Expanding Access to Electricity in Brazil

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Abstract

In 1993, the Brazilian electric sector initiated a restructuring process by unbundling the generation, transmission, and distribution components of the existing companies. This ultimately led to the privatization of most distribution assets and some of the generation assets. However, little attention was paid in the process to the expansion of services to low-income and rural areas. This paper characterizes the main policy, institutional and regulatory barriers that have negative impacts on electricity supply to low-income consumers in rural and urban areas in the country. It also analyses the effect of the power sector reform and discusses existing institutional arrangements that may affect the policy goal of universal access to electricity. Finally, it provides recommendations for feasible developments in policy, regulatory and institutional arrangements that would facilitate the expansion of electricity supply to low-income and rural areas.

1. Introduction

The Brazilian power sector is divided into two large systems, the interlinked one and the isolated one [Goldemberg et al., 2002]. The first one, with 80,000 MW of installed power, includes the Northeast-Southeast-South transmission line.[1] The isolated system includes small local grids mainly in Northern Amazon.

The energy supply of off-grid systems is based on diesel generators. There is an enormous consumption of diesel in the electricity generation and fuel transportation within the region. There are presently near 1,000 power plants supplying electricity for isolated cities and villages in the Amazon using diesel oil. Almost 700 units have an installed power capacity below 500 kW [Goldemberg, 2000]. The high overall fuel consumption is not only for the electricity generation itself, but also due to the local transportation, which is exclusively by boat.

The 1988 Brazilian Constitution considers the distribution of electricity to be an essential public service for which the Federal Government assumes full responsibility, either directly or through designated concessions or permits. There is a consensus emerging in Brazil related to the imperative need to supplying electricity to all of the population as a basic public service. However, lack of electricity access is a fact of life for many rural and also urban households.

The difficulties related to servicing the low-income markets, either urban or rural, are intrinsically characteristic of these markets. Low consumption per unit significantly reduces the recovery time for initial investments. This is aggravated in the case of rural markets by high

dispersion, which requires higher initial investments. This situation, which was already difficult under state-owned companies, has become more serious after the privatization process, which intended to maximize the value of assets to be sold and to minimize obligations to future concessionaires. Once private distribution companies were in place, weaknesses in the framework became evident. In particular there was a lack of incentives and obligations to implement rural electrification programs to improve supply to low-income consumers and to sustain existing off-grid projects.

This paper identifies and characterizes the main policy, institutional and regulatory barriers that have negative impacts on the electricity supply to low-income consumers in rural and urban areas in the country. It analyses the effect of the power sector reform, and discusses existing institutional arrangements that may affect the policy goal of universal access to electricity. Finally, it provides recommendations for feasible developments in policy, regulatory and institutional arrangements that would facilitate the expansion of electricity supply to low-income users.

2. Electricity access in Brazil - an overview

Electricity supply plays an important role in the increase of living standards because it allows high quality lighting, clean water, health care, and communications. A frequently mentioned figure for a minimum consumption level is 600 kWh per household per year (or 50 kWh per household per month). However, different electricity consumption levels have been proposed as adequate minimum standards to be targeted for the Brazilian poor.

There is a close relationship between poverty and low electricity consumption, in parallel to the relationship between poverty and lack of electricity access. The 2000 Census [IBGE, 2001a] shows that 64% of households without access to electric lighting have a family income below two minimum wages.[2] Considering up to three minimum wages, this figure increases to 89%. Out of the 5,507 Brazilian municipalities, only 214 have 100% of households with electricity [IBGE, 2001b]. Table 1 shows data concerning access to electricity of the urban and rural population in 2000.

Table 1. Access to electricity of the urban and rural population in 2000

	Permanent private households			Permanent population		
	Total	Urban	Rural	Total	Urban	Rural
Total (million)	44.78	37.37	7.41	168.45	136.98	31.47
With electric lighting	42.33	37.04	5.29	157.46	135.74	21.72
Without electric lighting	2.45	0.33	2.12	10.99	1.24	9.75
Electrification rate (%)	94.5	99	71	93	99	69

Source: IBGE (2001a).

Note: Privately owned housing unit - household composed of one person or a group of persons, where relationships are established by family ties, domestic dependence or rules for living together. The private housing unit is classified as permanent when it is a house, apartment or room .

