the previous remarks in mind, it is possible to conceive three definitions of sustainability:[20] nondeclining well-being; nondeclining value of natural capital; and nondeclining physical service flows from selected resources. The first definition assumes perfect substitution between physical and natural capital. The next assumes limited substitution between the two types of capital considering all natural capital as homogeneous. The third definition stresses the physical dimension of sustainability (unlike the previous ones that emphasized the value dimension) and distinguishes between the critical natural capital (essential for sustaining life and not substitutable) and the other types.

The three definitions are intended as a guide to the sustainability debate. If we are to debate intergenerational equity we need a dynamic concept. In order to make some comparisons between efficiency and sustainability, the concept of dynamic efficiency needs to be used. In all the discussions that follows it is necessary to know that not all efficient allocations are sustainable and not all sustainable allocations are efficient. The operational strategy to attack a problem of this type is to choose among all sustainable solutions one that is dynamically efficient.

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[17] The private participation was made possible by auctions called Brazil Oil & Gas Round. The first of this auctions occurred in 1999 and the second is expected to take place in 2000 or 2001.

[18] An accurate exam of the World Bank documents also shows that some money was lent for the oil sector but a part of it was applied in regulatory reforms possibly in the oil sector (Hydrocarbon Transp. Loan LO 3376-BR).

[19] World Commission on Environment and Development (1987) p. 43 (italics added).

[20] See Tietenberg (1996).

4.2. Environment reconsidered

The World Bank reports point out that regulation needs to address environmental questions. As a matter of fact, the reforms designed by the Bank are trying to achieve efficiency and sustainability as we saw in the last section. Our discussion of sustainability will stress the electric power sector reforms but similar measures can be thought of in other sectors.

The measures proposed are related exclusively to thermal power plants. These correspond to a share of 10% in electricity generation. One problem with a cheap solution is emissions of particulate matter, something very harmful to health. Adoption of gas-fired power stations and modifications of coal-fired stations either in location, chimneys or equipment can solve the problem, and the benefits largely compensate the costs. The evidence shows that it costs around 1% or 2% of the total capital costs.[21] We saw in examining Brazilian data (Tables 3-5) that the gas-fired stations are exclusively private. On the other hand the coal-fired stations are almost all state-owned (95%). The government will bear all the costs to do the necessary repairs if these plants are not privatized. The World Bank is progressively restricting the funds to projects involving coal. A good decision is to substitute cleaner technologies for coal.

Another problem is emissions of sulphur dioxide and nitrogen oxides. Apart from moving to gas or clean coal technologies the solutions are expensive (10% to 20% of the capital costs). The impact of emission reduction on health is smaller than in the previous case.

Empirical evidence shows that gas-fired stations and clean coal technologies reduces the emissions of particulates and carbon monoxide by 99.9% and of sulfur dioxide and nitrogen oxides by more than 90%.

The problem of carbon dioxide emissions does not have a technological solution. Lower emissions can be obtained by replacement of the fuels used, of coal by oil and then by gas (the best fuel) or preferably by hydro plants.

Let us see some data related to Brazil concerning carbon dioxide emissions from 1983 to 1996 (Tables 11-14). Table 11 gives raw data in a thousand metric tons of carbon. But it has an interesting indicator: Brazilian carbon dioxide emissions per capita. This index increased 35% from 1983 on (from 0.34 to 0.46). Table 12 stresses the fact that 75% of our emissions are caused by liquid fuels and 17% is due to solid fuels. Table 13 shows the contribution of Brazil to the emissions of Central and South America. In average the Brazil emits 20% of the total for this group of countries. The disaggregated data shows that Brazil is responsible for 50% of emissions of solid fuel, 30% of cement manufacture and 20% of liquid fuels. Gas fuels (4%) and gas flaring (10%) are not urgent problems yet. Table 14 classifies Brazil as the 17th highest carbon dioxide emitter in the world. Its contribution to world emissions is 1.14 %.

We have thermal plants that use liquid and solid fuels. Tables 3-5 shows that thermal plants using diesel oil and fuel oil accounts for 3% of electricity generation. The electricity generated by diesel oil plants is 80% from state-owned and 20% from private plants, while the state-owned and private fuel oil plants have an equal share. These plants need to be replaced by gas-fired plants in order to lower the carbon dioxide emissions. The coal-fired plants are in a similar situation.

The top 20 countries are responsible for 76% of the world carbon dioxide emissions. 1993 data show that the world electric power sector accounts for 30% of

[21] World Bank (1993b) p. 17.

all fossil fuel consumption and 50% of all coal consumption. It is in fact a key sector in this matter.

The profile of the Brazilian electric power sector is not the typical one. As we have seen the hydro plants predominate. Table 15 shows data from Erber (c. 1997)[22] that demonstrates the difference this fact makes on the final result. The fraction of total emissions of some pollutants attributable to the electric power sector in 1997 is around 3.8% for carbon dioxide, 4.3% for sulphur dioxide, 1.8% for nitrogen dioxide and 0.3% for methane. It is quite a small proportion. There is not too much potential to reduce emissions from this point of view apart from some measures sketched above.

The absence of technological solutions and an upward trend in emissions led to the formulation of the Kyoto Protocol, [23] which has the purpose of lowering the emission of pollutants that affect the ozone layer and induce climate changes in the long run. According to the Protocol many developed countries have explicit targets for emissions to be attained in the near future. The alternative to reducing emissions is the so called emissions trading (Kyoto Protocol article 17).

