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Executive Summary

Today, around 11.5 million people in Brazil still have no access to electricity, one third of the rural population. This is especially true in isolated rural Amazon communities and in the outskirts of urban areas. It is clearly necessary to give attention to these communities' energy needs and renewable energy can help to meet its requirements (Goldemberg et al, 2004). In Brazil, different governmental programs have been tried to achieve this goal. Its pros and cons are reviewed in this report.

Renewable energy sources are a real option for energy production in Brazil, not only for electricity generation to be injected in the national grid but also in the off-grid isolated systems. This report presents reviews the potential for promoting renewable energy technologies (RETs) available in the country as well as case studies.

It also shows the variety of initiatives designed to overcome existing barriers to rural electrification and analyses some policy outlines. The Federal Government supports some programs such as Luz no Campo (managed by Eletrobrás), which focuses on grid extensions and PROINFA (managed by the Ministry of Mines and Energy), on renewable power generation connected to the grid. In addition, there are rural electrification activities under several non-sectoral and decentralized initiatives.

Under the new administration started in 2003, the Ministry of Mines and Energy has undertaken a major change in the orientation of the power sector reform. Although the deregulation process in Brazil is being carried out gradually in comparison to other countries, some laws and decrees represent important steps towards the new power sector structure.

The National Electric Energy Regulatory Agency - ANEEL has introduced several measures to stimulate renewables, simplifying authorization procedures and establishing flexible commercialization prices.

The most significant barrier is that the Ministry of Mines and Energy and the National Electric Energy Regulatory Agency have proposed and implemented their own programs, but their actions are not coordinated and synergic effects are not clearly identified.

Some progress has been made in the improvement of the regulatory framework to favour RETs, with significant attention being given to minimizing distortions by allowing free access to grids, extension of benefits previously granted only to conventional energy sources, reduction of the bureaucratic demands for registration and authorization, and establishment of differentiated values for renewable energy by incorporating some of its positive externalities.

One of the great challenges in the country is to better integrate within the Brazilian society the people who still live in the dark, without access to electric energy. The new orientation of the energy policy focuses on ensuring the access to electricity to all citizens – the so-called universalization of energy access. The key findings of this report show the potential of RETs to help achieving this goal and provide some recommendations of future actions to tap the RETs potential in order to make progress towards this end.

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List of Acronyms and Abbreviations

ANEEL - Agência Nacional de Energia Elétrica
(Federal Electricity Regulatory Agency)
BNDES – Banco Nacional de Desenvolvimento Econômico e Social
(National Social and Economic Development Bank)
CCC - Conta de Consumo de Combustíveis
(Fuel Compensation Account)
CDE - Conta de Desenvolvimento Energético
(Energy Development Account)
CBEE – Brazil Wind Energy Centre
DIEESE - Departamento Intersindical de Estatística e Estudos Sócio Econômicos (Inter-Union Department of Statistics and Socioeconomic Studies)
Eletrobrás - Centrais Elétricas Brasileiras S.A.
(Brazilian Electricity Generation Company)
MAE (Mercado Atacadista de Energia)
Wholesale Energy Market
ESMAP (Energy Sector Management Assessment Programme)
HDI – Human Development Index
IBGE - Instituto Brasileiro de Geografia e Estatística
(Brazilian Geography and Statistics Institute)
IPCC –Intergovernmental Panel on Climate Change
LPG – Liquefied Petroleum Gas
MME - Ministério de Minas e Energia
(Ministry of Mines and Energy)
NGO – Non-Governmental Organisation
NIPE – Núcleo Interdisciplinar de Planejamento Energético
(The Interdisciplinary Center for Energy Resources Planning)
PRODEEM - Programa de Desenvolvimento Energético de Estados e Municípios
(State and Municipal Energy Development Programme)
PV - Photovoltaic
PNAD - Pesquisa Nacional por Amostra de Domicílio
(National Household Sample Survey)
RET – Renewable Energy Technology
RGR - Reserva Global de Reversão
(Global Reverse Fund)
SHS- Solar Home System
UNDP – United Nations Development Programme

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1. Background

The previous study, prepared for GNESD Energy Access I Working group has discussed the lack of energy access in Brazil.

That report pointed out that the difficulties related to servicing low-income markets, both urban and rural, are intrinsic characteristics of these markets. Low consumption per household significantly reduces the recovery time for initial investments. This is worse in the case of rural markets because of the high dispersion, which requires higher initial investment. 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 for 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 a rural electrification program, to improve supply to low-income consumers, and sustain existing off-grid projects.

Consequently, both the executive and legislative areas of Federal Government have jointly started initiatives to create incentives and obligations for the new concessionaires to invest in rural electrification and to supply such services to low-income consumers. Eletrobras, under the aegis of MME – Ministry of Mines and Energy, launched an ambitious program*, Luz no Campo*, to finance the electrification of one million new rural consumers over a three-year-period and to focus exclusively on grid extension. Concurrently, budgets for PRODEEM have been continuously increased. The Brazilian Congress passed Law 10438, in April 2002, with provisions for the reduction of tariffs to low-income consumers, the establishment of targets for concessionaires and 'permissionaires' to provide full energy coverage, and the creation of a national fund CDE (Energy Development Account) to promote universal access to electricity and the use of innovative sources of energy. ANEEL (Federal Electricity Regulatory Agency) is expected to pass regulations implementing that Law, whereby concessionaires must provide full coverage under a target timetable plan. On parallel lines, MME is preparing a program to accelerate universal access to electricity by ensuring additional resources, and particularly by creating rules for the use of CDE resources.

Based on the results obtained in the mentioned study, this work, developed under "Renewable Energy Technologies Working Group" of GNESD, aims at identifying the main barriers against RETs (renewable energy technologies) and at proposing actions to improve living conditions by implementing these RETs through energy access.

2. Rationale and motivation

There is a widening consensus emerging in Brazil nowadays related to the imperative need for supplying electricity to all the population as a basic public service. Meeting these basic energy needs is mainly related to the access to electricity in rural areas.

There is also a growing consensus among policy makers that energy is central to reducing poverty and hunger, improving health, increasing literacy and education and improving the lives of women and children.

Some 1.6 billion people in the world, more than a quarter of humanity, have no access to electricity and 2.4 billion people rely on wood, charcoal or dung as their principal source of energy for cooking and heating (World Bank, 2004). This fuel is literally killing people. Two and a half million women and children die each year from the indoor pollution from cooking fires.

Out of the 5,507 Brazilian municipalities, only 214 have 100% of households with electricity supply. The North and Northeast regions are the ones most lacking electric lighting. On the other hand, the South and Southeast regions are the ones that have the smallest rates of "electrical exclusion".

Different electricity consumption levels have been proposed as adequate minimum standards to be targeted for the Brazilian poor, and recent legislation suggests that household consumption under 200 kWh/month can be entitled to electricity tariff subsidies. 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.

In this context, renewable energy can collaborate to improve energy access, mainly in remote/rural areas: for instance, energy can be produced from biomass resources available in the region (at low or zero cost) or from PV panels without any fuel consumption.

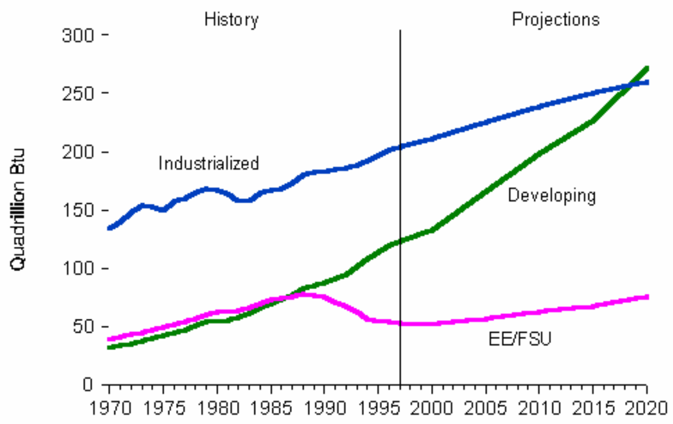
However, comprehensive data on the potential of renewable energy to supply electricity to remote-sited rural communities in Brazil are not fully available. General figures report the overall national potential, but further detailed studies are still required for some regions.

In these isolated regions, poor communities are far from the distribution grid and can not afford fuel supply (most of them depend on diesel oil to produce electricity). Then, the introduction of RETs must consider the profile of the community for supporting commercial activities. These activities should create local jobs, improve living conditions and guarantee maintenance of the RET system.

The rapid expansion of clean and sustainable energy offers a win-win situation for the poor and the environment. For the poor, particularly the rural poor, without basic energy services, renewable energy is often the most feasible option. For industrialized countries, a massive uptake of renewable energy will help to achieve the dramatic emissions cuts needed to prevent climate change. Increasing the use of renewable energy is necessary both to provide energy services without choking the planet and to create the economies of scale necessary for a global expansion of renewable energy.

There is no doubt that the global demand for energy is growing sharply, especially in emerging economies, like Brazil (as shown in Figure 1). Without a massive change in the energy mix worldwide, it will not be possible to ensure that supply will meet demand on a sustainable basis.

Figure 1 World Energy Consumption by Region, 1970-2020.



Source: EIA, International Energy Outlook 2000

In this context, the present report focuses on Brazil, one of the most important emerging economies, like a case study. Some of the actions in place to provide sustainable energy to the Brazilian poor have been analyzed. Examples are given of implementing energy initiatives that demonstrate the clean role that sustainable and renewable technologies have in fulfilling the energy needs of poor people in these countries. In general, this paper analyzes the “healthy” relationship between renewable energy sources and sustainable development looking at the following areas:

- Poverty alleviation, by reducing inequalities and creating new opportunities for employment and income generation;
- Increased energy security and the diversification of national and regional energy matrices, especially with respect to the reduction of the traditional dependence of the economy on the supply of fossil fuels;
- Reduction of the risks associated to hydrological variability;
- Decentralization of energy production, especially in rural and remote areas;
- Improvement of the country's technological and industrial bases; and
- Universalization of the supply and use of electricity.

An adequate supply of energy is an important key to sustainable economic and social development for many countries. An essential prerequisite for poverty reduction is the access to such modern energy services as mechanical power to drive irrigation pumps, light to facilitate studying, heat for cooking or refrigeration for the storage of medicines. Besides these poverty-reduction aspects – energy use for income-generating purposes, in social infrastructure institutions and in the domestic sphere – climate protection and preservation of natural resources also play an important role.

While supply structures similar to those in industrialized countries have been established in many of the urban-industrial agglomerations of the developing countries, rural areas in the developing world remain under-supplied. Particularly as far as grid-based electricity is concerned, the expansion of grids into remote areas with a low population density soon comes up against its limits: long transmission lines, a lower average purchasing power and hence a lower density of connections together with smaller loads mean that conventional energy utilities must operate such grid-based supply at a loss. This is the reason for the exceptionally low rate of electrification in many developing countries.

Renewable energy technologies (RETs), in addition to their undisputed ecological advantages, are often the most economical option for supplying energy to remote and thinly populated areas. The typically decentralized RE systems utilizing local energy sources can be easily adapted in size and capacity to meet a modest demand and are therefore especially suitable for overcoming energy poverty in rural areas.

Despite these advantages, the dissemination of technologies for using renewable energy sources has not yet achieved the desired momentum. Projects to spread renewable energies, particularly in developing countries, must overcome an array of obstacles:

- Even RETs that are competitive from a business management point of view must get over the hurdle of the high initial investment costs. Lack of security makes loans hard to obtain, especially in rural areas;

- In many places, fair competitive conditions have to be established before markets for new RE technologies can be developed. Experience in Germany and various other countries have shown that this objective cannot be achieved until economic policy framework conditions and an environmentally sound regulatory framework have been created and specific promotional measures are implemented;
- In many regions, the RE technology supply structures are inadequate. A shortage of qualified suppliers, distribution channels, which remain rudimentary, and inadequate service and maintenance, hamper market development.

In contrast to these obstacles, however, recent years have brought decisive improvements in the conditions for expanding the use of sustainable energy systems in developing countries.

Energy as a key factor in development and climate protection has gained prominence in public awareness all over the world, leading to greater readiness among bilateral and multilateral donors to contribute to its promotion. Many developing countries (including Brazil, China, India and South Africa) have taken active steps towards improving framework conditions in favor of sustainable energy systems. The lower product costs resulting from increased mass production and technological progress have made RET systems more competitive. International manufacturers and project developers show growing willingness to become engaged in the RET sector in developing countries.

3. Initial Assessment

3.1 National Context

3.1.1 Country profile

The current situation in the country can be summarized by some key social, economic and land-use indicators (World Bank, 2000). Unless otherwise specified, the figures presented below refer to the year 1998 (most recent available data).

Table 1: Key Social Indicators

2002	Population (million)	174.6
2002	Population growth (yearly rate)	1.3
2000	Population (million)	169.8
2002	Urban population (% of total population)	82.39
	Urban population growth (annual average 1992-1998)*	2,0
2002	Life expectancy (years)	68.6
2002	Infant mortality (per 1,000 born alive)	33
1998	Infant malnutrition (% of children below 5)*	6
2002	Immunization measles (% of children ages 12-23 months)	93
2001	Access of total population to sewerage (%)	45.6
2000	Access of total population to water supply system (%)	79.9
2001	Access of population to garbage collection	79.8
2001	Access of urban population to potable water (%)*	87
1998	Access of rural population to potable water (%)*	31
2002	Illiteracy rate (% of population above 15)	12.4
2002	Unemployed young people (15-24 years)	14%

Sources: World Development Indicators database, Brazil, 2002; SCHAEFFER et al, 2003; IBGE, 2003 and *World Bank, 2000.

Table 2 – Key Economic Indicators (year 2002)

GDP / capita (US$) *	4,641
GDP (billion US$) *	497,4
GDP growth (%)	1.5
GDP per unit of energy use (PPP$ per kg oil equivalent – 2001)	6.9
Industry (% of GDP)	21
Services (% of GDP)	73

Sources: World Development Indicators database, Brazil, 2002; SCHAEFFER et al, 2003; World Bank, 2000; *MME, 2001

Table 3: Key Land-Use Indicators

Total country area (million hectares)	845.651
Deforested land – 1980 (million hectares)	600.762
Forest area – 1990 (million hectares)	563.911
Forest area – 1995 (million hectares)	551.139
Average annual change 1980-90 (%)	(0.6)
Average annual change 1990-95 (%)	(0.5)
Protected areas – 1997 (million hectares)	582
National protected areas (% of total land area in 2002)	6.7
Crop production index 2002 (1989-1991=100)	142.4
Total fertile land – including arid land	80.762
Desertification of irrigated, cultivated and pasture land (million hectares) *	69.950
Desertification (%) *	87

Note: includes moderate, severe and very severe desertification, but not light desertification

Source: World Development Indicators database, Brazil, 2002; World Bank, 2000

3.1.2 Historical Evolution

In 1940, the Brazilian population was only 41 million, 69 % of which were living in rural areas, and the overall domestic energy supply was 24.3 M toe (million tonnes of oil equivalent) / year. By 1990, half a century later, more than 70 % of a total population of 145 million were living in the cities and the country had more than doubled its average energy consumption per capita (from 0.6 to 1.3 toe / year). From the end of the Second World War until the eighties, the face of the country changed dramatically and an accelerated economic growth was averaging 7 % per year. Under the import substitution drive, industrialization had raised average GDP / capita to 2,536US$ 2003 / year in 1990[1]. Industry had reached about 30 % of GDP, with services amounting to 60 % and agriculture barely 10 %. The unprecedented pace of urbanization helped to bring demographic growth down to 1.4 % per year from rates of above 3 % per year in the fifties.

Together with industrialization and urbanization, the building of a highway infrastructure coupled with the dominant role of a locally based car industry, thanks to the country's modernization drive, completely changed its energy demand and supply profiles. In 1940, firewood and charcoal supplied over 83 % of Brazil's energy needs, compared to 6 % oil, 6 % coal and only 1.5 % hydropower. In 1990, the two large centralized state-owned energy systems for oil and hydropower dominated about 60% of the energy supply, while the share of firewood was reduced to 12 % (see Table 4).