Although residential consumption of electricity per inhabitant is not an absolute indicator of life quality, it can indicate some important differences among regions. This is the case in Brazil, where there are significant regional differences. While only 68% of the rural population in the Northeastern Region had access to electricity, in the developed Southeastern this share was 98.7%. Rural electrification levels vary from 96% in the Southern Santa Catarina State to 0.8% in the Northern Amazonian Para [IBGE, 1998]. The North and Northeast regions are the most lacking in electric lighting, and the municipalities there have the worst Human Development Indexes in the country [UNDP, 2003]. Their metropolitan areas are the poorest and have the highest rates of "electrical exclusion". Figure 1 consolidates data by Brazilian regions (MW: Midwest, N: North, NE: Northeast, S: South and SE: Southeast).

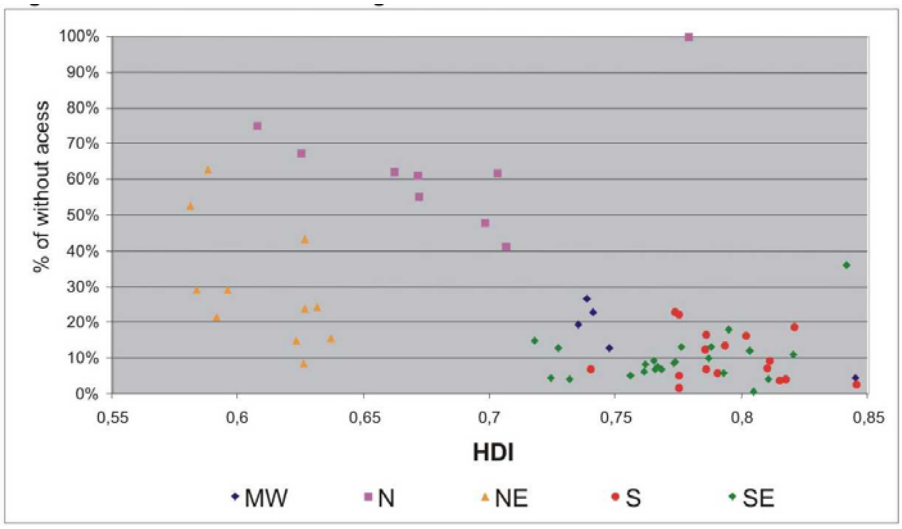

Figure 1. Electricity Access in Brazilian regions versus Human Development Index

Source : IBGE (2001 a and b)

Notes: The Human Development Index (HDI) is a non-dimensional factor. The three essential components of HDI calculation are life expectation, adult literacy rate and per capita income. According to UNDP (United Nations Development Program), HDI indicates where a country is developmentwise. Countries with an index over 0.800 are part of the High Human Development group; between 0.500 and 0.800, of the Medium Human Development group; and below 0.500 of the Low Human Development group.

Table 2 shows the progress in terms of electricity access for the Northern region and its states, compared to the national average. Access to electricity in Brazil has evolved from 89% of households in 1992 to near 96% in 2001, but some 1.8 million households lacked access in 2001 (Figure 2).

Table 2. Electricity access in 1991 and 2002 for urban and rural households

	Coverage (%) in 1991			Coverage (%) in 2002		
	Urban	Rural	Total	Urban	Rural	Total
Acre	95.0	13.0	70.0	98.5	32.6	80.4
Amazonas	96.0	16.0	79.0	97.8	27.2	85.4
Amapá	94.0	42.0	89.0	99.3	52.0	95.6
Pará	91.0	37.0	71.0	97.6	39.0	82.2
Rondônia	90.0	20.0	68.0	98.5	58.8	85.7
Roraima	97.0	30.0	82.0	98.9	42.4	88.6
Tocantins	81.0	14.0	64.0	95.2	37.9	82.4
NORTHERN REGION	92.0	54.0	75.0	97.6	40.3	83.9
BRAZIL	97.0	49.0	87.0	98.8	73.2	96

Sources: IBGE (1992) and MME (2003).

Note: The table uses the Demographic Census 2000 population and electricity access data projected to 2002 according to historical growth rate of each municipality.