The Prototype Carbon Fund (PCF) was approved by the Executive Board of the World Bank in July 1999 and intends to perform this type of trading[24]. It will be a fund of carbo-reducing investments in which there will be buyers and sellers interested in emissions trading. The purpose is to act as a market intermediary to bring capital from industrialized countries to developing countries so that the developed countries can meet their targets of emission reductions explicited on the Kyoto Protocol. If these funds are to go to developing countries to finance cleaner technologies and Brazil is one of the highest carbon dioxide emitters then there is a strong probability that we will receive a reasonable share of the funds. The electric power sector is not the best candidate for these funds because its participation in carbon dioxide emissions is relatively small. The gas flaring related to the oil sector is not a huge problem either. Perhaps the main part of these funds will go to projects related to the control of vehicle emissions.[25] But this is merely a conjecture because some researchers asseverate that the problem in vehicle emissions will be solved with additional regulations and taxes. It is likely that the funds will come as soon as Brazil makes some voluntary commitments on emission targets.

Another topic related to sustainability is energy conservation.[26] The potential for energy saving and conservation exists in all countries. With energy-saving measures, the supply will not need to be increased so much. In developed countries it is stressed the demand-side management (DSM), which is the utilization of more efficient electric appliances in all places, thus reducing the demand for electricity. If one considers the case of developing countries we can add another form of potential energy saving related to the efficiency of the electric power sector. The creation of appropriate incentives can increase efficiency on the supply-side and save extra energy.

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[22] This data comes from different sources than the previous tables. It is needed some caution in comparisons but we believe that the main findings are the same.

[23] Details about the Kyoto Protocol can be found in Grubb, Vrolijk & Brack (1999) and Barrett (1998). A contribution of the World Bank to the discussions about the Kyoto Protocol mechanisms can be found in World Bank (1999e).

[24] See World Bank (1999a).

[25] An evaluation of the control of vehicle emissions in Brazil can be found in Ferraz & Serôa da Motta (1999).

[26] See World Bank (1993a).

The World Bank has the "Operational Program Number 5", which is also related to the United Nations Framework Convention on Climate Change (UNFCCC), and consequently to the Kyoto Protocol. This aims to remove barriers to energy conservation and energy efficiency, one of the priorities of the Convention to mitigate climate change. The Brazilian electric power sector has some projects in this area which have the funding of the World Bank.[27] Brazil's concern with efficiency and conservation was addressed in a speech of the Minister of Science and Technology at the Conference of the Parties 5 held in Bonn (25 October – 5 November 1999). It is expected that the bulk of external funds in the near future will come under this heading.

5. Conclusions

Our purpose in this paper was threefold: to provide some basic facts on the Brazilian electric power sector; to discuss the sector reform from another perspective, considering the World Bank priorities and the Brazilian situation; and to trace some environmental considerations based on available documents and data.

We have concluded that the basic determinant forces that induced the reform in the electric power sector were the potential shortage of electricity, the need of external funds to face the increasing demand and the World Bank principles to lend funds. It is unreasonable to consider this decision as independent. We have shown that it was certainly constrained.

We have argued that the link between the government and the World Bank would be essential to identify future trends in the environmental area. Then we discussed some potential measures to reduce pollution in the energy sector based on World Bank documents. We stressed the fact that Brazil is one of the twenty higher carbon dioxide emitter countries. On the other hand the country is eligible to receive funds from the Operational Program Number 5 and the Prototype Carbon Fund, both related to the implementation of some aspects of the UNFCCC and the Kyoto Protocol. Perhaps some voluntary commitment on emission targets will be asked in exchange.

[27] See the references in fn. 8 for the projects. For a paper addressing the Brazilian situation on energy conservation and efficiency see World Bank (1995).

APPENDIX

FIGURES AND TABLES

TABLE 1
Electricity Real Prices
1983-1998

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Residential (R$/GJ)	55,75	50,86	46,17	42,72	62,14	48,94	36,50	39,92	46,53	44,53	32,08	33,06	30,58	39,08	40,81	42,97
Industrial (R$/GJ)	34,58	34,08	33,28	33,94	42,69	38,81	33,25	30,17	26,94	26,89	20,08	20,31	17,03	18,00	18,08	18,64
Residential (US$/GJ)	47,98	43,65	39,73	36,78	53,48	41,99	31,30	34,55	40,27	38,54	27,77	28,61	26,47	33,83	35,30	37,18
Industrial (US$/GJ)	29,78	29,28	28,64	29,23	36,73	33,29	28,53	26,11	23,33	23,27	17,39	17,58	14,74	15,59	15,66	16,12

Source: Ministry of Mines and Energy (1999). Prices at the 1998 level.

TABLE 2

Electric Power Sector:
Selected Data 1983-1998

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Consumption/Generation (%)	88,6	89,2	89,6	92,5	94,8	94,9	95,8	97,7	96,2	95,3	95,7	96,1	96,1	95,3	95,7	95,5
Total consumption (PJ)	518,1	576,0	624,8	673,4	693,9	734,1	764,6	783,6	811,3	829,7	868,2	899,3	953,3	999,7	1060,9	1105,2
Generation (PJ)	585,0	645,8	697,3	727,7	732,0	773,8	798,3	802,2	843,7	870,2	907,1	936,1	992,2	1048,5	1108,7	1157,7
Hydro Plants	545,3	599,7	642,2	656,7	668,2	716,8	736,9	744,1	784,0	804,1	846,3	873,7	914,0	956,8	1004,3	1048,9
Thermal Plants	39,6	46,1	55,1	70,9	63,9	57,1	61,4	58,0	59,7	66,2	60,8	62,4	78,1	91,7	104,4	108,8
Efficiency (%)	35,7	30,7	32,2	32,1	31,2	31,1	32,8	32,7	32,2	31,1	31,4	33,3	31,5	33,2	32,9	31,4
Public Utility Power Plants	15,5	22,5	32,5	44,9	36,6	29,6	34,8	26,4	26,4	29,3	22,5	23,1	36,8	42,7	51,3	53,3
Efficiency (%)	28,0	23,0	28,5	29,3	26,6	25,6	29,2	26,2	25,7	26,7	25,3	25,2	24,6	26,9	26,6	24,3
Auto-Generation	24,1	23,6	22,6	26,0	27,2	27,5	26,6	31,6	33,3	36,9	38,4	39,3	41,3	49,1	53,1	55,5
Efficiency (%)	40,6	38,1	37,5	37,0	37,5	37,0	37,5	38,1	37,3	34,5	35,0	38,1	37,6	38,6	39,0	38,3
Power outages (mean hours)	na	na	na	na	na	na	na	na	28,2	27,4	26,1	25,3	24,3	26,1	27,4	24,0
Power outages (mean events)	na	na	na	na	na	na	na	na	20,6	20,9	20,1	20,4	20,4	21,9	21,8	19,9