[1] In 1994, the GDP / capita in Brazil reached US$ 2003 / year. The most recent data for this economic parameter, for 2003, is 2,817 US$ 2003/ year

The large rise in the use of electricity could be met by the huge hydropower potential of the country, 70 % of which still remained to be tapped in 1990. Nevertheless, as Brazil did not seem to be an oil-rich country (total known resources corresponded to about 10 years of domestic consumption), oil imports have met most increased domestic needs. In 1973, the first oil shock caught Brazil with barely 17 % of its oil needs met by domestic production. After the second oil shock in 1979-80, the oil bill amounted to the financial equivalent of more than half of Brazilian exports (La Rovere, 1983).

An ambitious program was thus launched by the government to substitute alternative domestic energy sources for imported oil. The domestic oil production increased to 60 % of total consumption in 1990. The Alcohol Program has become the symbol of the struggle for energy self-sufficiency.

Ethanol production from sugar cane in Brazil reached 14.1 billion liters in the 2003/2004 harvest (PETROBRAS, 2004). This value represents the total ethanol production, including the production of anhydrous ethanol that is blended with gasoline[2]. And from the mid-seventies to the mid-eighties renewables gained momentum in Brazil to reduce the skyrocketing foreign exchange expenditures that were the result of the high international prices and the large imports of oil. The building of large hydropower plants was accelerated. Aside from this, the surface area covered by afforestation programs has continuously increased at fast-growing rates, providing renewable sources of firewood.

Table 4 - Domestic Energy Supply in Brazil – 1940/1970/1980/1990/2000 and 2003

Source/Year	1940		1970		1990		2000		2003	
	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%
Oil, Natural Gas and derivates	1.522	6.4	25.420	38	62.085	43.7	96.999	50.9	10.0523	47.9
Coal and derivates	1.520	6.4	2.437	3.6	9.615	5.1	13.571	7.1	13.145	6.5
Hydro and Electricity	0.352	1.5	3.420	5.1	20.051	14.1	29.980	15.7	29.494	14.6
Firewood and Charcoal	19.795	83.3	31.852	47.6	28.537	20.1	23.060	12.1	25.997	12.9
Sugar cane products	0.563	2.4	3.593	5.4	18.988	13.4	20.761	10.9	27.085	13.4
Other*	0	0.0	0.223	0.3	2.724	1.9	6.245	3.3	9.370	4.6
Total	23.752	100	66.945	100	142.000	100	190.615	100	201.704	100

Notes: *Include other renewable sources and uranium.
The Brazilian Energy Balance adopts a factor of 0.086 toe/MWh for hydropower.
Source: MME, 2004.

[2] In Brazil ethanol is used in two forms (MCT, 2004):

- As anhydrous ethanol blended with gasoline; the share is defined by Federal Government and can vary from 20 to 26%; currently is 25%), at 99.6º Gay-Lussac (GL) and 0.4 % of water. This "gasohol" mixture aim at increasing the gasoline octane number;
- As hydrated ethanol at 95,5º GL, used in ethanol-fueled cars sold since 1979 and in the new flex-fuel cars available since 2004.

In other countries, "gasohol" mixtures typically contain only 10% (or less) of ethanol. Ethanol is a superb automotive fuel: it has a higher octane number than gasoline and has a lower vapor pressure, resulting in fewer evaporative emissions. Air combustion is less than that of gasoline, which reduces the number and severity of fires in vehicles. Anhydrous ethanol has lower and upper calorific values of 22.4 MJ/l, (according to BEN 2004) and 23.4 MJ/l, respectively, against 32.2 MJ/l, (according to BEN 2004) and 34.9 MJ/l for gasoline.

Hydropower accounts for the overwhelming majority (90 %) of all the electricity generated. By the end of the eighties, ethanol from sugar cane provided more than half of the energy consumed by cars[3]. Today, sugar cane bagasse supplies 6 % of all Brazilian energy. Renewable firewood and forest wastes are estimated to provide up to 80 % of domestic firewood consumption (Schaeffer et al., 2003). Up to 20 % of the wood used in industry (that represents 20% of the total wood produced in Brazil, in 2003, as follow MME, 2004) is estimated to be renewably produced[4].

During the eighties, the economic picture deteriorated progressively with snowballing foreign debt and high inflation rates contributing to a decade of economic recession. Government deficits and a negative balance of payments meant that the government no longer had the capacity to persist with the same energy policy. Then, in the mid-eighties, a sharp decrease in oil prices on the international market seriously affected the cost-effectiveness of the extensive efforts aimed at reducing oil imports, such as the Alcohol Program.

If the energy policy helped to reduce the balance of payments crisis during the eighties, the financial effort needed to fund huge investments in the energy sector certainly aggravated inflationary pressures. Moreover, to avoid the risk of hyperinflation the government decreased the price of public services in real terms. This pricing policy deeply affected the largely state-owned energy industry, causing an acute financial crisis in the hydropower, coal and alcohol sectors and slowing down the growth rate of domestic oil production.

The expansion of the economic frontier towards the Amazon was stimulated by the military Government, which ruled the country from 1964 to 1985. Huge investments for mining, agriculture and cattle-raising activities started in this period and attracted both domestic and foreign capital. Public policies were designed to favor capital flow towards investments in the region. Fiscal exemptions were allowed for projects that required the removal of the forest cover, such as cattle-raising activities. Large infrastructure developments, such as the expansion of the road network and the building of the first large hydropower plants in the region, also indirectly contributed to deforestation. As a result, deforestation rates in the Amazon peaked at an annual average of 2 Mha/y (million hectares per year) in the period 1978-2004 (MMA, 2005).

3.1.3 The Recent Evolution in the Nineties

Since the renegotiations of the terms for the repayment of foreign debt at the beginning of the nineties, the current economic picture has improved slightly, but until 1994 very high inflation rates still hampered the recovery of economic growth, internal savings and investment levels. In

[3] In 2002, ethanol consumption (hydrated and anhydrous) represented 31.7% of the energy consumed by cars in Brazil (ethanol + gasoline) (PETROBRAS, 2004).

the second half of the decade, inflation was brought under control favoring economic activity, but financial constraints such as high interest rates have limited the acceleration of economic growth.

Population growth rate continued to decline in the nineties, reaching an annual average of 1.4 % in the decade. GDP per capita is currently 7 to 10 times less than it is in industrialized countries. Energy consumption per capita is much lower than in OECD countries. The energy-intensity of GDP (energy demand of 0.3 toe / 1000 US$ of GDP) in the nineties was higher than in OECD countries, given the relative weight of energy-intensive industries in the economy and the high demand for transportation. Energy consumption increased at a faster pace than economic activity during the nineties, fuelled by sustained growth of oil, natural gas and power consumption (see Tables 4, 5 and 6).

Table 5 - Population, GDP and Domestic Energy Supply in Brazil, 1990-2003 0

	1990	1994	1998	2000	2003
Population (million)	147.6	156.8	165.7	170.1	176.9
GDP (billions of 2003 US$)	374.3	416.7	461.1	485.1	498.4
Domestic Energy Supply (millions of toe / year)	142.0	157.4	185.6	190.6	201.7
GDP / capita (2003 US$)	2,536	2,658	2,783	2,852	2.817
Energy / capita (toe / inhab)	0,96	1,00	1,12	1,12	1,14
Energy / GDP (kgoe / US$)	0,379	0,378	0,403	0,393	0,405

Source: MME, 2004.

Table 6 - Population, GDP and Domestic Energy Supply Growth in Brazil in the Nineties (Yearly Average Rates)

	1990-1994	1994-1998	1998 - 2000	1990-2000
Population (% / year)	1.42	1.28	1.56	1.39
GDP (% / year)	2.78	2.58	2.61	2.67
Domestic Energy Supply (% /year)	3.00	4.36	1.59	3.26

Source: MME, 2001

Social indicators improved slowly in the nineties, particularly after 1994, but still lag behind economic performance due to the highly skewed income distribution across regions and social classes in the country. Literacy rates (of adults above 15 years of age) have reached 86 %, against 82 % in 1994. Infant mortality was reduced from 4.8 % in 1994 to 3.3 % in 2001. The share of the population living below the poverty line had decreased from 44% in 1994 to 33% by

[4] This percentage refers to the firewood used in industry and that comes from sustainable forest management. Charcoal production is not included in this percentage (20%) (Schaeffer et al., 2003).

the end of the decade. The lack of a comprehensive agrarian reform policy fuelled internal migration, mainly towards the Amazon region.

However, the recent evolution in the nineties shows a fast increase in the consumption of oil and natural gas – a growth of more than 50 % in the decade – which made the share of fossil fuels in the national energy balance grow from 37% in 1990 to almost 40.2 % in 2003 (MME, 2004).

The reversal of the trend observed after 1985 (Figures 2 and 3) is not only due to the relative decrease of international oil prices and the significant increase in domestic oil and gas production following the discovery of significant Brazilian off-shore resources. Financial constraints on the public budget have also severely affected the support of renewable energy production. Short-term prospects for Brazilian energy policy are now directly opposed to the minimization of CO_2 emissions,

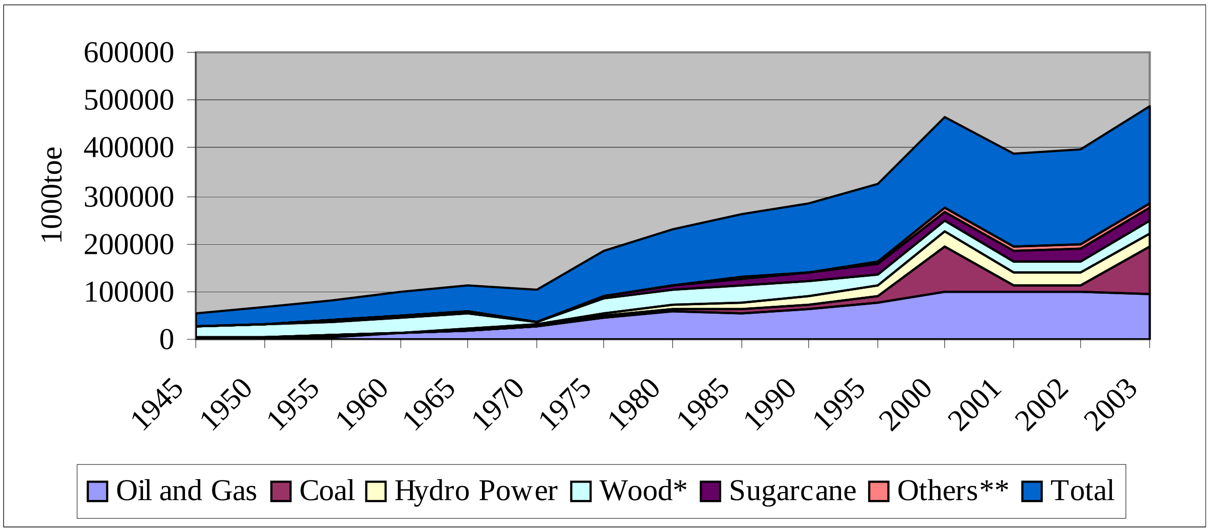
Hydropower development has been delayed and the building of new plants nearly stopped, due to the insufficiency of public funds to meet the huge investment required for expansion, Brazil's Government took the initiative to privatize and reform the electricity industry during the late 1980s and early 1990s. Despite coherent criticisms concerning the final selling prices of the national utilities (from civil society organizations, members of the academic sector, etc.), the utility privatization program for the energy sector has opened the doors for new Brazilian and foreign companies – such as Enron, Southern Electric, AES, Duke Energy, Électricité de France, Iberdrola, and Electricidade de Portugal – to this now-competitive market. The power sector organization, in this context, underwent significant changes[5].

The new trend points to the building of gas-fired thermopower plants by the private sector, as a less capital-intensive option generally coupled with the availability of foreign funding facilities.

Given the huge amount of natural resources available in the country, the potential for renewable energy production remains largely untapped. Similarly, there is still significant potential for energy conservation.

[5] Power sector organization / recent evolution: In 1995, the Federal Government began a restructuring Brazil's electricity sector. A regulatory agency, ANEEL, was established in 1996, and the creation of a national transmission operator (Operador Nacional do Sistema Elétrico) followed in 1998. In September 2000, a wholesale market was created (Mercado Atacadista de Energia Elétrica), which was put under the jurisdiction of ANEEL in 2002. Brazil had also planned to privatize three subsidiaries of the state-owned utility Eletrobrás - Centrais Elétricas do Norte do Brasil (Eletronorte), Furnas Centrais Elétricas (Furnas) and the Companhia Hidro Elétrica do São Francisco (Chesf) - but the Luis Inácio Lula da Silva administration put a halt to this after taking office in 2002. Eletrobrás, along with its subsidiaries, therefore retained their control over nearly half of the country's installed capacity and most of the large transmission lines. The largest private power company in Brazil is Tractebel Energia, a subisidiary of France's Suez,

Figure 2 - Domestic Energy Supply in Brazil - 1945 to 2003



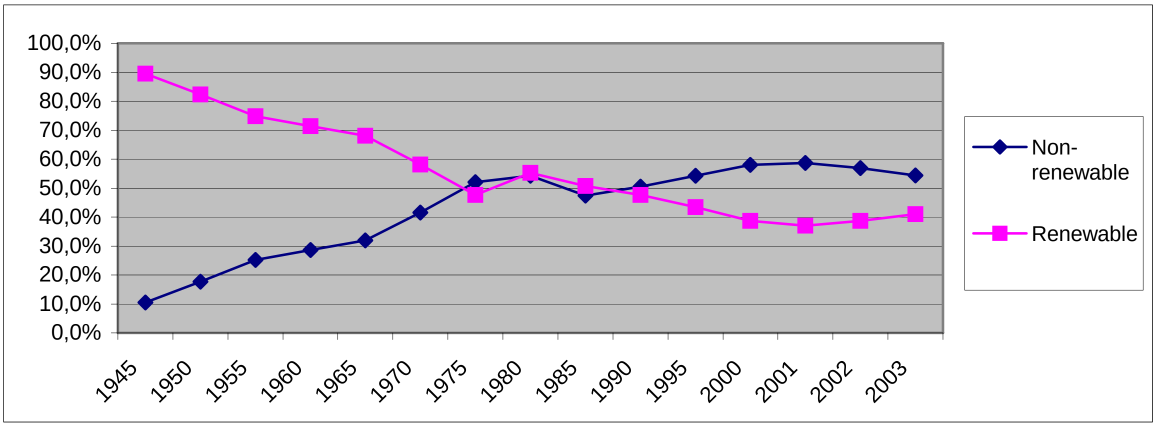
Notes:

* Part of the wood comes from deforestation and is not renewable.

** Others includes nuclear, new renewable (biomass, SHPs and aeolian) and non-rewable energy.

Source: MME, 2004.

Figure 3- Domestic Energy Supply in Brazil - 1945 to 2003 - Renewable x Non-renewable



Notes: * Part of the wood comes from deforestation and is not renewable

** including nuclear, renewable and non-renewable energy

The Brazilian Energy Balance adopts a factor of 0.086 toe/MWh to convert hydro electricity.
Source: MME, 2004.

3.1.4 Urbanization process and the great differences between Brazil's regions

In 2002, already 82% of the Brazilian population lived in cities. The urban population is still growing, the migration from the countryside to the city is continuing. The consumption of resources by city dwellers generally is much higher compared to inhabitants of rural areas.

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with an installed generation capacity of 6.7 GW. Although generation remains mostly under government control and transmission is not slated for privatisation in the near future, distribution is mostly in private hands.

These two aspects – the vast majority of the population lives in cities and their higher resource consumption leads to the conclusion that the quest of sustainability will be decided in cities.

Cities today are suffering from different environmental problems, like, for example, the pollution of ground water and soil due to insufficient sewage systems and landfills, air and noise pollution due to an excess of private and public transport based on combustion of oil derivatives and a lack of thermal comfort due to urban heat islands caused by insufficient urban planning.

The visibility of these problems is a result of the high population density in cities, which, at the same time, put in evidence the solutions: efficient mass transport systems and sewage treatment plants and the concentration of financial resources due to the horizontal and vertical concentration of income per hectare opens the way to more sophisticated solutions in the built-up environment.

The urbanization process has a direct relationship to the lack of investments in the rural regions of Brazil. Despite all the problems in the urban areas caused by the urbanization process, this lack of investments generated great regional differences in Brazil (see Table 7). Of course, there are other reasons for the large social and economic differences between Brazil's regions. The very historical evolution of Brazil, with high affluence in the South/Southeast explains much of this situation.