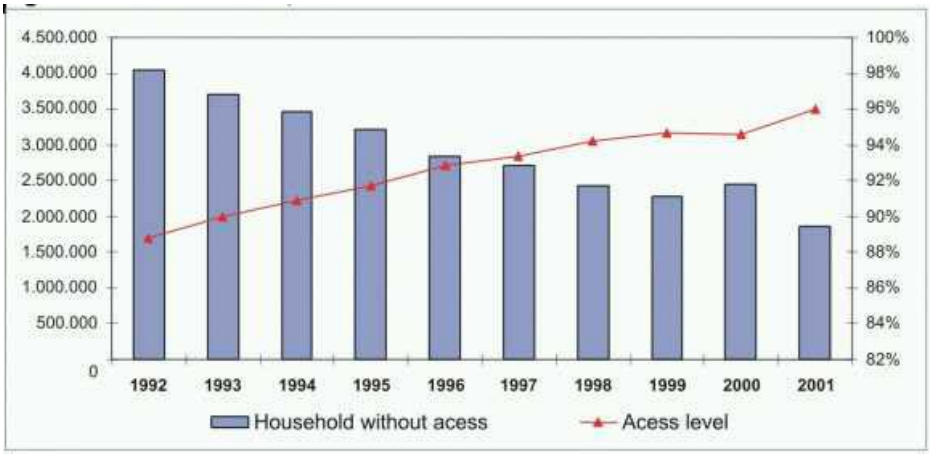

Figure 2. Electricity Access in Brazil 1992-2001

Source: IBGE (Census 2000 and *PNADs*).

Electricity is a crucial factor for the development of a region, but not enough by itself to ensure it. It is also necessary to create economic conditions for the local population to have electricity access and use it in a productive way, in order to be able to afford the cost of electricity supply.

The electrification of small isolated communities using conventional supply presents significant barriers such as high costs of the transmission lines, transportation of diesel oil and the low income of the community residents.

While many electrification efforts have concentrated on rural areas, the urban poor with no access to electricity are often neglected. In peri-urban areas such as slums (*favelas*), connection costs are up to seven times lower than in rural areas, as households are more concentrated and close to the existing grid. The overwhelming barrier to expand the access to electricity is poverty.

In poor urban areas, the proximity to the low-tension grid can lead to high non-technical losses such as illegal connections, tampering with meters, corruption of meter readers and non-payment. Solutions include fees for service arrangements, advance payment of consumption, down payments, or working through local wholesalers with better knowledge of customer's true ability to pay.

3. Existing rural electrification programs in Brazil

The Federal Government and other donors support a variety of initiatives designed to promote rural electrification. Federal programs include *PRODEEM* (managed by the Ministry of Mines and Energy), *Luz no Campo* (managed by Eletrobrás), and *Luz para Todos*, which expects to provide full electrification in the country by 2008 [MME, 2003c]. There are also rural electrification activities under several non-sectoral and decentralized initiatives. In addition, the National Bank of Social and Economic Development (BNDES) is structuring credits to finance electrical interconnection to rural households that already have expenditures with kerosene and batteries and could afford a R$12 (around US$4) per month electricity bill.

Diesel oil consumed for electricity generation in isolated areas is subsidized through the Fuel Consumption Account - *CCC (Conta de Consumo de Combustível*). This account is funded by energy utilities from special taxes on electricity bills for households in the interlinked system. The *CCC* helps to expand electricity access in isolated communities.

3.1 The PRODEEM Program

The *Programa de Desenvolvimento Energético de Estados e Municípios – PRODEEM* (Energy Development of States and Municipalities Program) – is the main government-sponsored program that aims to promote off-grid electrification of villages. Established by a Presidential Decree in 1994,

PRODEEM is sponsored by international donors and is implemented mainly through Brazilian utilities. It consists of several pilot off-grid electrification initiatives using photovoltaic (PV), wind or hybrid systems, and also conventional fossil fuels in remote villages. From 1996 to 2000, *PRODEEM* provided 3 MW in solar photovoltaic (PV) panels to 3,050 villages, benefiting 604,000 people on the basis of a total investment of R$ 21 million from National Treasury funds. The total budget was R$ 60 million for 2001, when 1,086 systems were installed, and another 3,000 community systems were put out to tender by way of international bidding (with a winning bid of R$ 37 million for equipment and installation, plus operation and maintenance for three years).

PRODEEM is a centralized project that uses a top-down approach to identify sites and install equipment. The central government procured photovoltaic panels that were allocated free of charge to municipalities upon demand. Instead of electrifying individual households, the program focuses on schools, health facilities and other community installations. Traditionally focused on PV systems, more recently *PRODEEM* has started to sponsor mini-grid pilot projects (with hydro and biomass generation) to test different service provision models.

A recent evaluation of the first phase of *PRODEEM* surveyed its impact on 43 villages in ten states. Only 44 out of the 79 systems (56%) were actually operating. Problems with *PRODEEM* include the following:

- A top-down approach, with installations sometimes made in unskilled and unorganized communities;
- No schemes for cost recovery, which results in a lack of funds for maintenance and hence unsustainable service;
- Lack of responsibility of local communities and states for the equipment (even under the new system requiring operation for three years);
- Occasional lack of coordination with grid expansion programs; and
- Difficulties in identifying suitable locations for equipment purchased in bulk.