Sources: Ministry of Mines and Energy (1999), ANEEL (1998). na=not available.

TABLE 3 - Electricity Generation 1983-1998 (PJ)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Generation	585,0	645,8	697,3	727,7	732,0	773,8	798,3	802,2	843,7	870,2	907,1	936,1	992,2	1048,5	1108,7	1157,7
Public Utility Power Plants	550,1	611,3	663,7	689,3	692,2	733,6	758,8	759,3	799,0	823,4	856,6	885,2	938,4	983,9	1039,8	1084,3
Auto-Generation	34,8	34,5	33,6	38,4	39,8	40,2	39,5	42,9	44,8	46,9	50,5	51,0	53,7	64,6	68,9	73,4
Hydro Plants	545,3	599,7	642,2	656,7	668,2	716,7	736,9	744,1	784,0	804,0	846,2	873,7	914,1	956,8	1004,3	1048,9
Public Utility Power Plants	534,6	588,8	631,2	644,4	655,6	704,0	724,0	732,9	772,6	794,1	834,1	862,1	901,6	941,2	988,5	1031,0
Auto-Generation	10,7	10,9	10,9	12,3	12,6	12,8	12,9	11,2	11,4	9,9	12,1	11,7	12,4	15,6	15,8	17,9
Thermal Plants	39,7	46,1	55,1	71,0	63,8	57,1	61,4	58,0	59,7	66,2	60,9	62,4	78,1	91,7	104,4	108,8
Public Utility Power Plants	15,5	22,5	32,5	44,9	36,6	29,6	34,8	26,3	26,4	29,3	22,5	23,1	36,8	42,7	51,3	53,3
Auto-Generation	24,1	23,6	22,6	26,0	27,2	27,5	26,6	31,7	33,3	36,9	38,4	39,3	41,3	49,0	53,1	55,5
Natural Gas	0,0	0,0	0,0	0,0	0,0	0,0	0,8	2,4	2,7	1,4	1,4	1,7	2,0	3,5	4,0	4,2
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,4	2,7	1,4	1,4	1,7	2,0	3,5	4,0	4,2
Steam Coal	9,4	10,3	12,4	16,6	13,3	10,2	14,0	10,1	12,4	12,0	11,3	12,2	14,2	15,7	19,9	17,6
Public Utility Power Plants	9,0	9,9	12,0	16,1	12,8	9,7	13,6	9,8	12,0	11,2	10,4	11,2	13,2	14,6	19,0	16,7
Auto-Generation	0,3	0,4	0,4	0,5	0,5	0,5	0,4	0,4	0,4	0,7	0,8	1,0	1,0	1,2	0,9	1,0
Firewood	1,6	1,9	2,0	2,2	2,3	2,1	1,9	2,2	2,1	2,8	3,1	2,4	2,3	2,4	2,6	2,5
Public Utility Power Plants	0,0	0,0	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	1,6	1,9	2,0	2,1	2,2	2,0	1,9	2,2	2,1	2,8	3,1	2,4	2,3	2,4	2,6	2,5
Sugar Cane Bagasse	6,7	5,9	6,3	6,1	6,9	6,8	6,4	6,3	6,8	7,4	7,3	8,3	9,3	12,9	14,0	14,3
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Auto-Generation	6,7	5,9	6,3	6,1	6,9	6,8	6,4	6,3	6,8	7,4	7,3	8,3	9,3	12,9	14,0	14,3
Black Liquor	2,4	2,4	2,5	2,5	2,9	2,5	2,8	3,6	3,6	6,5	6,0	7,8	7,9	8,2	9,0	9,1
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	2,4	2,4	2,5	2,5	2,9	2,5	2,8	3,6	3,6	6,5	6,0	7,8	7,9	8,2	9,0	9,1
Other Wastes	3,7	5,2	3,8	4,6	5,6	6,1	4,9	5,9	6,8	5,2	6,0	5,5	4,9	5,1	6,3	7,0
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	3,7	5,2	3,8	4,6	5,6	6,1	4,9	5,9	6,8	5,2	6,0	5,5	4,9	5,1	6,3	7,0
Diesel Oil	4,2	4,2	5,1	6,4	10,0	9,5	8,2	6,8	6,9	8,2	7,6	7,9	11,1	11,2	14,8	18,8
Public Utility Power Plants	3,3	3,2	4,1	5,3	8,8	8,3	7,0	5,4	5,6	7,0	6,3	6,6	9,7	8,7	11,7	15,0
Auto-Generation	1,0	1,0	1,0	1,1	1,2	1,2	1,2	1,4	1,4	1,2	1,3	1,3	1,4	2,6	3,1	3,8
Fuel Oil	10,2	7,9	8,8	30,1	17,5	15,4	13,0	10,1	10,4	11,4	11,4	11,8	12,4	18,4	16,7	17,5
Public Utility Power Plants	3,2	3,4	4,1	22,9	11,4	9,3	6,8	3,1	3,6	4,7	4,1	5,0	4,8	10,7	9,3	9,9
Auto-Generation	7,0	4,5	4,7	7,1	6,1	6,1	6,2	7,0	6,8	6,7	7,3	6,7	7,6	7,7	7,5	7,6
Gas Coke	1,1	2,0	1,9	1,7	1,2	1,4	1,9	1,6	1,9	1,8	1,9	1,1	1,1	1,5	1,1	1,6
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	1,1	2,0	1,9	1,7	1,2	1,4	1,9	1,6	1,9	1,8	1,9	1,1	1,1	1,5	1,1	1,6
Other Secondary Sources	0,3	0,2	0,2	0,2	0,5	1,0	0,9	0,9	1,0	3,2	3,4	3,5	3,8	4,0	4,7	4,4
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,3	0,2	0,2	0,2	0,5	1,0	0,9	0,9	1,0	3,2	3,4	3,5	3,8	4,0	4,7	4,4
Uranium contained in OU2	0,0	5,9	12,2	0,5	3,5	2,2	6,6	8,1	5,2	6,3	1,6	0,2	9,1	8,7	11,4	11,8
Public Utility Power Plants	0,0	5,9	12,2	0,5	3,5	2,2	6,6	8,1	5,2	6,3	1,6	0,2	9,1	8,7	11,4	11,8
Auto-Generation	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Source: Ministry of Mines and Energy (1999).