Table 7: Regional differences in Brazil, 1998

Region	% area	%pop	% of industrial jobs	Average income (US$ 1998)
North and Northeast	18	29	18	1,890
South and Southeast	11	43	57	3,720

Source: IBGE, 2001.

A recent study by the Brazilian Institute of Geography and Statistics (IBGE) clearly shows that the income gap between the most affluent part and the less affluent part of Brazil's population is immense and growing. Some 5% of the wealthiest population (concentrated in the South and Southeast regions) earning roughly as much of the aggregate domestic income as 80% of the poorest (concentrated in the North and Northeast regions) (IBGE, 2002).

This uneven situation is reflected in the access to energy: there are substantial variations among the different regions of the country concerning the access to electricity, as shown in Table 8. Only 68% of the rural population in the Northeastern Region have access in comparison to 98.7% of the urban Southeastern population. However, these figures refer solely to the access to electric lighting without taking into account the source or quality of the service. It is evident that those regions with the lowest rates of access are the poorest regions (NE and N).

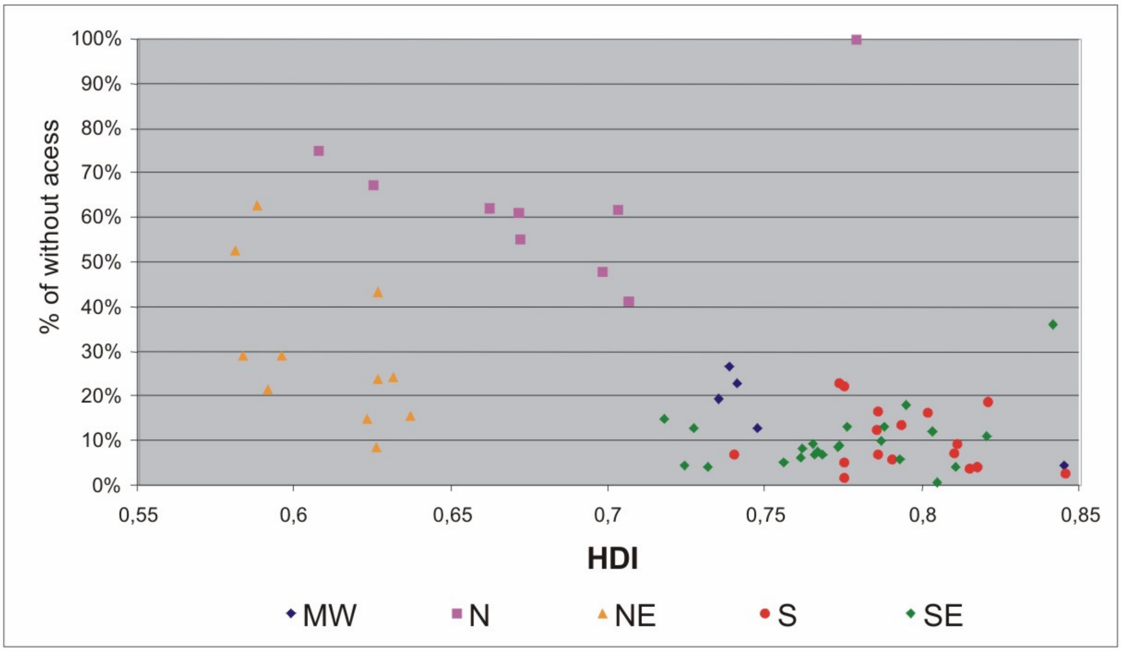
Table 8: Access to Electricity in the Different Regions of Brazil

Brazil and Regions	Non-connected private permanent households – Dec. 2002					
	Urban	%	Rural	%	Total	%
Brazil	774,355	1.9%	1,942,012	24.3%	2,716,368	5.5%
Northern	78,068	3.5%	464,449	56.1%	542,517	17.6%
Northeastern	264,644	2.9%	1,119,783	32.0%	1,384,427	11.1%
Southeastern	267,855	1.3%	144,121	7.7%	411,976	1.9%
Southern	106,499	1.6%	137,283	10.0%	243,782	3.1%
Mid-West	57,290	1.9%	76,375	17.5%	133,666	3.9%

Source: Estimate of Ministry of Mines and Energy based on the 2000 Census and the 2001 PNAD, taking into consideration the achievements of *Luz no Campo* Program.

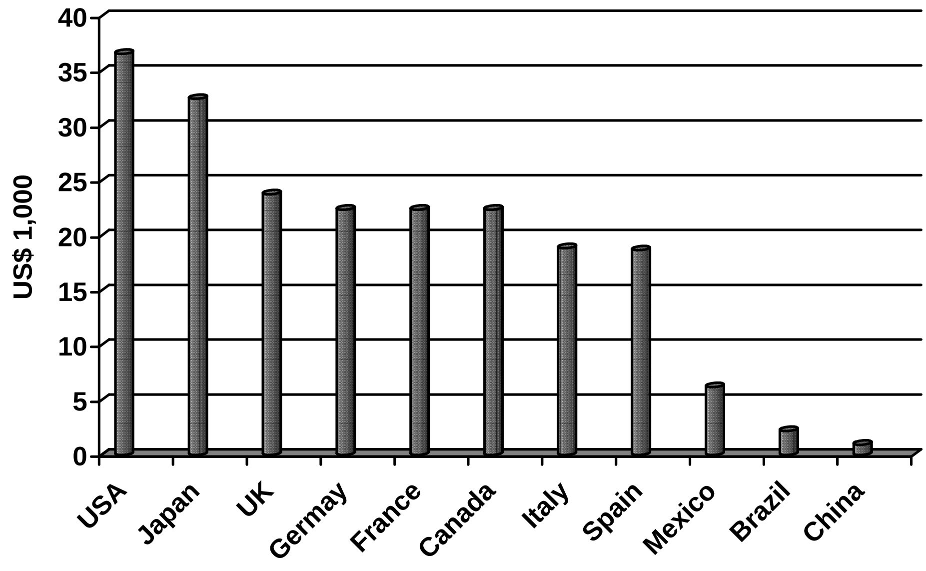
In fact, the notorious difference between the average incomes of the North/Northeast and South/Southeast regions reflects the great historical income accumulation in Brazil. This process reflects in the fact that the income of Brazilians is one of the worst of the world, as shown in Figure 4.

Figure 4: Access Level versus HDI in Brazilian regions



Source: IBGE, 2000.

Figure 5: Income of the population: Brazil versus selected countries of the world (2002)



Source: Global Invest, 2002.

3.2 Characterization of population and zones

Brazil's population growth was relatively high during the 20th Century, but it began to slow down in the 1980s. Until recently, the population was predominantly rural and agricultural. The latter half of the 20th Century brought rapid urbanization due to population growth and the migration of people from rural areas seeking employment in the expanding industries of the cities.

In 1950, Brazil had 51,944,000 inhabitants, and by 1980, the population had more than doubled to 119,002,700. The most recent census, in 2000, recorded a population of 169,799,170. A 2004 estimate placed the population at 184,101,109. Among the factors that contributed to these high growth rates were immigration, high birth rate, and a death rate that has declined steadily since 1870.

In Brazil, there are considerable regional variations in population density. The most densely peopled states are Rio de Janeiro and São Paulo in the Southeast and the Federal District in the Mid-West. The least populous states are Roraima and Amazonas, both in the North. About 80 percent of the population lives within 350 km (220 mi) of the coast. Until the mid-sixties there were more rural dwellers than people living in towns; since then, the urban population has increased as industrialization lures workers to the larger cities. About 82 percent of the population is now classed as urban, and a significant proportion lives in big cities.

Geographic Regions

Brazil's twenty-six states and the Federal District are divided conventionally into five regions: North, Northeast, Southeast, South and Mid-West. In 1996, there were 5,581 municipalities, which have municipal governments. Many municipalities, which are comparable to United States counties, are in turn divided into districts, which do not have political or administrative autonomy. In 1995, there were 9,274 districts. All municipal and district seats, regardless of size, are considered officially to be urban. For purely statistical purposes, the municipalities were grouped in 1990 into 559 micro-regions, which in turn constituted 136 meso-regions. This grouping modified the previous micro-regional division established in 1968, a division that was used to present census data for 1970, 1975, 1980, and 1985.

Differences in physical environment, patterns of economic activity and population settlement vary widely among the regions. The principal ecological characteristics of each of the five major regions, as well as their principal socioeconomic and demographic features, are summarized below.

3.2.1 North/Northeast

- *North*

The equatorial North, also known as the Amazon, includes, from west to east, the states of Rondônia, Acre, Amazonas, Roraima, Pará, Amapá, Tocantins.

With 3,869,638 square kilometers, the North is the country's largest region, covering 45.3 percent of the national territory. The region's principal biome is the humid tropical forest, also known as the rain forest, home to some of the planet's richest biological diversity.

In 1996, the North had 11.1 million inhabitants, only 7 percent of the national total. However, its share of Brazil's total population had grown rapidly in the 1970s and early 1980s as a result of interregional migration, as well as high rates of natural increase. The largest population concentrations are in eastern Pará and in Rondônia. The major cities are Belém and Santarém in Pará, and Manaus in Amazonas. Living standards are below the national average. The highest per capita income, US$ 5,718, in the region in 1998, was in Amazonas, while the lowest, US$ 441, was in Acre (IPEA, FJP, IBGE, UNDP, 1998).

- *Northeast*

The nine states that make up the Northeast are Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe.

The Northeast, with 1,561,178 square kilometers, covers 18.3 percent of the national territory. Its principal biome is the semiarid *caatinga* region, which is subject to prolonged periodic droughts. By the 1990s, this region utilized extensive irrigation. In an area known as the forest zone, the Atlantic Forest, now almost entirely gone, once stretched along the coastline as far north as Rio Grande do Norte. Sugar plantations established there in colonial times persisted for centuries. Between the *mata* and the *sertão* lies a transition zone called the *agreste*, an area of mixed farming.

Because its high rates of natural increase offset heavy out-migration, the Northeast's large share of the country's total population declined only slightly during the twentieth century. In 1996, the region had 45 million inhabitants, 28 percent of Brazil's total population. The population is densest along the coast, where eight of the nine state capitals are located, but it is also spread throughout the interior. The major cities are Salvador, in Bahia; Recife, in Pernambuco; and Fortaleza, in Ceará. The region has the country's largest concentration of rural population, and its living standards are the lowest in Brazil. In 1994, Piauí had the lowest per capita income in the region and the country, only US$ 835, while Sergipe had the highest average income in the region, with US$ 1,958.

3.2.2 Mid-South

- *Southeast*

The Southeast consists of the four states of Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo. Its total area of 927,286 square kilometers corresponds to 10.9 percent of the national territory. The region has the largest share of the country's population, 63 million in 1991, or 39 percent of the national total, primarily as a result of internal migration since the mid-nineteenth century until the 1980s. In addition to a dense urban network, it contains the megacities of São Paulo and Rio de Janeiro, which in 1991 had 18.7 million and 11.7 million inhabitants in their metropolitan areas[6], respectively. The region mixes the highest living standards in Brazil with pockets of urban poverty. In 1994, São Paulo boasted an average income of US$ 4,666, while Minas Gerais reported only US$ 2,833.

Originally, the principal biome in the Southeast was the Atlantic Forest, but by 1990, less than 10 percent of the original forest cover remained as a result of clearing for farming, ranching and charcoal making. The region has most of Brazil's industrial production. The State of São Paulo alone accounts for half of the country's industries. Agriculture, also very strong, has diversified and now uses modern technology.

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[6] In 2003, about 20 million people live in the Greater São Paulo metropolitan region, which is currently ranked as the fifth-largest in the world and the largest in the Southern Hemisphere (Wikipedia, 2004). In Rio de Janeiro, the larger metropolitan aera population is estimated at 10-13 million (2003 data) (Wikipedia, 2004).

- *South*

The three states in the temperate South - Paraná, Rio Grande do Sul and Santa Catarina - cover 577,214 square kilometers, or 6.8 percent of the national territory. The population of the South in 1991 was 23.1 million, or 14 percent of the country's total. The region is almost as densely settled as the Southeast, but the population is more concentrated along the coast. The major cities are Curitiba and Porto Alegre. The inhabitants of the South enjoy relatively high living standards. Because of its industry and agriculture, Paraná had the highest average income in 1994, US$ 3,674, while Santa Catarina, a land of small farmers and small industries, had slightly less, US$ 3,405.

In addition to the Atlantic Forest and pinewoods, much of which was cleared in the post-World War II period, the South contains *pampa* grasslands, similar to those of Argentina and Uruguay, in the extreme south. Agriculture - a large part of the anthropic activity developed in the Region, such as rice production, is carried out by small farmers - has high levels of productivity. There are also some important industries.

- *Mid-West*

The Mid-West consists of the states of Goiás, Mato Grosso, and Mato Grosso do Sul (separated from Mato Grosso in 1979), as well as the Federal District, site of Brasília, the national capital. Until 1988, the State of Goiás included the area that became the state of Tocantins in the North.

The Mid-West has an area of 1,612,077 square kilometers and covers 18.9 percent of the national territory. Its main biome is the *cerrado*, the tropical savanna in which natural grassland is partly covered with twisted shrubs and small trees. In the north, the *cerrado* blends into tropical forest. It also includes the *Pantanal* wetlands in the west, known for their wildlife, especially aquatic birds and caimans. In 1996, the Mid-West region had 10.2 million inhabitants, or 6 percent of Brazil's total population. The average density is low, with concentrations in and around the cities of Brasília, Goiânia, Campo Grande and Cuiabá. Living standards are below the national average. In 1994 they were highest in the Federal District, with per capita income of US$ 7,089 (the highest in the nation), and lowest in Mato Grosso, with US$ 2,268.

3.2.3 Inequality in Brazil

Brazilian society displays marked inequality between the cities and the inland, between regions, and between social classes. The gap between rich and poor is among the most substantial in the world. In 1998, the richest 20 percent of the population received 64 percent of the nation’s income, while the poorest 20 percent earned only 2 percent. Besides access to wealth, this inequality is also reflected in access to education, medical care and services such as water supply, sewerage and electricity.

In fact, one of the biggest problems in Brazil is that of inequality. This means that the wealth of the country is not divided fairly between the people: there are a few very rich people and many very poor people. In cities like São Paulo and Rio de Janeiro, many poor people live in shantytowns or slums.

Despite the rich resources, rapid economic development and the overall size of Brazil's economy, the nation has major problems with poverty, hunger, disease and inadequate services. In the cities, overcrowding compounds these problems. Rapid urbanization has brought people to the cities at a rate that has outpaced the growth of the job market and the urban services that they need to survive comfortably. Many of the larger cities have extensive slums. Homelessness—particularly among children and young teens whose families cannot support them—constitutes another major problem.

Despite these urban problems, poverty and lack of access to clean water, electricity, health care, and schooling may be more acute in the countryside. For example, 95 percent of urban dwellers have access to safe drinking water as opposed to just 53 percent in the countryside. Such distinctions are also evident between regions. The average head of a household in the Northeast is likely to earn only half as much as its counterpart in the Southeast, twice as likely to be illiterate, and have a life expectancy five years lower. A key challenge for the government remains the inequality of opportunity among citizens (IBGE, 2000).

3.3 Needs and Energy requirements

In 1950, Brazil's capacity to generate electricity was only 1.9 million kilowatts, and most of the required petroleum products had to be imported. An adequate supply of electric energy became critical, both for production and for a rapidly growing urban population. Petroleum requirements expanded quickly because of the decision to make the automobile industry the mainstay of import-substitution industrialization and because of the heavy reliance on trucks for short- and long-distance transportation. Ambitious road-building programs were implemented, and the domestic automobile industry quickly expanded the number of motor vehicles, reaching 1.05 million units in 1960, 3.1 million units in 1970, and 10.8 million units in 1980.

The unfolding of Brazil's current difficulties in the energy arena constitutes a classic example of distortions arising from misdirected regulation combined with the action of interest groups. When import-substitution industrialization began in the early 1950s, the country's main sources of energy were firewood, charcoal and bagasse (the dry residue from the processing of sugar cane). Because modern industrial expansion could not be based on these, a decision had to be made regarding the sources of energy to be used. Not surprisingly, electricity and petroleum products received special attention.