3.2 The "Luz no Campo" Program

The problems with *PRODEEM* prompted both the executive and legislative branches of the Federal Government to start parallel initiatives to create incentives and obligations for the new concessionaires to invest in rural electrification and to supply services to low-income consumers. In 1999, *Eletrobrás* (a state-owned holding of other Federal companies), under the coordination of the Ministry of Mines and Energy, launched an ambitious program, *Luz no Campo* (Light in the Countryside), to finance the

electrification of one million rural consumers over a three-year period exclusively through grid extension.

This program was a response to the evident standstill that beset rural electrification after the restructuring of the power sector. It aimed to provide electricity to five million people living in one million rural households by 2007, using funding of R$ 1.77 billion (US$ 650 million) from reserves (the so-called *Reserva Global de Reversão – RGR*) dedicated to electricity generation, transmission and distribution [ELETROBRÁS, 2003].

In 1996, Law 9427 decreed that 50% of the resources of *RGR* should be directed to the North, Northeast, and Midwest regions. Half of these resources were supposed to be allocated to programs for rural electrification and energy efficiency for low-income users. In the same year, a further law made concessionaires responsible for the cost of providing services to new customers. Customers would only have to meet tariffs.

In April 2002, the Brazilian Congress passed Law 10438, which provided for the reduction of tariffs to low-income consumers, the establishment of targets for concessionaires, and the granting of permission to permit holders to provide full coverage. The law also created a national fund, the Energy Development Account (*CDE - Conta de Desenvolvimento*

Energético), to promote universal access and use of innovative sources of energy. *ANEEL* (*Agência Nacional de Energia Elétrica* - Brazilian Electricity Regulatory Agency) is expected to pass the necessary regulation to implement the law, whereby concessionaires must provide full coverage under a target plan. In parallel, the Ministry of Mines and Energy is preparing a program to accelerate universal access by ensuring additional resources and by creating rules for use of *CDE*.

Financial resources from the *CDE* can be granted to accelerate the achievement of the targets. *ANEEL* will monitor the progress and the results achieved by utilities in the implementation of electrification programs. Those not meeting the targets will be subject to sanctions, mainly a reduction in the tariff increase, when the tariffs are periodically reviewed by *ANEEL*.

Despite the help of the *CDE*, huge investments will be required from the distributors, particularly in the case of the municipalities whose current rate of electrification is below 75%. The income loss from defaults on energy bills is one the main concerns of distributors, as this loss reduces the distributor's capacity to invest. Consequently, the universal access targets defined by *ANEEL* may become increasingly difficult to achieve.

As of September 2002, 480,000 connections had been made through the *Luz no Campo* program, and another 125,000 were in progress. The main problems of the program are:

- The lack of incentives for utilities to do low-cost grid connections or off-grid projects;
- Competition for the financial resources available from the *CDE*, which are also being used for the extension of the natural gas distribution [Abrace, 2003].

3.3 The "Luz para Todos" Program

In November 2003 the Brazilian Government announced the *Luz para Todos* (Light for All) Program to supply electricity throughout Brazil to 12 million people as yet unconnected to any transmission grid. The main objective of *Luz para Todos* is social inclusion through access to electricity supply. It is an important step towards achieving the much-longed-for dream of universal access to electrical energy services. This program will be implemented through partnerships between the Federal Government, the state governments and the concessionaires.

The first stage of the program has scheduled investments of US$843 million[3] funded by the Federal Government (US 543 million),

concessionaires (US$ 188 million) and state governments (US$112 million). Upon signature of contracts, 10% of the value of the contracts is made available to concessionaires. Eletrobras will monitor the progress of the work. In this first stage, 567,000 new connections will be done, giving 2.8 million people access to the regular electricity supply. The plan is for 12 million people to be reached by 2008.

Besides accelerating universal access to electric energy, *Luz para Todos* will allow for the generation of about 115,000 indirect and direct jobs, according to an estimate by the Ministry of Mines and Energy.

3.4 Non- sectoral or Decentralized Initiatives

The amendments included in the National Budget through the Ministry of Agriculture are another important source of funding for rural electrification. These funds are provided by the Federal budget to the municipal administrations on a non-refundable basis and are subject to a certain amount of political bargaining. The funds finance grid extensions for productive uses.