TABLE 4 - Relative Contribution to Electricity Generation 1983-1998 (%)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Generation	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	94,0	94,7	95,2	94,7	94,6	94,8	95,1	94,7	94,7	94,6	94,4	94,6	94,6	93,8	93,8	93,7
Auto-Generation	6,0	5,3	4,8	5,3	5,4	5,2	4,9	5,3	5,3	5,4	5,6	5,4	5,4	6,2	6,2	6,3
Hydro Plants	93,2	92,9	92,1	90,2	91,3	92,6	92,3	92,8	92,9	92,4	93,3	93,3	92,1	91,3	90,6	90,6
Public Utility Power Plants	91,4	91,2	90,5	88,6	89,6	91,0	90,7	91,4	91,6	91,3	92,0	92,1	90,9	89,8	89,2	89,1
Auto-Generation	1,8	1,7	1,6	1,7	1,7	1,6	1,6	1,4	1,4	1,1	1,3	1,2	1,3	1,5	1,4	1,5
Thermal Plants	6,8	7,1	7,9	9,8	8,7	7,4	7,7	7,2	7,1	7,6	6,7	6,7	7,9	8,7	9,4	9,4
Public Utility Power Plants	2,7	3,5	4,7	6,2	5,0	3,8	4,4	3,3	3,1	3,4	2,5	2,5	3,7	4,1	4,6	4,6
Auto-Generation	4,1	3,7	3,2	3,6	3,7	3,5	3,3	3,9	4,0	4,2	4,2	4,2	4,2	4,7	4,8	4,8
Natural Gas	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,3	0,3	0,2	0,2	0,2	0,2	0,3	0,4	0,4
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,3	0,2	0,2	0,2	0,2	0,3	0,4	0,4
Steam Coal	1,6	1,6	1,8	2,3	1,8	1,3	1,7	1,3	1,5	1,4	1,2	1,3	1,4	1,5	1,8	1,5
Public Utility Power Plants	1,5	1,5	1,7	2,2	1,7	1,3	1,7	1,2	1,4	1,3	1,1	1,2	1,3	1,4	1,7	1,4
Auto-Generation	0,1	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Firewood	0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,3	0,2	0,3	0,3	0,3	0,2	0,2	0,2	0,2
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,3	0,3	0,3	0,3	0,3	0,3	0,2	0,3	0,2	0,3	0,3	0,3	0,2	0,2	0,2	0,2
Sugar Cane Bagasse	1,2	0,9	0,9	0,8	0,9	0,9	0,8	0,8	0,8	0,9	0,8	0,9	0,9	1,2	1,3	1,2
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	1,2	0,9	0,9	0,8	0,9	0,9	0,8	0,8	0,8	0,9	0,8	0,9	0,9	1,2	1,3	1,2

Black Liquor	0,4	0,4	0,4	0,3	0,4	0,3	0,4	0,5	0,4	0,7	0,7	0,8	0,8	0,8	0,8	0,8
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,4	0,4	0,4	0,3	0,4	0,3	0,4	0,5	0,4	0,7	0,7	0,8	0,8	0,8	0,8	0,8
Other Wastes	0,6	0,8	0,5	0,6	0,8	0,8	0,6	0,7	0,8	0,6	0,7	0,6	0,5	0,5	0,6	0,6
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,6	0,8	0,5	0,6	0,8	0,8	0,6	0,7	0,8	0,6	0,7	0,6	0,5	0,5	0,6	0,6
Diesel Oil	0,7	0,7	0,7	0,9	1,4	1,2	1,0	0,9	0,8	0,9	0,8	0,8	1,1	1,1	1,3	1,6
Public Utility Power Plants	0,6	0,5	0,6	0,7	1,2	1,1	0,9	0,7	0,7	0,8	0,7	0,7	1,0	0,8	1,1	1,3
Auto-Generation	0,2	0,2	0,1	0,2	0,2	0,2	0,1	0,2	0,2	0,1	0,1	0,1	0,1	0,2	0,3	0,3
Fuel Oil	1,8	1,2	1,3	4,1	2,4	2,0	1,6	1,3	1,2	1,3	1,3	1,3	1,2	1,8	1,5	1,5
Public Utility Power Plants	0,6	0,5	0,6	3,2	1,6	1,2	0,9	0,4	0,4	0,5	0,5	0,5	0,5	1,0	0,8	0,9
Auto-Generation	1,2	0,7	0,7	1,0	0,8	0,8	0,8	0,9	0,8	0,8	0,8	0,7	0,8	0,7	0,7	0,7
Gas Coke	0,2	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,2	0,3	0,3	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,1	0,1	0,1	0,1
Other Secondary Sources	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	0,0	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,4	0,4	0,4	0,4	0,4	0,4	0,4
Uranium contained in OU2	0,0	0,9	1,7	0,1	0,5	0,3	0,8	1,0	0,6	0,7	0,2	0,0	0,9	0,8	1,0	1,0
Public Utility Power Plants	0,0	0,9	1,7	0,1	0,5	0,3	0,8	1,0	0,6	0,7	0,2	0,0	0,9	0,8	1,0	1,0
Auto-Generation	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Source: Ministry of Mines and Energy (1999).