Low electricity prices stemmed from the substitution policy and from the attempt to control inflation by restraining the increase in public-sector prices in nominal terms. Thus, the capacity of the electricity sector to generate resources for investment was considerably affected. As a result of federally induced borrowing in the late 1970s and early 1980s, the sector was also heavily indebted. Intermittent adjustments in electricity prices allowed the sector to generate profits and thus some resources for investment. However, on occasion, the government returned to the practice of manipulating consumer prices to contain inflation.

Although the federal treasury initially assumed many of the cost distortions of the energy policy, by the end of the 1980s the virtual bankruptcy of the public sector precluded this approach. In the early 1990s, the government implemented a series of measures to reduce its role. It introduced deregulation, market reforms, and privatization, but these reforms did not change the essence of the energy policy. Interest groups prevented the adoption of measures that would drastically alter the liquid fuel policy, and the agency controlling electric energy continued to lack resources for investments. Thus, the energy price structure was only marginally altered.

Low electricity prices induced a considerable substitution of electricity for other sources of energy and the expansion of electricity-intensive production, such as aluminum. The heavy investments in hydroelectricity of the 1970s and 1980s matured, creating a considerable generating capacity. Brazil is the third largest producer and consumer of electricity in the Western Hemisphere, behind the United States and Canada. As of December 2002, Brazil had an installed generation capacity of 76.2 GW, a 3.6% increase year-on-year. Hydroelectricity accounted for 83% of Brazil’s installed capacity in 2002, with an absolute year-on-year increase of 1.48 GW (EIA, 2004). One of the world's leading producers of hydroelectric power, Brazil has a potential of 106,500 to 127,868 megawatts, or, according to the World Factbook 1996, 55,130,000 kilowatts. The country's two largest operating hydroelectric power stations are the 12,600-megawatt Itaipu Dam, the world's largest dam, on the Paraná River in the South, and the Tucuruí Dam in Pará, in the North Region.

In principle, an increase in the electricity generating capacity should have been easy to achieve. Brazil has enormous hydroelectric potential, and investments in the sector were forthcoming, although with an initial delay. However, until 1995 nationalistic considerations excluded foreign capital from the electric energy sector, and regulatory obstacles prevented domestic private investment. After 1995, this situation underwent changes with regard to the privatization program, as analyzed in section 3.1.3.

3.3.1 Residential

Together with growing rates of urbanization, industrialization and concentration of economic activities over the Brazilian space, one can observe an increase in urban poverty, both in relative and absolute terms, as well as the proliferation of slums (*favelas*) and illegal settlements, either in central cities or in the outskirts of the metropolitan areas. Increased urban poverty, crime, social discrimination and spatial segregation within the cities adversely affect the environmental quality and living conditions of the urban population, especially the poor, increase the need for adequate shelter and urban infrastructure services and call for more efficient and better-targeted urban development and social policies. In fact, this situation explicit the disparity between rich and poor in the country. The wealthy live in luxurious mansions or on vast estates, employ maids and gardeners and enjoy the same consumer goods as any family in the developed world. Homes for the poor are shacks of cardboard and corrugated iron, furnished with the barest essentials and mostly without water, light or sanitation.

Residential cooking and hot water in rural areas of Brazil are supplied primarily by direct combustion of biomass—in the form of wood, crop wastes, dung and charcoal. In recent decades, the decline in forest resources in many countries directed attention to more efficient household use of biomass, as well as solar cookers.

Household and community demand for lighting, in isolated areas of Brazil (mainly in Amazon) without electricity has driven markets for solar home systems, small hydro minigrids, solar hybrid minigrids, vegetable oils and biomass.

3.3.2 Social Services

The Brazilian government first established a social security provision in 1911. During the 1930s, President Getúlio Vargas implemented a welfare system that was advanced for its time, providing workers with minimum wages, unemployment insurance and retirement benefits. During the 1960s a range of benefits covering medical assistance, sickness benefits, workmen's compensation and pensions were brought together under the National Institute for Social Security (INPS), which was financed by contributions from workers and employers. In 1988, the drafters of the new constitution sought to provide equal access to welfare, health care, and social assistance. They extended equal benefits for pensions and maternity rights to rural and urban workers.

Financial constraints have led to a decline in the quality of the public health service, and many of the more affluent people belong to private health programs. The federal government finances the majority of the public health services, the balance coming from states and municipalities. Considerable inequity also exists in access to medical services, favoring cities and the more populated Southeast.

In most Brazilian communities, social and health services are inadequate, overburdened, or both. In addition, local governments lack the infrastructure of service system supports needed to develop and maintain effective rehabilitation programs, such as those found in parts of the United States and elsewhere around the world. As a result, Brazilians with disabilities who cannot be properly cared for by their families have limited opportunities to develop the work skills and personal independence needed to lead productive and meaningful lives.

Despite these difficulties, life expectancy at birth rose from 57 years in 1960 to an average of 71 years—68 years for men and 75.6 years for women—in 2004. The infant mortality rate fell from 95 deaths per 1,000 live births in 1970 to 31 deaths per 1,000 live births in 2004. As a reflection of increasing prosperity, the principal causes of death match those found in developed countries. However, parasitic diseases, gastric ailments and malnutrition are still threats to the impoverished and the young. Tropical diseases, which are endemic to some areas, include malaria, yellow fever, Chagas' disease, hookworm and schistosomiasis.

3.3.3 Productive Uses

Productive uses of renewable energy are those that increase incomes or provide other social services beyond home lighting, entertainment and increased conveniences. As incomes increase, rural populations are able to afford even greater levels of energy service. The major emerging productive uses of renewable energy in Brazil are for agriculture, small industry, commercial services and social services, such as drinking water, education and healthcare.

Rural entrepreneurs are the key driving forces of new clean-energy technologies, particularly for household lighting and productive uses in small industry, agriculture and water supply. However, few clean-energy enterprises exist, and the challenges of rural-enterprise development and financing are large. New models of enterprise development and financing are needed, along with adoption of proven models.

3.4 Technologies for renewable energy

3.4.1 Biomass technologies

3.4.1.1 Steam Cycles

The most common technologies used for biomass conversion in Brazil are steam–based cogeneration systems in operation at sugar cane and pulp/paper mills.

These are conventional steam cycles, composed of a biomass boiler, where biomass is burnt, and a steam turbine for electric/mechanical energy conversion. Average systems (10 to 50 MW) in use include medium pressure boilers up to 65 bar.

The steam turbine, where the steam is expanded, is connected to a generator that produces electricity. This equipment can be back-pressure steam turbines, in which the exhaust steam goes to process, or extraction condensing turbines, in which the extracted steam goes to the process. In small-scale projects (under 1 MW), efficiency is lower because it is not feasible to install components to improve the efficiency, as it is in large ones. Consequently, the economics of the system are not adequate. Now, in Brazil, there are prototypes under development aiming to solve this problem. The medium-sized steam systems are in most cases connected to the transmission grid, supplying energy to all classes. In a few cases, the mills supply excess energy to the local villages located around the plant. The small-scale systems (under development) are especially important because they can supply electricity to remote villages, where the poorest people in the country are located. However existing steamn systems present a minimum installed power of 500 kW and, only in 2005, 200 kW-system are being tested (ENERMAD project, CENBIO). So there is a need for other technologies using biomass residues, such as gasification.

3.4.1.2 Gasification

3.4.1.2.1 Small scale gasification systems

Gasification is a process to produce a gaseous fuel (synthesis gas, composed mainly by CO and H_2) with better transport characteristics, better combustion efficiency and which can also be used as feedstock for other processes.

Most small-scale gasifiers that are now commercially available or under development can be classified according to the type of the bed: fixed or fluidized. The fixed bed gasifier is the type most used for small-scale supply and can be used in isolated communities, as it is happening in

India (CENBIO, 2004).

The fixed bed system developed by the Indian Institute of Science, Bangalore, India presented good results in tests developed in São Paulo by CENBIO/USP and IPT - Technology Research Institute of São Paulo State (CENBIO, 2002).

In 2004, this 20 kW system was installed in a remote village (Aquidaban) in Amazon to be operated by the community, using residues from a local fruit (“cupuaçu”). A second one, produced by Ankur (India) is expected to be installed in a remote village (in the municipality of Maracapuru, Amazonas).

This technology seems to be promising for the efforts to increase the energy supply in the region. The most important use of biomass residues (locally available) is the replacement of diesel oil, currently used in old and inefficient diesel engines, with positive consequence of reducing the village’s diesel expenditures.

In the past, there were others experiences with small-scale gasifiers in Brazil. These experiences were mentioned in CENBIO, 2003.

3.4.1.2.2 Medium-Large-scale gasification systems

There were two important large-scale projects (30 MW): the Wood Gasification Project (in NE Brazil, coordinated by CHESF – Attachment 1) and the Bagasse Gasification Project, managed by Copersucar, São Paulo (Attachment 2). Both were expected to use atmospheric fluidized bed systems, a technology developed by TPS, from Sweden (also responsible for the ARBRE – ARABLE BIOMASS RENEWABLE ENERGY project, in the UK), with significant perspectives for electricity generation in wood and sugar cane sectors. In the Copersucar project, the bagasse/barbojo tests were held in Sweden by TPS and the availability of the biomass (bagasse/barbojo) as well as the best agricultural procedures for the sugar cane harvesting were evaluated by Copersucar. In addition, the introduction of mechanical harvesting of crude cane (green cane) has been developed by several Brazilian institutions (Copersucar, Unicamp, among others). These two projects are currently suspended for economic reasons.

Discussions with World Bank/GEF have been held during several years but the construction of the plant has not yet been decided. At the time of this report, the construction of the NE plant had been postponed and the Copersucar one was under discussion, looking for Brazilian investors to complement GEF grant.

3.4.1.3 Biomass-Fueled Engines for transportation

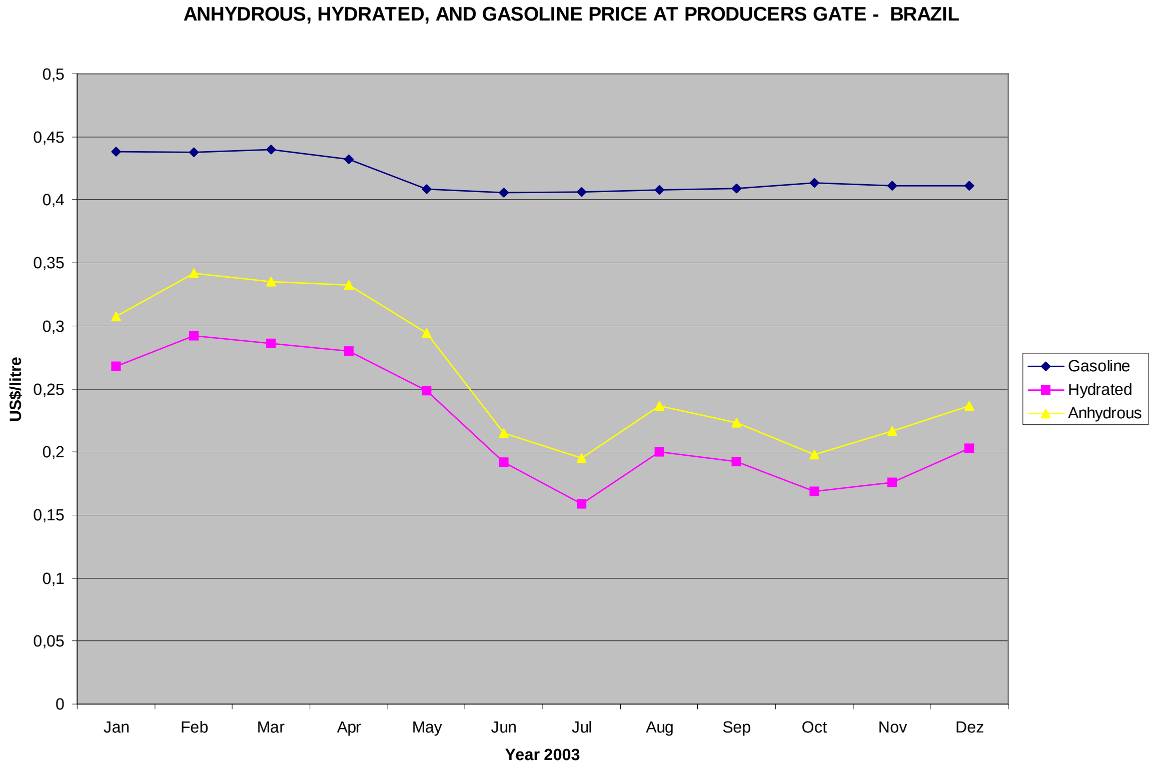
3.4.1.3.1 Dedicated Ethanol Engines

In Brazil 3.5 millions cars run on pure hydrated ethanol (UNICA, 2004), and all gasoline in the country is blended with anhydrous ethanol (20 to 26% of ethanol, volume basis).

Ethanol makes an excellent motor fuel: it has a motor octane number that exceeds that of gasoline and has a lower steam pressure than gasoline, which results in lower evaporative emission. Ethanol's flammability in air is also much lower than that of gasoline, which reduces the number and severity of vehicle fires. Anhydrous ethanol has lower and higher heating values of 22.4 mega joules (MJ) per liter and 23.4 mega joules per liter, respectively; for gasoline the values are 32.2 and 34.9 mega joules per liter (www.mct.gov.br,2005).

Currently no subsidies are given to ethanol fuel producers and ethanol is sold at 50 to 65% the price of gasoline at gas stations (volume basis). This is possible because production costs have reduced significantly showing the current economic competitiveness of ethanol when compared to gasoline. Considering the higher consumption rates for net-ethanol cars, ethanol prices at the station could be as much as 70% of gasoline (volume basis) and still providing a gain to consumers. Figure 6 shows the comparison of price at producers' gate of different transportation fuels in Brazil in 2003.

Figure 6: Anhydrous, hydrated, and gasoline price at producers' gate in Brazil.



Source: UNICA, 2003.

3.4.1.3.2 Flex-fuel vehicles

Flex-fuel vehicles are those which can operate with multiple fuels (or fuel blends). Such technology was created 1980 and in the US today there are around two million vehicles using it.

The main fuels to be used include gasoline and several alternative fuels, such as pure ethanol (already used in Brazil in automotive vehicles); ethanol-gasoline blend (already in use in Brazil, in a percentage of 20 to 26% ethanol); methanol-gasoline blend (also existing in US, with 85% methanol).

The methanol-gasoline blend presents lower perspectives of being introduced, because most of automobile manufacturers do not allow its use in their motors. In Brazil only ethanol and ethanol-gasoline blend are used.

Technically speaking, in flex-fuel vehicles a sensor in the fuel system identifies the actual fuel blend being used and automatically adjusts the ignition time and the air/fuel mixture. The greatest advantage of the flex fuel vehicles is that these motors can operate with regular gasoline – when alternative fuels are not available or are not economically competitive.

Flex-fuel cars in the US are built to choose between natural gas, pure gasoline and gasoline with a few percent of ethanol. In Brazil they are built to accept a larger percentage of ethanol (even pure ethanol), which requires changing the lining of the fuel tank and other parts of the engine system and are bound to be more expensive.

The use of flex-fuel vehicles is an interesting option for Brazil, ending the necessity of different engines for gasoline and ethanol. When compared to an ethanol vehicle, there is a small reduction of the efficiency, but the strategic advantages justify the adoption of this technology.

The possible use of gasoline and ethanol in the engines increase the versatility of ethanol consumption in the country.

The demand for this type of car in Brazil is increasing. The manufacturers had sold from January to July 2004, seventy one thousand vehicles. In the near future all cars sold in Brazil are expected to be "flex-fuel". However, these engines are only for light vehicles (medium/high classes). For poor people, the most adequate RETs in transportation are related to biodiesel, to be used in public transportation partially replacing Diesel oil, as discussed in section 3.4.1.4.2**.**

3.4.1.3.3 Fuel Cells

Fuel cells produce electricity. Like a battery, a fuel cell converts energy produced by a chemical reaction directly into usable electric power. However, unlike a battery, a fuel cell needs an external fuel source — typically hydrogen gas — and generates electricity as long as fuel is supplied, meaning that it never needs electrical recharging. Inside most fuel cells, hydrogen from a fuel tank and oxygen combine in an electrochemical device to produce electricity and warm water. One difficulty in using fuel cells is hydrogen production and storage. The predominant method for making hydrogen today involves using natural gas as a feedstock. Petroleum-based fuels, including gasoline and diesel, can also be used, but this may compromise a major objective behind alternative fuels, which is to reduce oil consumption.