Operating under a different name in each state, the Rural Poverty Alleviation Program (*RPAP*), established in 1993 and sponsored by the

World Bank,[4] has been another important source of investment. The program provides grants to the local associations to finance projects that have been previously approved by the Municipal Committee. To date the program has financed essential infrastructure investments for a total of 42,750 community associations in 1,400 of the 1,600 rural municipalities in Northeast Brazil. Communities make their own development decisions through a process that promotes and depends on community organisations. The projects include grid-connected rural electrification projects and off-grid solar systems, in addition to a plethora of other rural development projects.

A key issue related to these projects is sustainability. Unless the associations are strongly organized, their projects are difficult to maintain. The case of grid-connected systems is less troublesome as they are absorbed by concessionaires, who are obliged to maintain them.

4. Brazilian electricity sector reform and electricity access

Beginning in 1993, the structure of the electricity sector's institutional model was significantly altered by the Federal Government, with the aim of stimulating competition and attracting private-sector investors. The new model for the sector has the characteristics shown in Table 3.

Table 3. Main Characteristics of Brazilian Electricity Sector Pre and Post Reform

Pre-Reform	Post-Reform
A few state-owned companies	Privatization and a large number of agents
Vertically bundled industry	Vertical unbundling of the industry
Regional/state monopolies for generation, transmission and distribution	Competitive generation and distribution regulated monopolies on transmission systems and shared distribution
Ban on foreign investors	Restrictions on foreign investors lifted
Centralized planning	Indicative planning
Equalization of tariffs	Regulated prices and tariffs
Captive market	Gradual easing of restrictions on consumers

A new institutional framework was established by creating three regulatory agencies: *ANEEL* (*Agência Nacional de Energia Elétrica* - Brazilian Electricity Regulatory Agency), *ANA* (*Agência Nacional de Águas* – National Water Agency) and *ANP* (*Agência Nacional do Petróleo* – National Oil Agency). *ANEEL* was established in 1996 to regulate all operations of the power sector.

Little attention was paid in the restructuring process to the expansion of electricity services to low-income and rural areas. Several Federal laws have tried to oblige utilities to guarantee electricity access, but their results have not yet proved positive. In 1997, Law 9478 stipulated that national energy policies must aim to identify the most suitable solutions to supply electricity to the different regions. It also established a national council for energy policy (*CNPE – Conselho Nacional de Política Energética*), one of whose responsibilities is to propose measures to supply energy to remote areas. Lack of enforcement has detracted greatly from the effectiveness of these measures. In addition, the obligation to provide full coverage was not included in contracts between *ANEEL* and new concessionaires.

The 2002 Law 10438 established rules for strengthening the universal service obligations of distribution concessionaires and introduced a series of changes in the structure of Brazilian energy sector, including:

- The definition of the low-income consumer as having monthly consumption up to 80 kWh, plus a second group up to 200 kWh under special conditions to be defined by *ANEEL*;
- The establishment of the Energy Development Account – *CDE*, discussed above;

- Special incentives to renewable energy sources through the *PROINFA* Program (discussed further below);
- An extension of *RGR* until the end of 2010 to ensure resources for the continuation of the *Luz no Campo* Program.

Concerning rural electrification, *ANEEL* is to impose targets for full coverage on concession and permit holders. Consumers falling within low-income groups would not be required to pay anything on top of the tariffs. Households would be able to accelerate their service connections by paying a part of the full investment, and the concessionaires would be required to reimburse them when the target for electricity access is met. Even accelerating investments by public entities will have to be reimbursed. The achievements of targets would be surveyed by *ANEEL* during the tariff revision process.

In an attempt to accelerate full coverage, *ANEEL* would be able to initiate open bidding within the concession areas to award permits whenever no exclusive provisions are present in contracts with existing concessionaires. Permit holders would be able to use either the conventional grid or establish partnerships with renewable energy dealers, distributors, or IPPs (Independent Power Producers).

Several problems may be solved if Law 10438 is properly regulated. One of the initiatives should be a study on the impact of the Law's obligations on tariffs. Pressure for substantial tariff increases is expected. If they are not attached to suitable mechanisms like cross-subsidies, high tariffs will postpone the objective of universal access.

Decree 4336/2002 authorized the loaning of *RGR* resources to concessionaires to cover their losses due to the introduction of subsidies for lifeline tariffs to low-income consumers. The loans would be in effect up to the date of revision of the tariffs of the concessionaires. This Decree would result in an annual reduction of R$500 million (US$ 180 million) in the *RGR* funds, significantly reducing the resources available for *Luz no Campo*. Law 10604 has minimized this impact via the identification of other sources to cover the subsidies to low-income consumers, but *RGR* can still be used as a back-up source for these subsidies.