TABLE 5 - Relative Contribution of Public and Private Plants to Electricity Generation by Type of Plant 1983-1998 (%)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Generation	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	94,0	94,7	95,2	94,7	94,6	94,8	95,1	94,7	94,7	94,6	94,4	94,6	94,6	93,8	93,8	93,7
Auto-Generation	6,0	5,3	4,8	5,3	5,4	5,2	4,9	5,3	5,3	5,4	5,6	5,4	5,4	6,2	6,2	6,3
Hydro Plants	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	98,0	98,2	98,3	98,1	98,1	98,2	98,2	98,5	98,5	98,8	98,6	98,7	98,6	98,4	98,4	98,3
Auto-Generation	2,0	1,8	1,7	1,9	1,9	1,8	1,8	1,5	1,5	1,2	1,4	1,3	1,4	1,6	1,6	1,7
Thermal Plants	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	39,1	48,8	58,9	63,3	57,4	51,9	56,7	45,4	44,2	44,2	36,9	37,0	47,1	46,5	49,2	49,0
Auto-Generation	60,9	51,2	41,1	36,7	42,6	48,1	43,3	54,6	55,8	55,8	63,1	63,0	52,9	53,5	50,8	51,0
Natural Gas	na	na	na	na	na	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	na	na	na	na	na	100,0	100,0	1,8	0,5	0,8	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	na	na	na	na	na	0,0	0,0	98,2	99,5	99,2	100,0	100,0	100,0	100,0	100,0	100,0
Steam Coal	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	96,4	96,5	97,0	97,2	96,3	95,3	97,2	96,3	96,9	94,0	92,7	91,5	93,0	92,6	95,5	94,6
Auto-Generation	3,6	3,5	3,0	2,8	3,7	4,7	2,8	3,7	3,1	6,0	7,3	8,5	7,0	7,4	4,5	5,4
Firewood	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	0,2	0,2	3,5	5,2	5,2	4,4	1,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	99,8	99,8	96,5	94,8	94,8	95,6	98,7	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Sugar Cane Bagasse	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Black Liquor	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Other Wastes	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Diesel Oil	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	77,4	76,6	80,0	82,1	88,3	87,5	85,8	79,5	80,0	84,9	83,3	83,8	87,7	77,2	79,2	79,8
Auto-Generation	22,6	23,4	20,0	17,9	11,7	12,5	14,2	20,5	20,0	15,1	16,7	16,2	12,3	22,8	20,8	20,2
Fuel Oil	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	31,5	42,9	46,9	76,2	65,0	60,5	52,5	30,4	35,0	41,1	36,1	42,8	38,9	58,2	55,4	56,6
Auto-Generation	68,5	57,1	53,1	23,8	35,0	39,5	47,5	69,6	65,0	58,9	63,9	57,2	61,1	41,8	44,6	43,4
Gas Coke	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Other Secondary Sources	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Auto-Generation	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Uranium contained in OU2	na	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Public Utility Power Plants	na	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Auto-Generation	na	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Source: Ministry of Mines and Energy (1999). na=type of plant not available.

TABLE 6

Electric Power Sector: Installed Capacity 1983-1998 (GJ/s)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Installed Capacity	40,37	41,10	44,11	44,95	47,56	49,58	52,13	53,05	54,14	55,05	56,22	57,63	59,12	61,53	62,97	65,21
Public Utility Power Plants	37,20	37,93	40,82	41,66	44,26	46,27	48,84	49,76	50,85	51,76	52,75	54,11	55,53	57,92	59,15	61,31
Auto-Generation	3,17	3,17	3,29	3,29	3,30	3,31	3,29	3,29	3,29	3,29	3,47	3,52	3,59	3,61	3,82	3,90
Hydro Plants	34,18	34,92	37,08	37,79	40,33	42,23	44,80	45,56	46,62	47,71	48,59	49,92	51,37	53,43	54,89	56,76
Public Utility Power Plants*	33,56	34,30	36,45	37,16	39,69	41,58	44,17	44,93	45,99	47,09	47,97	49,30	50,68	52,74	53,99	55,86
Half of Itaipu Plant	0,00	0,70	1,05	2,10	3,15	4,20	5,25	5,60	6,30	6,30	6,30	6,30	6,30	6,30	6,30	6,30
Auto-Generation	0,62	0,62	0,62	0,62	0,64	0,65	0,62	0,62	0,62	0,62	0,62	0,62	0,69	0,69	0,90	0,90
Thermal Plants	6,19	6,17	6,37	6,51	6,58	6,69	6,67	6,84	6,87	6,68	6,97	7,05	7,10	7,44	7,43	7,79
Public Utility Power Plants	3,64	3,63	3,71	3,85	3,91	4,03	4,01	4,17	4,20	4,02	4,13	4,15	4,20	4,52	4,51	4,80
Auto-Generation	2,55	2,55	2,67	2,67	2,67	2,67	2,67	2,67	2,67	2,67	2,85	2,90	2,90	2,92	2,92	3,00
Nuclear Plants	0,00	0,00	0,66	0,66	0,66	0,66	0,66	0,66	0,66	0,66	0,66	0,66	0,66	0,66	0,66	0,66

Source: Ministry of Mines and Energy (1999). * Includes half of Itaipu Plant from 1984 on.