Hydrogen is produced by the so-called "reform reaction" of an existing fuel (natural gas, methanol, ethanol, naphtha), a chemical reaction that "extracts" the hydrogen from the fuel, producing a gaseous mixture of carbon monoxide (CO) and hydrogen. The hydrogen must be separated from the CO to be fed to the fuel cell.

This reaction can be performed in a stationary system (in this case the vehicle will carry a high-pressure hydrogen storage tank) or in an on-board-reformer-fuel-cell system (and in this case the vehicle will carry a conventional fuel tank to feed the system). Both possibilities are now under study in several countries.

According to some specialists, ethanol should be the fuel of choice for fuel cells due to its lower emissions and to the fact that it can be produced from a renewable source (biomass). Several Brazilian institutions are working on ethanol reformer systems to allow its use in fuel cells (MCT, 2004).

However, this is still a technology under development and perspectives for cost reducing seems remote in a near future.

3.4.1.4 Biofuels

3.4.1.4.1 Ethanol

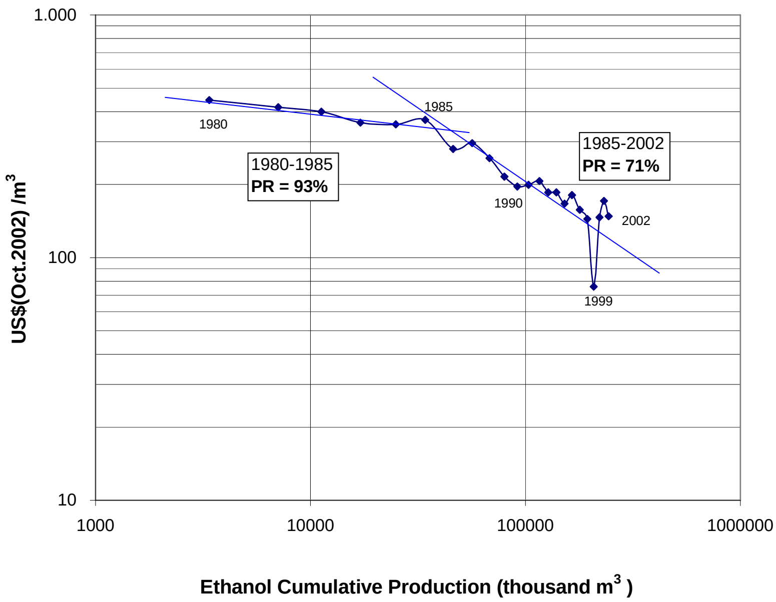
In Brazil, as mentioned, ethanol is used in automotive vehicles in one of three ways:

- As an octane enhancer in gasoline in the form of 20 to 26% anhydrous ethanol (99.6 Gay-Lussac - GL and 0.4 percent water) and gasoline, in a mixture called gasohol;
- In pure-ethanol engines in the form of hydrated ethanol at 95.5 GL;
- In flex-fuel vehicles.

The increase in the production and use of ethanol as a fuel was made possible and ethanol is now competitive with gasoline due to the large-scale production (14.8 billions liters – in 03 / 04 harvest), and the extremely favorable energy balance. The energy balance of the conventional ethanol production process (extraction, fermentation, distillation) from sugar cane is around 8.3:1 (8.3 units of energy produced against 1 unit of fossil fuel consumed). This is due to the fact that all energy consumed in the industrial plant derives from sugar cane (sugar cane bagasse from sugar cane crushing).

Ethanol production costs were close to 100 US dollars a barrel in the initial stages of the Proalcool Program in 1980 (the Program was created in 1975 with the main objective of increasing the production of alcohol for fuel purposes in the face of the threat from rising oil prices on the international market). Up to 1985, as production increased, prices paid to producers reflected average costs of production, which were surveyed by government mandate through the Getúlio Vargas Foundation. During this initial phase, prices fell slowly, reflecting the gains in agro-industrial yield and economies of scale achieved by producers, and these gains were transferred to consumers through a pricing regulation scheme. After 1985, however, prices were set at levels below the average costs of production, as the federal government tried to curb inflation by controlling public prices. Due to economies of scale, the price fell much more rapidly, as shown in Figure 7.

Figure 7: Ethanol learning curve: prices, trends and progress ratios



Source: Goldemberg *et al*, 2003.

As consequence of the observed cost reduction, subsidies were fully eliminated by 1997 and are no longer applied on anhydrous or hydrated ethanol. Hydrated ethanol is sold to consumers for just 50 – 80 per cent (by volume) of its break-even price vis-à-vis gasoline. Yet it avoided the need to import 220 thousand barrels of oil per day, which represents a direct savings of US$ 29 billion in foreign exchange over the first twenty years of existence of PRO-ALCOOL, and continues to save US$ 1.5 billion each year. (MACEDO et al., 2004)

The original motivation of PROALCOOL is no longer of any great significance for Brazilian society but the ethanol production involves large plantations of sugarcane and this is the reason for the creation of a large number of jobs. Table 9 provides a comparison of the number of jobs from different energy sources. Today the issues to be considered are: the important technological inheritance that has been developed in Brazil over the years; the advantages derived from the production and use of a fuel which is cleaner and renewable; the vital need to maintain the jobs directly and indirectly dependent on the alcohol industry; and the beneficial effects from the use of alcohol on air quality in the cities, with important gains in the field of public health and improved quality of life. Even after the use of three-way catalytic converter the advantages of ethanol to air quality are still even after valid because reposition converters are not reliable, owners do not perform the car´s preventive maintenance and also chemical characteristics of gasoline and alcohol (evaporative emissions of formaldehyde is more toxic than acetaldehyde's). Just to create the original infrastructure an investment of around US$ 11.7 billion was necessary to make the production of fuel alcohol possible, but investments are still occurring in order to modernize and enhance the production capability of the mills, and provide the infrastructure needed to sell sugar and alcohol production.

Table 9: Direct jobs in energy production

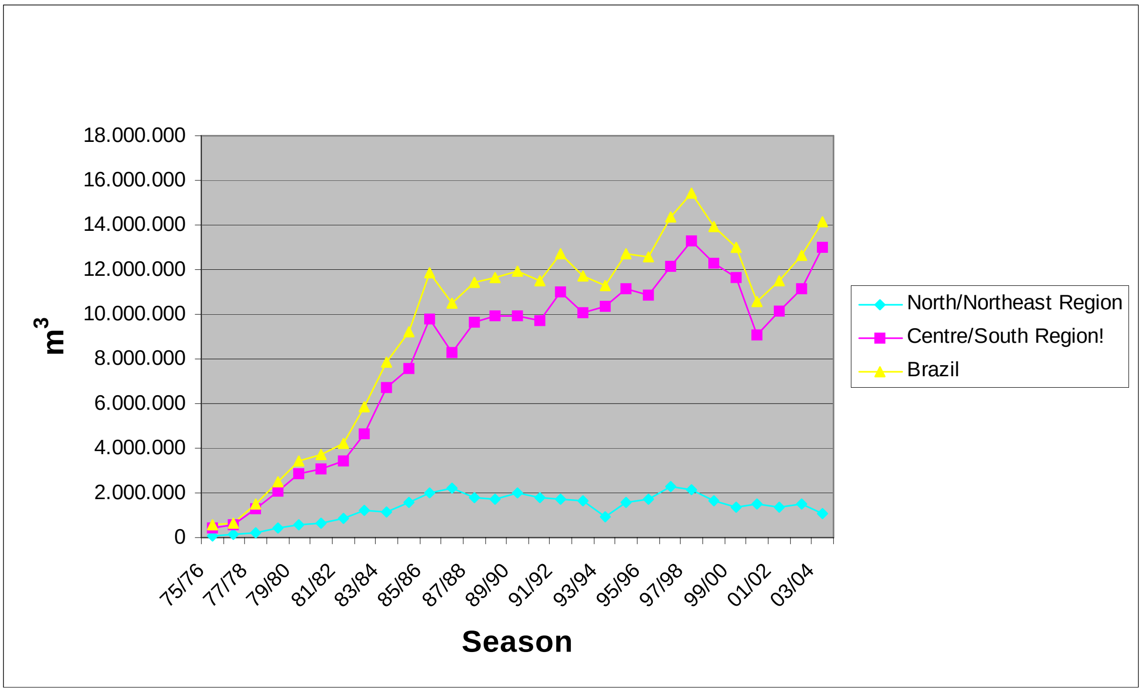
Sector	Jobs (person-years)/terawatt-hour
Petroleum[1]	260
Offshore oil[1]	265
Natural gas[1]	250
Coal[1]	370
Nuclear[1]	75
Wood energy[1]	1,000
Hydro[2]	250
Minihydro[3]	120
Wind[3]	918
Photovoltaics[3]	7,600
Ethanol (from sugar cane)[2]	4,000

*Sources: **(1)** G. Grassi "Potential Employment Impacts of Bioenergy Activity on Employment" Proceedings of the 9th European Bioenergy conference Vol. I, pp. 419-423 Eds. – P. Chartier et al. Elsevier, Oxford (1996). **(2)** L. C. Carvalho and A. Szwark "Understanding the Impact of Externalities, Case Studies" Brazil International Development Seminar on Fuel Ethanol December 14, 2001 Washington D.C. **(3)** Perez, E. M. "Energias Renovables, Sustentabilidad y Creacion de Enpleo: Una Economia Impulssionada por el Sol", ISBN:84-8319 – 115 –6 pp. 270, 2001.*

This is an especially important sector for the country because it is highly intensive in labor work (ethanol industry provides 33 direct jobs/ million liters in Brazil, where ethanol production in the 1992-2001 period ranged between 10.6-15.4/yr, UNICA, 2003) , contributing to job creation in the country.

Figure 8 shows the ethanol production in different regions of Brazil. As shown in figure 7, ethanol production in the Southeast is higher than in the Northeast, due to different production conditions, such as, the effective harvest days in the southeast region are higher than in the Northeast region. It can also be observed, that the sugar cane agricultural productivity of the Southeast region is higher (82.4 tonnes per hectare) than the Northeast Region (55 tonnes per hectare) (MACEDO *et al*, 2004).

Figure 8: Total Ethanol Production in Brazil



Source: Unica, 2004.

3.4.1.4.2 Vegetable oils / biodiesel

Another opportunity for biomass use is the electricity generation from unprocessed vegetable oils in diesel engines. The Amazon region in Brazil has an enormous diversity of native oil plants and weather conditions for the culture with high productivity, with environmental and social advantages.

There is a significant potential (still to be evaluated) for small communities to extract oil from locally available nuts or other vegetable sources. For power generation applications, palm oil is one of the most readily available sources. This is because palm is currently the only crop, among those considered as fuel sources, that is already being produced for oil extraction on large commercial plantations, with reliable yields and standardized production. Pilot units for small scale generation (under 200 kW) are being tested in some municipalities in the Amazon region, using *in natura* vegetable oil fired in modified engines, such as in Vila Soledade (State of Pará), (CENBIO, 2004).

Additionally, Brazil is starting to consider the development of biodiesel, and its blends with diesel. The feasibility of the option is being analyzed by the local automotive industry, together with research institutes and fuel/lubricant developers. Biodiesel is an ester resulting from a chemical reaction, called transesterification, of a vegetable oil with an alcohol (methanol or ethanol). Due to the large ethanol capacity already installed, ethyl ester (from vegetable oil and ethanol) is the most interesting option.

Transportation fuels from biomass, like biodiesel (biodiesel can be used in diesel blends, replacing diesel oil in vehicles and public transportation buses), can significantly reduce air pollution in large cities such as sulfur gases (CENBIO, 2004). In global terms, their use reduces the greenhouse effect. This approach will have very strong positive effects on a global scale.

The rules for introducing biodiesel introduction into the Brazilian fuel market were established by November 2004. Currently, biodiesel is only authorized for tests and research. The new fuel was authorized for commercial use, for addition to mineral diesel oil in the ratio of 2% in volume (B2). The National Association of the Automotive Vehicles Manufacturers (ANFAVEA) has committed itself to maintaining the diesel engines' warranties even with the addition of 2% biodiesel to mineral diesel.

Brazil has a large diversity of raw material for the production of biodiesel, such as castor beans and palm oil, as well as availability of soil, especially in the less developed regions. The Federal Government believes that the production of biodiesel for use in a 2% blend can generate more than 150,000 jobs in 2005, especially in family agriculture.

3.4.2 Small Hydro

Small Hydros (SHPs) are characterized as small load hydroelectric power plants, with an installed capacity of between 1 and 30 MW and with a reservoir area equal to or less than 3 sq. km. SHPs have smaller implementation risks than the large hydroelectric projects, as a result of its characteristics, in some cases based on the use of natural drops, with small reservoirs and works of small or medium complexity. The current estimated cost of installation for a SHP, on average, is about 1.000 U$/kW (SCHAEFFER *et al*., 2000), which tends to be competitive in the Brazilian market, in short and medium terms.

In the case of isolated/rural communities, the most significant perspectives in the context of expanding the access to electric energy (and to reduce the poverty) are the small hydros. Small hydroelectric plants accounted, by early 2004, for almost 1.2 GW installed in 242 plants. In the short term, additional 3.5 GW could be built. According to Eletrobras, small hydros represent a potential of 9.5 GW, a figure that can be even higher considering the lack of existing information. The inventory on the small hydro potential is still under development.

Generally, this technology minimizes the adverse environmental impacts of large hydro plants.

3.4.3 Solar PV

Considering only the isolated systems, the PV systems installed up to the year 2000 reach 105 MWp in Residential Photovoltaic Systems (RPS) and 170 MWp in Professional Applications in the world. In developing countries, the RPS number corresponds to 1.3 million installations (Zilles, 2003).

According to this development of photovoltaic solar energy applications, in Brazil important programs for the dissemination of this technology have been formulated and implemented during the last decade, at the same time that technological research and development groups were consolidated. Among the programs developed in the country is PRODEEM (Program for the Energy Development in States and Municipalities), designed and operated by the Ministry of Mines and Energy. The Ministry estimates that, currently, there are about 15 MWp installed in the country in isolated systems. It should be mentioned that the development of photovoltaic solar energy applications in Brazil was motivated by the necessity of alternative means of electricity supply for communities far from the distribution grid. There are also social aspects of the program that should be considered.

The Brazilian photovoltaic modules market is supplied by one domestic manufacturer and by the major foreign large-scale manufacturers, all of which have established commercial representations in the country. Estimated total installed capacity is more than 15 MWp, of which about 2 MWp were produced by the Brazilian company Heliodinamica since it was established in the State of São Paulo, in 1983. The only other company to manufacture photovoltaic modules in Brazil was Siemens Solar, which operated a factory from 1998 to 2001 in Gravataí, State of Rio Grande do Sul. Annual production reached approximately 500 kWp, with a total installed production capacity of 1 MWp/year. The factory imported Siemens solar cells, mounted the modules in Brazil, and then, to take advantage of the lower IPI tax (Industrialized Product Tax), to which modules were subject to in comparison to the solar cells, exported the modules to then import them for sale in Brazil. Recently, this distortion has been corrected and both solar cells and modules benefit from IPI and ICMS exemption. As of this time, Heliodinamica is the only company manufacturing within Brazil, under-utilizing its announced production capacity of 2 MWp/year and with very little participation in the Brazilian market.

Other components of photovoltaic systems, such as batteries, inverters, charge controllers and DC appliances can be found with some difficulty. The market for equipment specifically designed for renewable energy applications is still not well developed, and more often than not, components are adapted from other uses. For example, only recently a few of the more than 100 manufacturers of vehicular batteries have begun to offer deep-cycle models, more suited to household and stationary power storage.

Although the range is limited, charge controllers and inverters are produced locally. More sophisticated inverters with grid-intertie capability are imported. Certain direct-current components are available from both local and overseas manufacturers, such as water pumps, TV sets and 12-volt compact fluorescent lamps. There are suitable conditions for local production as the electronics industry is well developed and competent technicians are available.