Decree 4541/2002 established rules for the use of *CDE*, but there are very limited resources left from that account for promoting universal access. Analyses of the amount of resources that will be collected in that account show that these funds will not initially be spent on other programs that the account is supposed to promote (e.g. renewable sources, natural gas), and thus could be reallocated to promote universal access.

A required step to accelerate universal access is establishment of the rules for implementing Law 10438/2002 through a review of the Decree 4541/2002. It is important to assure additional resources for promoting universal access and to clarify some points of the Law's implementation. Also needed are a series of resolutions by *ANEEL* that will establish rules for concessions and permits.

Resolution *ANEEL* 219 (April 2003) offered a discount of 50% for electricity tariffs to utilities generating electricity from wind and biomass – a benefit that was already enjoyed by utilities generating electricity from small hydro. *ANEEL* has also issued Resolution 223, regulating aspects of Law 10438/2002 related to targets for universal access to electricity in Brazil. Expenses related to the connection to the grid will be borne by utilities, and not the consumers. All utilities are to submit to *ANEEL* within determined deadlines their programs to expand access to electricity. Targets were defined in order to reach the goal of full coverage established by the Federal Government.

A new institutional model of the electric sector is being proposed by *MME* through a technical report presented for discussion in December

2003.[5] It aims to provide affordable tariffs and to guarantee universal supply. The new model has the following elements:

- Re-structuring medium and long term planning and contracting;
- Utilization of the lowest tariff criteria;
- Monitoring of services provided;
- Two contracting environments, one regulated and another free;
- The institution of a regulated contracting pool;
- Separation of distribution from any other activity;
- Provision of contingency reserves to re-establish the balance between supply and demand;
- The return of the Executive as Conceding power (instead of *ANEEL*).

This proposal has drawn some criticism from specialists[6] for being too centralized and for having too many amendments.

5. The impact of the reforms on electricity access and consumption of poor urban and rural households

According to *ANEEL*, from January 1995 to October 2001, residential consumers faced an average rise in electricity price of 30% above inflation. The situation worsened after 1999, when a 70% devaluation of the Brazilian currency occurred.[7] Such price increases tend to inhibit the access of the population to electricity, especially the lower-income groups. They have placed a heavy burden on the budgets of the low-income sector of the population. Moreover, the high price of electricity and liquefied petroleum gas (LPG) has negative environmental side-effects, since the poorer population switch to the use of cheaper options for their energy needs, leading to deforestation from the excessive use of wood fuels.

Under Brazilian electricity tariff structures, domestic and commercial customers cross-subsidize rural, public lighting, and low-income consumers. For households, the discount is tapered according to the consumption level, so that those consuming up to 30 kWh per month pay only 35% of the overall tariff, and those consuming up to 100 kWh per month pay 60% of the overall tariff. The discount declines to zero for those

consuming more than 220 kWh per month. The overall tariff and regional limits vary from concession to concession.

The discounts for low-income households tend to affect the financial health of the distributors, particularly the smaller ones. Current plans point to a greater number of consumers paying reduced tariffs. In this situation, the competence of the distributor's performance may well define its financial health, or even its survival in the domestic energy market.

The restructuring of the Brazilian power sector exhibited a generous policy of profit sharing with the new owners. While most electricity was produced by already amortized hydro plants, tariffs were calculated on the basis of the financial costs of new projects. Before privatization, the state-owned utilities could supply energy to low-income consumers at extremely low tariffs (or even free of charge) through a policy of cross-subsidies in which the tariffs of the highest consumers are slightly increased. This policy could be introduced by the privatized utilities.

Table 4 shows some key indicators, comparing the situation of Brazilian consumers in 1994 (before the reform) and in 2000 (after the reform). It is too early to definitively evaluate the implications of the power sector reform for expanding access to electricity in the country, but this table allows some

preliminary discussion. Electrification levels in rural areas have progressed from 68% to 74%. The most striking change is the increase in the average electricity tariff, which more than doubled in this period. This increase limited growth in per capita electricity consumption.