TABLE 7
Relative Contribution to Installed Capacity 1983-1998 (%)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Installed Capacity	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Public Utility Power Plants	92,15	92,29	92,54	92,68	93,06	93,32	93,69	93,80	93,93	94,03	93,83	93,89	93,93	94,14	93,93	94,02
Auto-Generation	7,85	7,71	7,46	7,32	6,94	6,68	6,31	6,20	6,07	5,97	6,17	6,11	6,07	5,86	6,07	5,98
Hydro Plants	84,67	84,98	84,06	84,06	84,79	85,18	85,94	85,88	86,10	86,67	86,43	86,62	86,89	86,84	87,16	87,04
Public Utility Power Plants*	83,13	83,47	82,65	82,67	83,46	83,88	84,74	84,70	84,95	85,53	85,32	85,54	85,72	85,72	85,73	85,66
Half of Itaipu Plant	0,00	1,70	2,38	4,67	6,62	8,47	10,07	10,56	11,64	11,44	11,21	10,93	10,66	10,24	10,00	9,66
Auto-Generation	1,54	1,51	1,41	1,39	1,34	1,30	1,20	1,18	1,15	1,13	1,11	1,08	1,16	1,12	1,43	1,38
Thermal Plants	15,33	15,02	14,45	14,48	13,82	13,49	12,80	12,88	12,69	12,14	12,40	12,24	12,00	12,10	11,79	11,95
Public Utility Power Plants	9,02	8,82	8,41	8,55	8,22	8,12	7,69	7,86	7,76	7,30	7,34	7,20	7,10	7,35	7,16	7,36
Auto-Generation	6,31	6,20	6,04	5,93	5,60	5,38	5,11	5,02	4,92	4,84	5,06	5,03	4,91	4,75	4,64	4,59
Nuclear Plants	0,00	0,00	1,49	1,46	1,38	1,33	1,26	1,24	1,21	1,19	1,17	1,14	1,11	1,07	1,04	1,01

Source: Ministry of Mines and Energy (1999). * Includes half of Itaipu Plant from 1984 on.

TABLE 8
Electricity Consumption
1983-1998 (PJ)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Total consumption*	518,1	576,0	624,8	673,4	693,9	734,1	764,6	783,6	811,3	829,7	868,2	899,3	953,3	999,7	1060,9	1105,2
Energy Sector	18,1	20,5	22,4	22,9	23,0	23,6	24,0	24,6	28,0	28,3	28,6	27,9	29,9	32,5	32,9	34,7
Residential	107,0	111,3	117,5	128,7	138,2	145,9	157,4	175,2	183,7	186,7	193,1	201,4	228,9	248,6	266,7	285,7
Commercial	60,3	63,7	66,5	70,5	73,7	76,8	81,0	85,8	87,7	93,4	98,7	104,0	116,2	125,2	137,4	149,7
Public	46,2	48,8	51,8	53,5	56,1	59,8	62,3	65,3	67,5	70,1	73,9	77,3	83,1	86,7	93,0	98,1
Agriculture	11,6	13,8	16,1	18,0	21,2	22,4	22,9	24,0	26,3	27,1	28,8	30,2	33,0	35,5	38,9	41,8
Transportation**	3,8	4,0	4,1	4,2	4,3	4,3	4,7	4,3	3,9	4,3	4,3	4,2	4,4	4,1	4,1	4,2
Industrial	271,1	313,9	346,4	375,7	377,7	401,2	412,4	404,4	414,1	419,7	440,9	454,2	457,8	467,1	487,9	491,0
Cement	8,8	8,4	8,8	10,8	10,1	10,0	10,1	10,6	11,1	10,3	10,7	11,0	11,8	13,2	15,5	16,3
Pig-iron and Steel	33,5	40,7	44,5	47,7	48,7	51,6	53,9	46,0	46,5	48,3	52,0	53,9	51,7	51,4	51,6	50,2
Ferro-alloys	11,9	13,7	15,0	17,9	18,3	20,9	23,3	22,4	22,3	27,0	25,9	22,9	22,7	24,8	22,6	19,0
Mining/Pelletization	15,4	18,3	19,7	21,0	21,4	20,9	20,2	21,4	20,6	21,2	21,6	23,2	22,7	21,1	23,3	25,9
Non-ferrous/Other Metals	42,8	51,8	61,8	74,3	77,5	85,7	88,9	92,0	100,9	100,6	102,6	103,0	102,8	103,3	100,1	99,9
Chemical	36,1	40,6	47,3	46,9	45,0	47,0	46,6	47,9	46,8	48,6	52,4	53,8	53,5	54,4	57,0	57,3
Foods and Beveradges	27,0	33,0	34,9	35,2	33,1	34,8	34,3	37,2	38,6	39,8	42,1	43,2	45,8	49,1	51,9	54,5
Textiles	16,0	18,4	20,1	21,2	20,2	21,9	22,5	22,6	22,1	22,1	23,6	24,3	23,1	21,5	22,1	22,0
Paper and Pulp	20,5	21,3	23,9	24,7	24,5	26,0	28,1	27,7	30,6	32,3	34,7	35,0	35,3	35,8	38,2	39,3
Ceramics	6,1	6,2	6,8	8,0	7,7	7,5	7,8	6,6	6,3	6,2	6,5	6,8	7,2	7,8	9,3	9,7
Others	52,9	61,5	63,7	67,8	71,3	74,8	76,8	70,1	68,5	63,3	68,8	77,3	81,2	84,7	96,2	97,0

Source: Ministry of Mines and Energy (1999). * Total consumption=Final Consumption=Final Energy Consumption. ** Railroads.