3.4.4 Wind

The use of the wind energy comes across two basic problems: low energy density of the winds and their intermittent nature. According to Nascimento (1998), the cost of windpower plants installation varies between 900 and 1,400 US$/kW, for already installed plants, and between 760-1,000 US$/kW, for the next generation of turbines. According to Bezerra (1998), the installation cost of an operational center with a capacity of 600-1650 kW, corresponded to about US$ 800/kW in Brazil. However, the distribution of costs of a windpower project is still unknown, due to the reduced number of windpower projects implanted. As the load of the windpower park strongly influences costs, scale gains in the projects are not achieved. It explains the relatively high costs of installation of small load Brazilian projects, such as Camelinho (MG), Porto of Mucuripe (CE) and Fernando de Noronha Archipelago (PE).

A typical obstacle related with the expansion of windpower generation refers to the high cost of the equipments (or even the maintenance of these costs). As for the maintenance costs in windpower uses, it is observed that the lifetime of an air-generator depends as much of the quality of the turbine as on the climatic conditions of the area. The experience in countries with larger windpower uses shows that, for new machines, the maintenance costs are between 1.5% and 2% per year of the initial investments.

3.5 Renewable resources

As shown in Table 10, Brazil has a significant amount of renewable energy sources included in the country’s energy matrix. Table 11 shows the installed capacity for electric power generation in Brazil (MME, 2002). It is possible to verify that electricity generation from renewable sources is predominant, due to the large-scale hydroelectric power plants[7]. Nevertheless, new renewable energy sources are emerging.

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[7] Dams provide electricity by guiding water down a chute and over a turbine at high speed. Small-scale hydropower (less than 30 MW) is considered renewable, large-scale usually not. Although hydropower does not produce any air emissions, large dams must also consider environmental issues such as flood control, water quality, and fish and wildlife habitat. Therefore, only small hydro power is 'green' and large hydro is 'clean'. But in this paper we decided to use the general definition for hydroelectric power to classify large-scale hydro as a renewable source: “Hydroelectric power is a so-called renewable energy source. This means that the source, which provides the energy, can be renewed. This is because, unlike non-renewable energy sources such as crude oil, we will not run out of water fully. It can be renewed after we have used it for energy generation” (Campus Encyclopedia, 2004).

Table 10: Brazilian Energy Matrix, 2003 (based on domestic energy supply)

Non-renewable Energies	**56.2%**
Oil and derivates	40.2%
Mineral coal and derivates	6.5%
Natural gas	7.7%
Uranium and Others	1.6 %
Renewable Energies	**43.8%**
Hydro and Electricity	14.6%
Firewood and Charcoal	12.9%
Sugar cane products	13.4%
Others (basically, Aeolian and Wind)	2.9%

Source: MME, 2004

Table 11: Installed Capacity for Electricity Generation – Brazil (ANEEL, 2005)*

Hydroelectric power plants > 30 MW	69,665 MW
Thermoelectric power plants	16,549 MW
Oil products	5,257 MW
Natural gas	9,877 MW
Mineral coal	1,415 MW
Nuclear	2,007 MW
Biomass*	3,062 MW
Small Scale Hydroelectric stations	1,740 MW
Wind energy	28 MW
Solar energy	15 MWp
Imported energy	8,170 MW
Total capacity	99,483 MW

Source: MME, 2002.

The new renewable energies, wind and solar, still don't have a noticeable participation in the electricity generation matrix, as Table 12 shows. However, in data related to "Self Generation", it is included in the generation by biomass (bagasse of sugar cane, garbage, etc.).

Table 12: Evolution of the electricity generation matrix in Brazil (%)

	1980	**1985**	**1990**	**1995**	**2000**	**2001**
Hydroelectricity	90.5%	95.1%	91.3%	90.9%	85.5%	80.7%
Heavy Fuel	1.1%	0.6%	0.4%	0.5%	2.2%	2.6%
Diesel	0.7%	0.6%	0.7%	1.0%	1.0%	1.2%
Natural Gas	0.0%	0.0%	0.0%	0.0%	0.1%	1.3%
Nuclear	0.0%	1.8%	1.0%	0.9%	1.7%	4.4%
Coal	1.8%	1.8%	1.3%	1.3%	2.1%	1.7%
Wind	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Solar	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Self Generation	6.0%	5.1%	5.4%	5.4%	7.4%	8.2%
Total	100%	100%	100%	100%	100%	100%
Total Gross Generation (GWh)	139,447	184,180	223,089	275,578	349,364	325,380

Source: MME, 2003.

In the case of hydraulic energy, only power plants that are less than or equal to 30 MW (SHPs) have been considered as a new renewable energy. Moreover, in the thermal energy case, only plants that use urban residues, biomass, sugar cane bagasse, black liquor, picked firewood and, more recently, rice husks as fuel have been considered as a new renewable energy.

Recent reforms in the Brazilian electrical sector have significantly increased the potential use of renewable energy sources, particularly by assuring the access of independent energy producers to transmission and distribution lines.

Such access has made large-scale cogeneration projects possible, as well as private investments in small-scale hydroelectric plants and substantial progress in the definition of large-scale wind power energy generation projects. Recent initiatives from the sector's regulation authorities – particularly in the definition of timeframes for universalization of the services – will contribute significantly to increase the use of solar energy in areas far from transmission lines. Additionally, the definition of a reference value for wind power energy will contribute to introduce the implementation of large-scale wind power farms in specific regions of Brazil, where the evaluation of resources is at a more advanced stage.

There is also tremendous potential both for the use of new renewable energy sources and for enhancing the effectiveness of energy use in the country. Naturally, this context is related to the diversification of the Brazilian energy matrix. Moreover, the best opportunities to achieve this diversification are directly related to increasing the use of new energy sources, i.e., biomass (sugar cane, rice husks and planted forests), small-scale hydroelectric plants, windpower and solar energies, and some technological alternatives currently under R&D stage, or in the first stages of marketing, such as biodiesel.

In fact, expanding the use of new renewable energy technologies (RETs), that is, diversifying the energy matrix, is one of the best policy options to reduce the greenhouse gases emissions. RETs can be provided with local resources to remote communities, guaranteeing the necessary energy supply with much lower environmental impacts than transporting energy produced in distant places. Another advantage, among many others, is the achieved energy independence (Goldemberg and Coelho, 2003).

3.5.1 Biomass

Biomass produced in a sustainable way — the so-called modern biomass — excludes traditional uses of biomass as fuelwood, but includes electricity generation and heat production, as well as production of transportation fuels, from agricultural and forest residues. On the other hand, “traditional biomass’’ is produced in an unsustainable way and it is used as a non-commercial source —usually with very low efficiencies for cooking in many countries.

Biomass, in the form of wood products, is one of the oldest and most widely used (unsustainable) sources of energy in Brazil. Although traditional, informal uses of biomass, such as firewood for heating and cooking, are becoming less significant, since it is being replaced by LPG (Lucon et al., 2004).

In fact, in recent years, in poorer areas, wood consumption in residential sector is rising and LPG is reducing.

For industrial sector, large scale, industrial applications have the potential to regain the importance of biomass in Brazil’s energy matrix, such as sugar and alcohol sector(bagasse) and pulp and paper sector (wood residues and black liquor).

Several factors have created a favorable environment for this development: the 2001/2002 hydroelectric power shortage revealed the importance of diversifying the nation’s power generation, while specific legislative tools and incentives are now in place targeting renewable energies, (IAEA, 2004).

Brazil’s intense solar radiation and plentiful rainfall favor biomass cultivation. Furthermore, large tracts of sparsely populated territory and high unemployment create auspicious conditions for developing an ambitious program.

Biomass is a good option to decentralized generation in the country. The most used are agricultural residues, wood residues, vegetable oils and biogas.

3.5.1.1 Agricultural residues

There have been many attempts to estimate the energy potential of agricultural residues, but this is a very difficult task and only rough estimates are possible; worldwide, 4 Gt/yr, (IAEA, 2004), may be close to reality. There is no doubt that large amounts of residues are wasted, or handled inappropriately, causing undesirable environmental and ecological effects. The worldwide (straw, animal slurries, green agricultural waste) is estimated as about 4,500 MWth, (IAEA, 2004).

In Brazil, as can be appreciated from Table 13, the volume of agricultural residues is high but only a relatively small proportion is utilized for energy purposes, if one excludes bagasse. This is due to a combination of factors (i.e. availability of cheaper alternatives, lack of commercially available technology for residues collection, high cost of baling, transport, etc). Table 14 shows the theoretical potential for electricity production from residues in Brazil.

However, this situation could change with improved technologies, greater institutional support, environmental pressures, etc, but its difficult to identify the real potential from agricultural residues that can be implemented because there is not reliable statistics in Brazil on this subject.

Table 13: Brazil- Main commercial crops and residues production only

Crops	Planted area (Mha)	Average productivity (ton/ha)	Annual production (Mt)	Type of residue	Quantity of residues (t/ha/yr)	Total amount of residues (Mt/yr)
Sugarcane	5.33	73	389.09	Bagasse	21.9 [1]	116.73
Eucalyptus [4]	2.9	30	87	Bark	14.21	5.89
Pines spp	1.8	24	43.2	Bark	10.64	2.49
Rice	3.18	3.2	10.18	Husks	0.64 [2]	2.04
Maize	13.2	3.5	46.2	Trash, cobs	2.45 [3]	32.34
Soybean	18.4	2.8	51.52	Straw etc	1.96 [3]	36.06
Wheat	2.4	2.3	5.52	Husks	1.61 [3]	3.86

Notes:

[1] based on a recoverable residue ratio of 0.3 ton per ton of harvested cane

[2] This is based on a recoverable residue ratio of 0.2 ton per ton grain harvested

[3] This is based on a recoverable residue ratio of 0.7 ton per ton grain harvested

[4] Excludes eucalyptus for the production of charcoal

Sources:

Ministry of Agriculture, 2004

SBS - Brazilian Society of Silviculture, 2004.

IBGE- Brazilian Institute of Statistics and Geografics, 2004.

Table 14 Theoretical Potential for Electricity Production from Biomass Residues (Brazil)

Region	Biomass	Theoretical Potential (MW)
Center-West	Sugar cane	329
	Wood residues	70
	Agricultural residues	1,561
Southeast	Sugar cane	2,505
	Wood residues	135
	Agricultural residues	1,449
South	Sugar cane	283
	Wood residues	67
	Agricultural residues	4,664
Northeast	Sugar cane	725
	Agricultural residues	593
	Wood residues	56
North	Sugar cane	10
	Agricultural residues	1,035
	Wood residues	103
	Sugar cane	3,852
	Wood residues	430
	Agricultural residues	9,302
TOTAL		13,584

Source: CENBIO, 2001.

Sugar cane is one the world's major crops, and one of the most promising for energy generation (transportation and electricity production). About 350 Mt of bagasse are produced annually worldwide, mostly used as fuel in sugar factories (plus a further 350 Mt of tops and leaves, currently mostly wasted). Most of the bagasse is used as fuel or as raw material in pulp and paper industry.

Sugar cane bagasse is, the most important energy residue used in Brazil and in many other parts of the world, and the one with the greatest potential for further development. Brazil has the world's largest and most efficient sugar cane industry with about 360 Mt of cane milled annually (Table 15).

Table 15: Sugar and ethanol production in Brazil 2001/02 through 2003//04

Year	2003//04*	2002//03	2001/02
Cane (million tonnes)	360.0	321.0	293.0
Sugar (million tonnes)	24.9	22.5	19.2
Ethanol (billion m^3)	14.8	12.6	11.5
- Anhydrous	8.9	7.0	6.4
- Hydrated	5.9	5.6	5.1

* Estimated

Source: UNICA, 2005

3.5.1.2 Wood residues

This chapter discusses the use of wood residues in industrial sector (sawmills, pulp and paper, etc).

In Brazil, despite existing legislation, there are still several sawmills in Brazil that are using wood from deforestation (unsustainable biomass). A recent study developed at the municipality of Ulianópolis, Pará State, Amazon Region (Varkulya Jr., 2004) confirms the unsustainable use of wood by most of the sawmills in Amazon.

A global survey of sawmill industries in Brazil is not available, but estimates show an enormous quantity of plants. In this report it was used a survey data collected by Imazon (a Brazilian NGO) during 1997-98, referring to the production of 75 locations where logging industries concentrate their activities, situated in 9 states in the Brazilian Amazon.

These 75 locations are responsible for approximately 95% of the wood production of the region. From the total amount produced in the Amazon, 14% is exported, 10% is consumed within the Amazon itself, 20% is consumed in São Paulo and 56% in the rest of Brazil. In fact, there are also wood producing regions outside the Amazon, like Mato Grosso do Sul and the Southern states of the country as show in the table 16, but data from these regions are not available yet.

Table 16 Wood Production in Amazon

Producer State	Production ($10^6 m^3$)	Production (t)	Internal Consumption (t)	Total Residues (t)
AC	0.30	135	93	70
AP	0.20	90	90	61
AM	0.70	315	57	84
MA	0.70	315	76	93
MT	9.80	4410	265	911
PA	11.90	5355	428	1159
RO	3.90	1755	105	362
RR	0.20	90	54	43
TO	0.10	45	35	25
Total	**28**	**12.51**	**1.202**	**2.809**

Source: IMAFLORA 1999, CENBIO 2000.

Usually, wood is processed in the destination state and the potential amount of residues produced in each state can be evaluated based on the amount of processed wood. For example, in the State of Acre, out of the 0.3 million of cubic meters of wood produced, 69% is consumed in the same state (probably by sawmills located in the state). Outside the Amazon, the largest part is probably consumed in furniture manufacture, as is the case of the State of São Paulo, (CENBIO, 2000).

3.5.1.3 Vegetable oils

Currently nearly 1000 power plants, mainly using diesel oil, supply electricity to isolated cities and villages in the Amazon. More than 670 of theses units have less than 500 kW capacity and, in general, are old and inefficient, emitting high levels of pollutants (Goldemberg, 2000). The cost of the electricity produced by these diesel units is high, in some cases reaching US$ 200/MWh. This cost is partially subsidized by the Fuel Consumption Account (CCC), whose resources derive from a surcharge on electricity tariffs for all consumers in areas serviced by the national electric grid. This subsidy was provided essentially for power plants burning diesel and oil but, in August 1999, however, Resolution 245 partially extended the benefits to electric power plants replacing fossil-fuel plants, thus opening the opportunity for the use of engines operating with vegetable oils.

The main plants from which vegetable oils are derived in Brazil are palm oil (*Elaeis guineensis*), macauba (*Acronomia aculeata*) and buriti (*Mauritia flexuosa*), with corresponding annual productions of 71 thousand tonnes, 25 thousand tonnes and 35 million tonnes, respectively.

There is widespread potential for small communities to extract oil from locally available nuts or other vegetable sources. For wide-range applications in power generation, palm oil is the most readily available source. This is because palm is currently the only crop, among those considered as fuel sources, that is already being produced on large commercial plantations for oil extraction, with reliable yields and standardized production. Annual yields in these plantations are approximately 5 tonnes of oil/hectare; when burned in a multi-fuel diesel engine, electricity can be produced at the ratio of 0.235 kg/kWh generated (Kaltner, 1999). Other uses of vegetable fuels, such as selling to the food industry, often generate more profit for producers than if the oil were to be used as a fuel. However in isolated communities, without energy access from the grid, however, where the sale of the oil is not an option because it is difficult to export this oil to the market, the use for generating electricity may be feasible.

3.5.1.4 Biogas

At an average daily production of 0.5 kg/inhabitant, over 20 million tonnes of municipal solid waste (MSW) are generated in Brazil annually. Using these wastes to produce electric power could provide 50 million MWh/year (Winrock International, 2002). The two principal means to extract useable energy from MSW are anaerobic decomposition for the generation of combustible gases, and the direct combustion of the waste material.

As an example of the potential available for power generation from MSW, it is estimated that the São Paulo Metropolitan Area, with its 15 million inhabitants, emits 500-600 million cubic meters of methane annually from landfills, with significant impacts on GHG emissions (Alves, 2000). In a very rough estimate, if this amount could be used to generate electricity, around 188 MW could be produced. Estimates from USEPA indicate a technical potential of 150 MW in São Paulo State, from biogas already being produced in appropriate landfills. With respect to liquid effluents, figures from SABESP (São Paulo city's water supply and sewage treatment company) indicate that the São Paulo Metropolitan Area produces 50 m^3/s of wastewater. From this amount, 20% is treated through anaerobic digestion, but the biogas produced is burned. If all liquid effluents were treated, the biogas produced could be used to generate 15-20 MW.