Table 4. Electricity indicators pre- and post-reform

Indicator	1994 - Pre-reform	2000 - Post-reform
National electrification (%)		
Total electrification	92	95
-- rural areas	68	74
-- urban areas	98,5	99,2
Residential electricity consumption per capita (kWh/year)		
National average	442	499
Rural population	390	440
Urban population	560	576
Electricity tariffs		
Average residential tariff (US$/kWh)	0.098	0.179
Connection fees & charges (US$/connection)	810	970 (2002)

6. The potential of renewable energy technologies to expand access to electricity

There is significant potential for increasing electricity access in isolated systems through the use of renewable energy. Renewable energy, such as PV, biomass, and small hydro, can be provided with local resources to remote communities, can guarantee the supply, have much lower environmental impacts, and allow energy independence [Goldemberg, 2002]. These aspects are significant for remote systems.

Comprehensive data on the potential of renewable energy to supply electricity to remote rural communities in Brazil is not fully available. General figures report the overall national potential, but further detailed studies are required for some regions.

Until 2001, there were no significant incentives for renewable energy technologies in Brazil, and therefore it was difficult for operators of small renewable energy projects to become established. A first important step was the enactment of Resolution 24/2001, which created the Emergency Program of Wind Energy (*PROEÓLICA*) and intervened in the market via price regulation. Later on, with the *PROINFA* Law (10,438/2002), a general policy to promote renewable electricity in the interlinked system started. *PROINFA* provides that the following resources will be added to the grid by

2006: 1,100 MW from wind, 1,100 MW from biomass and 1,100 MW from small hydro plants. In the next 20 years, a target of 10% of such sources in the electricity mix is to be achieved.

6.1 Photovoltaic (PV) Energy

Although PV technology has been used in Brazil for almost two decades, only in the last few years is PV being seen as an alternative for electricity supply for basic needs in remote areas. Government programs, electricity distribution utilities, private entrepreneurs and a few NGOs are gradually paving the road that will lead to broader dissemination of the PV technology. Large initiatives are already under way but still need very close attention in this initial stage. The installation of PV systems is not enough to guarantee their proper operation and maintenance. It is necessary to train operators and to provide long-term technical assistance.

6.2 Biomass Energy

As a large tropical country, Brazil has a high potential for the use of biomass. The main modern biomass sources are sugarcane products (ethanol and bagasse) and wood from reforestation. The use of bagasse for electricity production in sugar mills yields a considerable energy surplus potential of

up to 4,000 MW, but in 2003 only a 400 MW surplus was produced. Use of this resource requires connection to the interlinked system.

In isolated regions, residues from agricultural activities, forest residues (branches, leaves, etc) and sawmill residues (sawdust, wood chips etc) can be used as fuel to generate electricity with technologies commercially available in the country, such as gasification and small-scale steam cycles. However, there are still some difficulties related to the technical availability of small-scale systems. In Brazil at present there are several prototypes under development aiming to solve this problem.

Another huge opportunity for biomass use in remote villages is electricity generation from *in natura* vegetable oils. The Amazon region in Brazil has an enormous diversity of native oil plants, as well as favourable conditions of soil and weather for the cultivation of highly productive exotic oil plant specimens.

The use of animal wastes is also a technical and economically viable renewable energy. The biogas produced can be utilized for heating, refrigeration, illumination, incubators, feed mixers, electric energy generators, etc.

6.3 Small Hydropower Plants (SHP)

There are 297 small hydro plants (less than 30MW of capacity) plants operating in Brazil, totaling 802 MW. Another 465 MW are under construction. According to Eletrobras, small hydro has a potential of 9,456 MW (12% of the total installed power in the country). The true value may be higher, given that there is still a paucity of information about small hydro. Properly located, this technology significantly reduces adverse environmental impacts compared to large hydro plants, helping the recovery of areas alongside rivers.

6.4 Wind Power

There are several large regions in the country that have favourable wind conditions and are naturally suited for wind farms. The installation of these systems in sites with high annual yield factors would allow them to reach competitive generation costs. At present, there are 21.2 MW of wind power installed. Wind power has recently witnessed an impressive development in Brazil and has potential for large-scale use in grid-connected generation.

6.5 Barriers to the Use of Renewable Energy in Off-grid Power Systems

The technical barriers for renewable energy use in isolated villages are not significant. In most cases it is a matter of adapting technologies already in use in other developing countries. The important aspects in relation to isolated areas are their small electricity demand, the lack of skilled people, and difficulties in properly operating and maintaining power equipment. In consequence, power systems for these areas must be of small capacity and as simple as possible. Also, technical assistance and training must be provided on a long-term basis. An additional problem for renewables is that investors consider the risks to be greater, so financial agents may refuse projects or require higher interest rates for loan approvals. An indirect barrier to the implementation of renewables is the current environmental legislation for stationary sources in Brazil. It does not cover highly polluting small-scale diesel electricity generators, which amounts to an indirect subsidy for these systems.