TABLE 9

Relative Participation in Electricity Consumption by Sector 1983-1998 (%)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Total consumption*	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Energy Sector	3,5	3,6	3,6	3,4	3,3	3,2	3,1	3,1	3,5	3,4	3,3	3,1	3,1	3,2	3,1	3,1
Residential	20,7	19,3	18,8	19,1	19,9	19,9	20,6	22,4	22,6	22,5	22,2	22,4	24,0	24,9	25,1	25,9
Commercial	11,6	11,1	10,6	10,5	10,6	10,5	10,6	10,9	10,8	11,3	11,4	11,6	12,2	12,5	13,0	13,5
Public	8,9	8,5	8,3	7,9	8,1	8,1	8,1	8,3	8,3	8,5	8,5	8,6	8,7	8,7	8,8	8,9
Agriculture	2,2	2,4	2,6	2,7	3,0	3,1	3,0	3,1	3,2	3,3	3,3	3,4	3,5	3,5	3,7	3,8
Transportation**	0,7	0,7	0,7	0,6	0,6	0,6	0,6	0,5	0,5	0,5	0,5	0,5	0,5	0,4	0,4	0,4
Industrial	52,3	54,5	55,4	55,8	54,4	54,7	53,9	51,6	51,0	50,6	50,8	50,5	48,0	46,7	46,0	44,4
Cement	1,7	1,5	1,4	1,6	1,5	1,4	1,3	1,3	1,4	1,2	1,2	1,2	1,2	1,3	1,5	1,5
Pig-iron and Steel	6,5	7,1	7,1	7,1	7,0	7,0	7,0	5,9	5,7	5,8	6,0	6,0	5,4	5,1	4,9	4,5
Ferro-alloys	2,3	2,4	2,4	2,7	2,6	2,8	3,0	2,9	2,8	3,3	3,0	2,5	2,4	2,5	2,1	1,7
Mining/Pelletization	3,0	3,2	3,1	3,1	3,1	2,8	2,6	2,7	2,5	2,6	2,5	2,6	2,4	2,1	2,2	2,3
Non-ferrous/Other Metals	8,3	9,0	9,9	11,0	11,2	11,7	11,6	11,7	12,4	12,1	11,8	11,4	10,8	10,3	9,4	9,0
Chemical	7,0	7,1	7,6	7,0	6,5	6,4	6,1	6,1	5,8	5,9	6,0	6,0	5,6	5,4	5,4	5,2
Foods and Beveradges	5,2	5,7	5,6	5,2	4,8	4,7	4,5	4,7	4,8	4,8	4,8	4,8	4,8	4,9	4,9	4,9
Textiles	3,1	3,2	3,2	3,1	2,9	3,0	2,9	2,9	2,7	2,7	2,7	2,7	2,4	2,2	2,1	2,0
Paper and Pulp	4,0	3,7	3,8	3,7	3,5	3,5	3,7	3,5	3,8	3,9	4,0	3,9	3,7	3,6	3,6	3,6
Ceramics	1,2	1,1	1,1	1,2	1,1	1,0	1,0	0,8	0,8	0,8	0,7	0,8	0,8	0,8	0,9	0,9
Others	10,2	10,7	10,2	10,1	10,3	10,2	10,0	8,9	8,4	7,6	7,9	8,6	8,5	8,5	9,1	8,8

Source: Ministry of Mines and Energy (1999). * Total consumption=Final Consumption=Final Energy Consumption. ** Railroads.

TABLE 10

Relative Participation in Industrial Electricity Consumption 1983-1998 (%)

	Year															
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Industrial Consumption	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Cement	3,2	2,7	2,6	2,9	2,7	2,5	2,5	2,6	2,7	2,4	2,4	2,4	2,6	2,8	3,2	3,3
Pig-iron and Steel	12,4	13,0	12,8	12,7	12,9	12,9	13,1	11,4	11,2	11,5	11,8	11,9	11,3	11,0	10,6	10,2
Ferro-alloys	4,4	4,4	4,3	4,8	4,9	5,2	5,6	5,5	5,4	6,4	5,9	5,0	5,0	5,3	4,6	3,9
Mining/Pelletization	5,7	5,8	5,7	5,6	5,7	5,2	4,9	5,3	5,0	5,0	4,9	5,1	5,0	4,5	4,8	5,3
Non-ferrous/Other Metals	15,8	16,5	17,8	19,8	20,5	21,4	21,6	22,7	24,4	24,0	23,3	22,7	22,4	22,1	20,5	20,3
Chemical	13,3	13,0	13,7	12,5	11,9	11,7	11,3	11,9	11,3	11,6	11,9	11,8	11,7	11,7	11,7	11,7
Foods and Beveradges	9,9	10,5	10,1	9,4	8,8	8,7	8,3	9,2	9,3	9,5	9,5	9,5	10,0	10,5	10,6	11,1
Textiles	5,9	5,9	5,8	5,6	5,3	5,5	5,4	5,6	5,3	5,3	5,4	5,3	5,1	4,6	4,5	4,5
Paper and Pulp	7,6	6,8	6,9	6,6	6,5	6,5	6,8	6,8	7,4	7,7	7,9	7,7	7,7	7,7	7,8	8,0
Ceramics	2,3	2,0	2,0	2,1	2,0	1,9	1,9	1,6	1,5	1,5	1,5	1,5	1,6	1,7	1,9	2,0
Others	19,5	19,6	18,4	18,0	18,9	18,7	18,6	17,3	16,5	15,1	15,6	17,0	17,7	18,1	19,7	19,8

Source: Ministry of Mines and Energy (1999).