Both these processes, however, require large investments and can only be carried out in the context of integrated waste management programs. In many municipalities, the challenge of adequate treatment of MSW stalls at the first step—collection, and the governments' primary effort has been on extending the garbage collection service to the unassisted population (in some cases, more than 50% of the households). Of the MSW that is collected, over 80% receives no treatment, being disposed of in open-air sites. The use of properly constructed and operated landfills is becoming more widespread, however, therefore increasing the opportunities of harnessing the energy available from urban waste.

In the year 2003, a thermoelectric power plant was inaugurated in the Bandeirantes landfill, located in the city of São Paulo. The project was developed through a partnership headed by a private bank. The Bandeirantes landfill is one of the largest in the world in its category and has the largest plant fueled with biogas in the country. The biogas generated from the solid wastes is collected from the landfill subsoil through a 50 km extension pipe network. It is pumped and distributed between 24 engines, which run 24 generators. The gas surplus is burnt in flare.

The landfill produces 12,000 m^3/h of biochemical gas, with a minimum content of 50% of methane, during 24h/day over 365 days/year. This amount is enough for the installed capacity of 20 MW, which will produce up to 170.000 MWh of electricity. This amount of energy is enough to supply a city of 400.000 inhabitants, during 10 years.

In the case of energy generation from animal waste, there is a considerable lack of information available as to the type and quantity of material available, as well as about technically and financially feasible systems. There are a few studies being developed on the subject, mainly at UNESP, ESALQ/USP and other universities in São Paulo State. Brazil has strong swine, poultry and dairy industries, which generate considerable amounts of concentrated animal waste, thus indicating potential for methane generation through anaerobic digestion. Brazil leads the world in commercial bovine production with a national total of 160 million head of cattle and its swine production is one of the world's largest, with 32 million head (Associação de Criadores de Suinos do Rio Grande do Sul, 2002). In the majority of swine, poultry and dairy industries, animals are confined, while in the beef industry the tendency towards production in feedlots is growing, thus creating favorable conditions for the implementation of biogas generation and utilization systems. As of yet, however, the technology has not been introduced into the industry in any significant way.

3.5.2 Small Hydro Plants

Several estimates of the remaining Brazilian generation potential exist given the kind of hydroelectric power plants: micro (below 100 kW), mini (between 100 and 999 kW) and small (between 1 and 30 MW). A study conducted by Tiago (2001) concludes that the generation potential for all power plants below 30 MW SHPs is 7 GW, while the MME (2002) estimates this potential to be around 14 GW.

Only 5 out of the 27 Brazilian states have no plants in operation, under construction or authorized. If the number of plants in operation, under construction or authorized is considered, a capacity of around 2,450 MW is installed just in Small Hydro Power plants (CndPCH, 2004). The capacity already under construction is 463 MW and another 1,088 MW are undergoing legal procedures (construction of new plants must be analyzed by the Government). PCH-COM and PCH-MG programs had, when of their releases, goals for achieving, respectively, 1,200 MW (national basis) and 400 MW (regional basis), over 3 years.

The provision of financial support by the Government for SHPs is essential, since SHPs have a high investment cost.

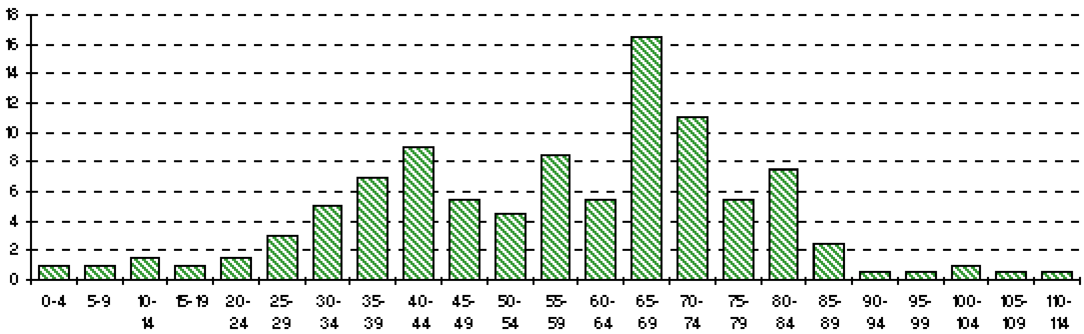
In this context, maybe the most important Government incentive for SHPs is the fact that SHPs can now sell energy to consumers without paying for the use of the grid. In fact, under these conditions, SHPs can participate actively in the energy market.

The main advantages of the participation of SHPs in the energy market are easier credit lines. In addition, most of SHP equipment is locally produced, stimulating the Brazilian economy.

Over the past few years, incentives for building SHPs were in place. As a result of this effort, in the period between 1995 and 2002, approximately 1,000 MW from SHPs were added to the matrix. During this period, ANEEL granted authorization for several other undertakings.

The primary role of SHPs built in the last decades has been in the electrification of isolated areas. Today there are in Brazil 204 Small Hydropower Plants in operation, adding 798,784 kW to the national interconnected system, which represents about 1% of the installed capacity. The state with the largest concentration of SHPs is Minas Gerais, where there are 62 plants under construction, totaling 233,795 kW (CndPCH, 2004).

Figure 9: Distribution of Brazilian SHPs by Age (in years)



Source: ANEEL, 2004

Under centralized energy planning, implemented through regional and state utilities, SHPs gradually gave in to large-scale projects. The situation seems to be changing with privatization and new regulations that make the planning of generation expansion more flexible.

Taking into account an average cost of US$ 900/ installed kW, it is possible to reach US$ 7.2 billions of future possible investments in Brazil, just in SHPs. In this context, partnerships with the international market could be fundamental.

Taking into account the high Brazilian hydroelectric potential, the SHP market is attractive to foreign and national entrepreneurs. this sense, its important to mention a positive factor: BNDES (National Bank for Social Development) assumed a new posture towards the supporting program for credit lines that are connected to PROINFA, showing significant improvement in solving the financial needs related with the implementation of SHP plants in Brazil.

The majority of SHPs in operation are situated in the southern (especially in the *Paraná* River Basin) and southeastern regions, next to the major consumption centers. The majority of new projects will be concentrated in the mid-western region, to meet anticipated future demand.

3.5.3 Solar PV[8]

Brazil is one of the most suitable countries in the world for using renewable energy, especially solar (availability of high levels of solar radiation, large size of the country - Brazil is the fifth largest country in the world - and has a significant percentage of rural population living without access to electricity). Concerned with the importance of a consistent and sustainable

[8] Written by Zilles, R., Professor, Institute for Electricity and Energy, University of São Paulo

development of new renewable technologies in Brazil, mobilization started in 1994 to establish a national policy.

Although PV technology has been developed and used in Brazil for almost 2 decades, it was only in the last few years that it was actually recognized as a potential option to help the country overcome the challenge of improving the quality of life of citizens living far from urban centers. Until recently PV was predominantly used by the telecommunications and military sectors, but has finally being seen as an alternative for generating electricity for basic needs (lighting, water pumping, refrigerators etc.) in remote areas. Government programs, electricity distribution utilities, private entrepreneurs and a few NGOs are gradually paving the road that will lead to a broader dissemination of the PV technology.

Initially stimulated by international cooperation agreements (rural electrification pilot projects implemented through bilateral cooperation programs making up a total of about 250 kWp, distributed over 10 of the 27 Brazilian states and almost 2,000 systems), PV dissemination in Brazil is finally taking off. Huge initiatives are already in course but still need very close attention in this initial stage. Today there are around 15 MWp installed.

Regarding application programs, special attention must be given to PRODEEM, a program of the Ministry of Mines and Energy (MME) aimed at the development of municipalities using local energy resources for energy generation. PRODEEM has already installed around 4 MWp, and it has also closed the bidding process for 2 MWp to be installed in 3,000 rural schools.

PRODEEM was conceived to address three different sectors: residential, commercial or productive and complementary. Initial actions were directed to the social sector, but PRODEEM is now also focusing on the productive sector. By increasing the scope of its actions, PRODEEM is gradually becoming the core of the Brazilian PV Dissemination Program.

In Brazil, the introduction of the solar photovoltaic technology has not differed greatly from the experience of other countries. Initially, the spread of photovoltaic technology generally took place in rural areas, either through government initiatives or through power companies financing the installation of autonomous photovoltaic systems such as Solar Home Systems – SHS or water-pumping systems.

It was only by the second half of the 1990s that the first experiences related to the connection of photovoltaic systems to the conventional power grid began to accumulate, thus confirming in Brazil the international trend towards the increasing application of the technology. Table 17 presents a brief summary of the connection experiences carried out in Brazil to date.

Table 17: Characteristics of the photovoltaic systems connected to the power network as installed in Brazil.

System	Installation (yr)	PV Power
CHESF	1995	11 kWp Polycrystalline
Lab. Solar	1997	2 kWp Amorphous
LSF	1998	750 Wp Monocrystaline
COPPE	1999	848 Wp Monocrystaline
Lab. Solar	2000	1 kWp Amorphous
LSF/USP	2001	6 kWp Monocrystaline

Source: Winrock International, 2002.

The connection of photovoltaic systems to the grid in a decentralized form is one of the applications of solar photovoltaic technology that has developed significantly over the last few years. However, the main practical applications of this technology have been in remote systems, capable of supplying loads away from the conventional power distribution network.
The Brazilian potential for the use of grid-connected photovoltaic systems, expressed by the first projects already implemented and by those in the planning stage, coupled with the international experience in the use of such systems, has revealed a need to take certain actions before this type of photovoltaic installation spreads out over the country.

These actions such should provide the capacity building of local population and development of economic activities in order to guarantee the sustainable development aiming at helping consolidate this application, in order to make it a source of competitive sustainable electricity.

3.5.4 Wind

In Brazil, the first instruments for measuring wind energy potential were installed in Ceará and Fernando de Noronha (PE) in the early 1990s. Current data indicate that the wind energy potential of Brazil is approximately 143,000 MW, of which 7,694.05 MW has already been authorized. Currently, the plants in operation have an installed capacity to generate only 22 MW (according MME, 2003) (corresponding to a very small share of the total power capacity) – of which almost 65% is located in Ceará. The capacity connected to the grid is estimated at 20.3 MW and, in these cases, windmills of medium to high capacity are used. This technology is currently made available in Brazil by international manufacturers.

The best wind potentials are concentrated on the coastline of the Northeast region and, to a lower extent, on the coastline of the South and Southeast of Brazil. Moreover, some very good sites located far from the coast have been reported in the states of Minas Gerais and Paraná (Brazilian Wind Energy Potential Atlas, 2004).

It is estimated that the worldwide wind energy potential is of the order of 500,000 TWh/year, which is 30 times more than the current worldwide consumption of electricity. Of this potential, at the very least 10% is estimated to be technically usable: about four times the worldwide consumption of electricity.

According to a study of the Brazilian Wind Energy Center (CBEE), the cost of wind power generation in Brazil lies between US$ 39/MWh (2001 R$ 101.40/MWh) and US$ 84/MWh (2001 R$ 218/MWh).

3.6 Case Studies

3.6.1 Biomass gasification in Amazon region

A 20 kW-gasification system was installed at Aquidabam Village in Amazon State[9]. The main aim of the project was to test and adapt biomass small scale fixed bed gasification technology, imported from the Indian Institute of Science – IISc, in order to provide electric energy, in a sustainable way, to isolated communities in the Amazon Region, offering an alternative to fossil fuel (CENBIO, 2001).

The gasification system is composed of a 20 kW fixed bed downdraft gasifier, ashes extractor, water cooler and treatment system, internal combustion engine, generator, biomass drier and a control panel.

The project evaluated the operating conditions of the gasification system: gas cleaning, electric energy generation; as well as providing capacity building in the Amazon region and the possibility of replicating the system in other villages.

There are already institutions working with biomass gasification in the country. However, there are problems that prevent its commercialization, mainly the lack of gas cleaning procedures in order to feed the engine and simplified operation and maintenance procedures. Considering that in India there are over ten years of similar systems in operation running in isolated communities, similar to those in Brazil, this project will allow use of the results of the Indian experience to improve the technology for energy generation in isolated communities. Thus, a 20 kW biomass gasification system was imported from the Indian Institute of Science – IISc (MUKUNDA et al., 1994).

[9] The project "Comparison Among Existing Technologies of Biomass Gasification", FINEP/CT-ENERG 23.01.0695.00 Agreement, is a partnership between CENBIO - The Brazilian Reference Centre on Biomass, BUN - Biomass Users Network of Brazil, IPT - Technology Research Institute of São Paulo State and UA – Amazon University.

The gasifier imported from IISc is downdraft, meaning that the solid fuel outflow flows in same direction as the gas. Both the biomass stream and the air stream enter on the top of the gasifier that is open and go to the base. The gasifier operates in depression, with inside pressure slightly lower than the atmospheric pressure, enough to guarantee the outflow of gases through the biomass load.

The tests of the gasification system were performed by IPT (Institute of Technology Research) with eucalyptus chips, cupuaçu and babaçu have been satisfactory, (CENBIO, 2004).

The Aquidabam village was chosen because it presented the basic conditions for implementing the system: biomass disposal, experience with diesel engines, easy access and, most of all, great interest and involvement of the community in the project. Aquidabam village is located at the municipality of Manacaparu, in Amazon state. There are 700 people living in this community, in around 180 households. One of the agricultural products produced by the community is Cupuaçu (an Amazonian fruit), which is sold *in natura*, with a very low added value, due to the non-existence of electricity that would allow them to keep the cupuaçu pulp frozen (CENBIO, 2003).

Nowadays the gasification system is installed in Aquidabam village, the first stage was training the population to operate the gasifier, the second stage will be the operation of gasifier. The propose is that the gasifier work eight hours per day replacing 75% of diesel oil. The electric energy will be used for the *cupuaçu* pulp factory to improve the process.

The obtained results will be shared with local research institutions. It is a particularly relevant project because of the great local availability of biomass residues. The results of the project will be replicated in other similar communities in northern Brazil. This project is of special importance to existing programs for increasing energy access in the region, established in 2003 by the Ministry of Mines and Energy.

With the experience acquired in this project, CENBIO is starting with IPT the GASEIBRAS Project “Nationalization of the Gasification Technology and Formation of Human Resources in the Amazon Region”, approved by Ministry of Mines and Energy, that will supplement the GASEIFAMAZ project, building a 20 kW system and discussing the perspectives for local manufacture of the system in the country.

3.6.2 Use of *in Natura* vegetable oils in adapted engines in the Amazon Region

The project to implement and test a demonstration unit for the energy use of vegetable oil has the objective of installing and testing, in operating conditions in the field, the functioning of a conventional diesel engine that has been adapted to operate with "*in natura*" palm oil, in the community of Vila Soledade, city of Mojú, Pará State. The Vila Soledade is an isolated community that has, approximately, 700 inhabitants. It is located at one hundred kilometers from the city hall by car and another 30 minutes by boat.

The electric energy of this community was previously generated by a conventional diesel engine, technically inefficient, causing imperfections in the supply, and economically inefficient as it used fossil fuel. During the Provegam project in 2003, in the community of Vila Soledade, a new generating group, MWM TD229, manufactured in Brazil, was installed and adapted with a conversion kit to operate with *in natura* palm oil, working 6 hours a day (1/3 of the load) on the distribution grid, totaling 3.3 MWh a month.

The operation begins and finishes with diesel oil, in order to clean possible residues deposited in the interior of the engine. Currently, the generating group is working perfectly in the community and it has already undergone more than 1,200 hours of testing.

One of the great social benefits brought about by the project was the beginning of night classes, attended by the whole community. The replacement of the old generator has brought other benefits, such as the elimination of technical failures of the system and the increase in the energy supply.

All the modifications required for the engine and to the conversion kit will be presented at the end of the project. The results of this project, so far, have confirmed expectations, and this model has already been recommended for implementation in other communities in the Amazon region. The project was financed by FINEP.

The experience of this project is being replicated in the PROVENAT project which will install and test and diesel engine with a conversion kit develop in Brazil.

This initiative aims at reduce the initial investment costs and allow the utilization of *in natura* vegetable oils in any diesel engine in isolated communities.