Worldwide, the main economic barriers to renewable energy projects include high initial costs and the small-scale production of equipment and systems. To overcome these barriers the creation of a market of minimum size is essential. The successful implementation of renewables has been

based on tax incentives, but the Brazilian government has never formulated a comprehensive and long-term policy for renewables with this kind of incentive. Instruments such as tax reduction for imported devices of higher efficiency, credits on taxable income and accelerated depreciation have also been helpful elsewhere [CENBIO, 2000].

In general terms, regulatory actions by *ANEEL* address important issues, but there are many doubts concerning their effectiveness as tools for fostering renewable electricity in Brazil. In the event that the mandatory market is approved with no corresponding action regarding economic and science and technology policies, an external dependence on equipment suppliers will be created in several renewable energy sectors.

7. Final considerations and recommendations

Nearly 31% of the Brazilian rural population, or 6.5% of the total population (12 million people out of 165 million total inhabitants), have no access to electricity services. Low-income populations in peri-urban areas also lack access. These households either have to pay the most expensive electricity (from batteries) or have very poor quality lighting.

Power sector reform has discouraged provision of electricity to rural and low-income areas due to its emphasis on the maximization of proceeds from privatization. The initial reform process did not focus on expanding access to electricity through concessionaires' actions. In addition, the regulators were not able to protect the prices of electricity tariffs from substantial increase, and as a result, access to electricity by the poorest portion of the Brazilian population has slowed. In this context, *PRODEEM*, *Luz no Campo* and *Luz para Todos* are important government initiatives to achieve universal access.

It is recognized that the power sector restructuring has not yet improved access to energy services. It can even be argued that privatization has contributed to reducing the pace of rural electrification and to increasing the

cost of grid extension, due to new standards introduced, and to the freezing of incipient renewable energy projects based mainly in solar home systems. A concerted effort of the Ministry of Mines and Energy, *ANEEL* and *Eletrobrás* is vital to change the situation. The following is suggested:

- Regarding rural electrification, the full implementation of *Luz no Campo* program is necessary, as is an increase in the funding of *PRODEEM;*
- To improve the performance of the *Luz no Campo* and *Luz para Todos* programs, lessons learned from the *PRODEEM* implementation should be taken into account;
- Rural electrification through grid connections is generally not economically feasible; energy supply in these cases must be decentralized, and there is an excellent opportunity for the introduction of renewable energy;
- Institutional models such as the permanence of the *CCC* Program for Renewable Energy are needed to assure the sustainability of off-grid solutions;
- The permanence of *RGR* must be assured, and *CDE* funds that display a preference to renewable electricity sources must be supported;
- Electrification targets for universal access that have been recently established must be actually implemented and should give priority to

remote areas with precarious energy access; it is important that the rules for award of permits within concession areas be clearly defined;

- Incentives such as the *PROINFA* Program must be created to stimulate concessionaires to diversify their supply alternatives;
- Community participation in electricity management is fundamental in remote areas to reduce O&M costs;
- The social and economic benefits must be maximized to rural/remote communities through the implementation of sustainable local activities.

Notes

1. Of the 80,000 MW of installed capacity in Brazil, about 81% is hydropower. The remaining electricity generation comes from poor quality coal and an ever-increasing supply of domestic and imported natural gas. Small Northern and larger Southern electric grids were interconnected in January 1999 into one grid that serves 98% of the country.

2. The minimum wage in Brazil in that year was around US$83 per month.

3. The exchange rate was US$1 = R$3.131.

4. http://lnweb18.worldbank.org/ESSD/sdvext.nsf/61ByDocName/Brazil-RuralPovertyAlleviationProgram

5. http://www.mme.gov.br/Noticias/2003/dezembro/Modelo_11.dez.03_Final1.pdf

6. Peter Greiner, former Secretary of Energy of Ministry of Mines and Energy (source: Ex-secretário vê risco deredução de competição. O Estado de São Paulo, Sábado, 13 de dezembro de 2003)

7. The maxi devaluation also made even more expensive the price of imported capital goods and fuels, such as the Bolivian natural gas supplied under a take or pay contract in dollars.

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[1] Of the 80,000 MW of installed capacity in Brazil, about 81% is hydropower. The remaining electricity generation comes from poor quality coal and an ever-increasing supply of domestic and imported natural gas. Small Northern and larger Southern electric grids were interconnected in January 1999 into one grid that serves 98% of the country.