TABLE 11
Brazilian CO_2 Emissions 1983-1996 (1000 metric tons of carbon)

	Year													
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Per Capita	0,34	0,34	0,35	0,38	0,39	0,39	0,39	0,37	0,39	0,38	0,39	0,41	0,43	0,46
Total	44396	44428	47564	52509	55057	55443	56780	55298	58377	58702	61112	64192	68305	74610
Gas Fuels	922	1138	1363	1634	1812	1867	1994	2025	1981	2128	2324	2411	2587	2899
Liquid Fuels	33277	31769	32937	37128	38184	38646	39784	39399	40880	42030	43776	46215	49131	53926
Solid Fuels	6526	7854	9518	9588	10983	10857	10900	9751	11193	10758	11031	11487	12110	12184
Bunker Fuels	1418	1312	1337	1155	1089	821	893	860	1076	1099	1304	1539	1569	1801
Gas Flaring	833	983	941	718	615	628	577	614	585	536	602	634	634	896
Cement Manufacture	2838	2685	2803	3440	3464	3445	3526	3509	3739	3251	3379	3445	3843	4705

Source: Marland, Boden, Andres, Brenkert & Johnston (1999).

TABLE 12

Composition of Brazilian CO_2 Emissions 1983-1996 (%)

	Year													
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Gas Fuels	2,1	2,6	2,9	3,1	3,3	3,4	3,5	3,7	3,4	3,6	3,8	3,8	3,8	3,9
Liquid Fuels	75,0	71,5	69,2	70,7	69,4	69,7	70,1	71,2	70,0	71,6	71,6	72,0	71,9	72,3
Solid Fuels	14,7	17,7	20,0	18,3	19,9	19,6	19,2	17,6	19,2	18,3	18,1	17,9	17,7	16,3
Bunker Fuels	3,2	3,0	2,8	2,2	2,0	1,5	1,6	1,6	1,8	1,9	2,1	2,4	2,3	2,4
Gas Flaring	1,9	2,2	2,0	1,4	1,1	1,1	1,0	1,1	1,0	0,9	1,0	1,0	0,9	1,2
Cement Manufacture	6,4	6,0	5,9	6,6	6,3	6,2	6,2	6,3	6,4	5,5	5,5	5,4	5,6	6,3

Source: Marland, Boden, Andres, Brenkert & Johnston (1999).

TABLE 13

Brazilian Share in Central and South American CO_2 Emissions 1983-1996 (1000 metric tons of carbon)

	Year													
	1983	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Total	18,5	18,9	19,9	21,8	21,5	21,4	21,5	20,6	20,8	19,9	19,8	19,5	20,6	22,1
Gas Fuels	2,3	3,0	3,5	4,3	4,5	4,4	4,5	4,4	3,9	4,1	4,1	3,9	4,1	4,7
Liquid Fuels	20,1	19,6	20,2	22,4	21,7	21,9	22,1	21,5	21,3	20,7	21,0	20,9	22,2	23,7
Solid Fuels	44,0	48,2	51,1	51,2	54,2	52,2	49,2	46,5	52,7	49,9	49,8	48,2	47,6	47,6
Gas Flaring	9,1	11,3	11,2	9,4	7,8	8,3	8,8	9,3	9,5	8,1	7,5	7,1	7,4	10,5
Cement Manufacture	31,2	28,9	28,9	32,4	30,2	29,6	31,3	30,3	31,5	27,2	27,2	25,7	29,6	34,1

Source: Marland, Boden, Andres, Brenkert & Johnston (1999).

TABLE 14
Top 20 Highest Fossil-Fuel CO_2-Emitting Countries (1996)

	Country	Emissions	%Total
1	United States of America	1446777	22,20
2	Peoples Republic of China	917997	14,08
3	Russia Federation	431090	6,61
4	Japan	318686	4,89
5	India	272212	4,18
6	Germany	235050	3,61
7	United Kingdom	152015	2,33
8	Canada	111723	1,71
9	Republic of Korea (South Korea)	111370	1,71
10	Italy	110052	1,69
11	Ukraine	108431	1,66
12	France (including Monaco)	98750	1,52
13	Poland	97375	1,49
14	Mexico	95007	1,46
15	Australia	83688	1,28
16	South Africa	79898	1,23
17	Brazil	74610	1,14
18	Saudi Arabia	73098	1,12
19	Islamic Republic of Iran	72779	1,12
20	Democratic Peoples Republic of Korea (North Korea)	69412	1,06
	Total 20 Countries	4960020	76,10
	Total All Countries	6518000	100,00

Source: Marland, Boden, Andres, Brenkert & Johnston (1999)

TABLE 15

Proportion of Brazilian Total Emissions Related to the Electric Power Sector (%)

	Year				
	1970	**1980**	**1990**	**1996**	**1997**
CO_2	4	2,9	2,9	3,4	3,8
SO_2	4,6	2,7	2,7	3,5	4,3
NO_2	1,6	1,1	1,1	1,5	1,8
CH_4	0,3	0,2	0,2	0,3	0,3

Source: Erber (1998)

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