The project is being developed in the community of Igarapé-Açu, city of Mojú, Pará State, far 2 hours by boat from Vila Soledade.

3.6.3 Sugar cane bagasse cogeneration

Among several recent case studies existing for sugar cane cogeneration, recent case studies were chosen here: one in São Paulo State (Brighenti, 2003) and one from the northeastern region (Paletta, 2004).

The São Paulo case study chosen is the Santa Adélia mill, placed in the municipality of Jaboticabal. During the harvesting season 2002-2003 2,033,000 tonnes of sugar cane were crushed, producing 87 million liters of alcohol and 172,000 tonnes of sugar.

The study was developed aiming at the optimization of the existing cogeneration system, to produce electricity surplus. It was considered the installation of a 63 bar system, with extraction/condensation steam turbines.

The project took as a basic premise that the steam rate was enough to supply the industrial process and the generation of the electric energy. In this context, the electric energy surplus to be commercialized is about 22.5 MW. The existing configuration was a 21 bar system, producing 8 MW, without any surplus (Brighenti, 2003).

It should be noted that nowadays most 21 bar cogeneration systems are around 25 years old, dating back to the beginning of the alcohol program. Therefore, they are almost at the end of their lifetime and will need to be replaced.

Most industries are replacing them, but many of them are not implementing equipment with higher efficiency rates (63 or 80 bar systems). The need for special policies, as well as for funding programs, is significant (CENBIO, 2002).

During 2004, in several other plants in São Paulo State, similar processes to this one were installed (63 bar boilers and back pressure steam turbines).

The NE study chosen here was conducted by CENBIO (funded by Winrock/USAID) aiming to provide the generation of electricity surplus in a sugar cane plant in this region. The Pindorama Agroindustrial Cooperative, and its Pindorama Distillery were chosen, located in the city of Coruripe, Alagoas State.

In this distillery, the bagasse were produced and used for electricity and process heat generation through the cogeneration process, without any electricity surplus. The electricity generation system was composed of two boilers, which generate 85 tonnes per hour of steam at 21 bar and 280ºC.

For the surplus electricity generation, it was decided to change the current 21 bar boilers for 65 bar, 480ºC boilers. The new configuration will allow the generation of 26.5 MW of surplus electricity, to be sold to the grid.

This case study is one of the few existing studies in NE of Brazil. Most mills involved in generating surplus are located in CW/SE Brazil.

3.6.4 Small hydro

Two cases studies dealing with the implementation of SHPs in Brazil are presented here. This type of undertaking can certainly assist in the process of expanding access to electric energy services of the country's isolated communities. This will result in several improvements from a socioeconomic perspective: access to lighting, expansion of health and education services, economic development, etc. Nevertheless, each project must be implemented in the most judicious manner possible, taking into account associated environmental, social and economic variables. Two SHPs are analyzed in this context. A sustainable case (case A) and an unsustainable case (Case B) will be presented.

Case A

The BNDES (Brazilian Economic and Social Development Bank) Board approved the financing of R$ 13.7 million for the installation of a SHP with a capacity of 12,350 kW, in the Municipality of Ijuí, in the State of Rio Grande do Sul. The project, developed by the Ijuí Energy and Development Regional Cooperative (Ceriluz), which foresees a total investment of R$ 17.5 million, also includes the construction of a transmission line connecting the plant to the Ijuí grid, in the Municipality of Campo Novo, Rio Grande do Sul. Among the benefits generated by the project are improved living conditions for the rural community, the main objective of Ceriluz (PCHONLINE, 2004).

Ceriluz basically services rural consumers, who represented in 2001 88% of its total consumers and 54% of the distributed energy. Industry, however, which has 0.83% of connections, representing 28% of the total distributed energy. The area of action of the Ceriluz Cooperative encompasses 18 municipalities, where the major consumers are Ajuricaba, Augusto Pestana, Catuípe, Chiapeta, Coronel Barros, Nova Ramada and Santo Augusto. Ceriluz`s major clients include Elegê Alimentos, Corsan/Ijuí, Empresa Mineradora Ijuí Ltda and Fidene-Ijuí. The Cooperative provides energy to 11,340 households, a universe of about 45 thousand people. Ceriluz was created in 1966 with the aim of managing and executing a rural electrification project for 160 rural properties of the northwestern region of Rio Grande do Sul. Today Ceriluz has 11,342 associates and a distribution network of 3,996 km (PCHONLINE, 2004).

In the area of influence of the Ijuí SHP, there are small and medium-sized rural properties that produce soybeans (397 thousand tonnes/year), maize (86 thousand tonnes/year), wheat (39 thousand tonnes/year) and milk (88 million liters/year).

Case B

The indigenous leaders and communities of Raposa Serra do Sol (State of Roraima, north of Brazil) have been apprehensive since 2002 because of the State Government's and the Army's moves against a definitive acknowledgement of the land as belonging to its ancestral inhabitants . This is because of the construction of a SHP near the Uiramutã village for supplying the village and a border platoon.

The Amazon Commission allocated funds from the federal budget for the construction of a SHP in Uiramutã. In addition to supplying the town, the Army headquarters built in the area would also benefit. The SHP would have the capacity to generate up to 150 kW, enough to supply the village and the platoon.

The indigenous communities were not consulted about the undertaking. According to the Roraima Indigenous Council, the inventory and electromechanical project for the SHP were drafted in 1999.

The planned spot is a water drop in the Paiwá River, a sacred site for the Macuxi people, approximately five kilometers from the Uiramutã village. The construction of the SHP could also destroy one of the most beautiful landscapes of the region.

After many political debates (in regional and national context) and considering the notorious unsustainable of the enterprise, the Federal Government decides to prohibit the construction of the mentioned SHP. In April 15, 2005, a ministerial entrance and a presidential ordinance, the government of the President Luís Inácio Lula da Silva, finally, decided to ratify the demarcation of the indigenous land Raposa Serra do Sol in Roraima, opening space for the definition of a new (and more sustainable) Brazilian indigenous politics.

3.6.5 PV Systems

The implementation and management of a household and community photovoltaic system project was begun under the PTU/MCT project and later continued with the support of the ANEEL/UNDP Renewable Energies Use in the Amazon Reference Project, Sub-Project 2 – Solar photovoltaic electrification in Four Isolated Communities in the Alto Solimões Region.

For household electrification a community was chosen that had the best organization level. The community of Vera Cruz was selected, which currently supplies the household lighting demand (6 residences) with a 5 HP/3 kVA diesel generator, which operates 3 hours a day, supplying the total load of 15 60 W lightbulbs. According to community data, 2 liters of Diesel oil are consumed a day, representing an annual expense of R$ 720.00 just for fuel. In this amount, expenses with lubricants and maintenance are not included.

Based on these data, a pilot project for the introduction of household photovoltaic systems was designed the characteristics of this system are shown in the table below.

Table 18: Characteristics of the household photovoltaic systems

Equipment	Manufacturer	Model	Quantity
Photovoltaic Modules	ATERSA	A-75 (75 Wp)	1
Load Regulator	ATERSA	Mino, 11A	1
Battery	MOURA	120 Ah	1
DC/AC Inverter	Statpower	Prowatt50	1

With the photovoltaic system in use, maintenance expenses were reduced to replacement of distilled water in the battery.

The proposal for the electrification of individual residences is based on the financial contribution of the user in the purchase of batteries and in the installation and maintenance of the systems. Moreover, each user provided the construction of the battery shelter and the mast for installing the photovoltaic generator.

This pilot project also included monitoring of energy consumption of users, to be registered on a daily basis.

It was observed that the consumption in the beginning of the operation was less than 250 Wh/day, lower than the supplied by the system, 7.5 kWh/month. It is expected that consumption will increase when users become familiar with the system and they recognize its possibilities. It is estimated that the average monthly consumption will be around 6.0 kWh/month.

3.6.6 Wind – The State of Ceará

The last hydroelectric power plants in the Brazilian Northeast were built in the last decade and, in fact, there was a tendency to use natural gas thermopower plants to supply future energy. But now, considering economical aspects (related with the use of natural gas in thermopower plants and the competition with other applications, just like the transport) this tendency is not so clear. .

In the field of renewable energy, the Northeast region has great wind energy potential. This is true mainly in the State of Ceará, which is the leader in the use of wind energy in Brazil, with an installed capacity of 16.2 MW in wind parks, whereas the total installed capacity in Brazil today is 22 MW (MME, 2003).

According to the wind energy resource atlas of the State of Ceará, the statistical distribution in the dry season (July – December) averaged for 5 towers, with an anemometer height of 40 to 50 m, installed in sites with very low turbulence in the coastal area of Ceará, shows that wind speeds lower than 4 m/s occur for an average of 2 hours per month (0.27%). For more than 90% of the time wind speeds are between 7 m/s and 13 m/s, which correspond to the maximum aerodynamic efficiency of existing wind turbines. For this six-month period, an operation factor of 5.85 is found. Considering the technological trend towards Megawatt-sized wind turbines, corresponding to hub heights of 70 m or higher, the annual potential wind energy production in Ceará is estimated at 233.7 TWh/year (in comparison, the Brazilian electrical power consumption in 2002 was 290.5 TWh). The State of Ceará occupies less than 1.8% of the Brazilian territorial area (SEINFRACE, 2001).

Independent studies conducted by CHESF (the power generation and transmission utility for the Northeast Region) (CHESF and COELCE, 1996), show the wind power electricity production potential for 10% of the area along the coast of Ceará (573 km coastline x 5 km width) for the construction of wind parks. This means an area of 286.5 sq. km. It is adopted number of twenty one wind turbines per square kilometer. This leads to 6,045 turbines. The average turbine spacing is 5D x 7D. The array efficiency considered is 90%.

The hourly average wind speed data at 10, 20 or 30 m were taken at ten stations situated at most 5 km from the sea. The temperature and the air density measurements are obtained by the weather stations close to each anemometer tower. The daily wind speed and speed frequency distribution for the 1991-1995 period are utilized for estimating energy production.

The potential wind power electricity production depends on the month of the year. Estimates show a potential of 390 GWh in April (minimum value) and 1,200 GWh in October (maximum value). These estimates were calculated based on representative samples of state-of-the-art wind turbines in the class of 500 kW (50 m height) that means a total wind park capacity of 3,022.5 MW. Considering adjustments due to local pressure and temperature and reductions due to losses, the annual renewable energy delivered would be 9,548.6 GWh. This value corresponds to circa 11% of the expected energy to be produced by wind parks in Europe in 2010. Based on the energy delivered, the model calculates a capacity factor of 33.3%.

3.7 Assessment of Capacities

In remote areas, there is a repressed demand that will increase the need for energy sources introduced together with more reliable and regular generation systems, particularly photovoltaic solar energy, small sized wind systems and vegetable oil generation systems. It is expected that the introduction of institutional and regulatory incentives can reduce the share of fossil fuels in favor of local renewable sources.

Some progress was seen in the regulation/legal structure, with significant attention given to minimizing distortions by allowing free access to grids, extension of benefits previously granted only to some energy sources, reduction of the bureaucratic demands for registration and authorization, and establishment of differentiated values for renewable sources by incorporating some positive external features inherent to the use of this kind of energy source.

Obviously, the basic premise is economic feasibility but at least it can be observed that, with the decrease of distortions, renewable energies start to play a role in niches where they already show competitiveness. There is also a tendency towards the establishment of small hydroelectric power plants, a tendency that is understandable considering Brazil's traditional use of hydraulic energy, which reduces the requirements for technical support and external products and creates a greater supply of local job opportunities. Certainly the extension of the same benefits to cogeneration, biomass, and, to a certain degree, other renewable sources, would contribute to increase economic rationality, especially in extremely remote areas, where individual or extremely small load systems are the only available option.

Although the deregulation process in Brazil is being carried out gradually in comparison to other countries, some laws and decrees represent important steps towards the new structure, such as:

Law n. 8987 of February 13, 1995 (Law of Concessions), which defined important responsibilities for the concession authority:

- To regulate the granted service and to investigate it permanently;
- To intervene in the installment of the service and to extinguish the concession;
- To ratify the readjustments of tariffs and carry out their revision;
- To ensure the good quality of the service;
- To encourage competitiveness;
- To stimulate the formation of consumer associations.

Law n. 9427 of December 26, 1996, which creates the regulatory agency (ANEEL). The ANEEL is a special structure, with its own legal nature, and totally independent from the government.

Law n. 9648 of May 27, 1998 and Decree n. 2655 of July 2, 1998, which create the wholesale energy market (MAE) and the independent system operator (ONS). This decree establishes a schedule, which the current activities of the GCOI (Coordinating Group of the Interconnected System) will gradually be transferred to the ONS. The GCOI is the current operational coordinator, in which the main utilities share the system operation.

Many other specific rules are being drafted by ANEEL to structure the entire regulatory framework.

Competition in the electric industry has been introduced by departing from the rate of return pricing philosophy to a market-based price. In this approach, an auction mechanism at the generation side seems to be the best alternative to accomplish this goal. Then, electric energy is seen as a commodity, which is traded in the cash and futures market.

In the Brazilian case, a wholesale energy market (WEM) was created but some particularities made it unlike the general approach used by other countries. The spot price is not determined by a generation bidding process but by the simulation of a hydrothermal optimization program. One big reason for this is that 95% of the generation sources are hydro plants, which need to be coordinated, otherwise the risk of deficit can be very high. As a sub-product of this simulation, the dispatch and the exchanges between the generation companies are also determined. There is only freedom in bilateral contracts, which is a way to avoid exposing the agents to volatile spot prices. It may be considered as a forward market. Market rules are currently under revision, but the main guidelines are:

- Power purchase and sale transactions accomplished through the WEM using Market Agreement signed among the agents
- The Market Agreement includes:
  - Obligation to buy and sell all energy through WEM;
  - Registration of bilateral contracts;
  - Rules for commercialization, accountancy and settlement;
  - Financial warranty related to the amounts marketed in WEM;
  - Mediation of issues among the members
  - Hiring independent auditing to inspect market operation;
  - Rules for dealing with hydrological risks.

3.8 Renewable energies niches

3.8.1 Interconnected system

In the area supplied by the Interconnected System, there are two significant issues: low-income population consumption and energy supply guarantees:

- The unfeasibility of supply of low income consumers, which cannot afford the energy services,
- The need for investments in generation and transmission to support the increase in consumption and distribution.

The use of biomass in electric energy production, in Brazil, is mainly concerned to the pulp and paper and to the sugar and alcohol sectors that use cogeneration systems. Even so, there are some cases of small scale applications in agricultural cooperatives and sawmills, using low conversion efficiency processes.

It can be concluded that there are no technological barriers for generating electricity from biomass in the industrial segments. This confirmation is valid for the use of steam cycles, a technology that is commercially available in the country. The equipment industry existing in Brazil has the necessary conditions to supply practically all items, resulting in a substantial reduction of investments compared to alternatives for which equipment must be imported.

Although cogeneration from biomass in the sugar cane sector is a well-known alternative and many projects are economically feasible, the installed capacity is still very low in relation to the existing potential. In April 2005 the installed capacity is 2.17 GW (ANEEL, 2005), or 10% of the country's thermal power. Large-scale electricity production from sugar cane bagasse and garbage would help to increase diversification and to further reduce production costs of its traditional products – sugar and ethanol.

According to Brazilian Association of Small and Medium Electric Energy Producers, in the meantime the only result of the PROINFA is the signing of the CCVEs (Contract for the Purchase and Sale of Electric Energy) for the SHPs and wind power (1,100 MW per each source) and only 330 MW for biomass. However, the program will be successful when all of these enterprises are generating energy, which is foreseen for December 2006. From now on, financing for small and medium producers must be created. The financial conditions currently available could be decisive for the success of PROINFA projects.

APMPE estimates that after PROINFA is implemented, an average of 200 to 300 MW a year will be added to the system from SHPs, with investments estimated at only about R$ 900 million a year.

Current re-structuring of the national power sector, and the more recent energy crisis, has begun to attract private investments in independent power generation. In comparison with other energy sources used in Brazil, both renewable and conventional, SHPs offer several advantages: lower environmental impact, smaller investments, shorter payback period and legal incentives. As a result of the favorable fiscal and legal policies that Brazil has recently adopted, small-scale hydropower is developing rapidly. The main focus of investment has been on small hydro plant projects. Although historically used for self-production, micro and mini hydropower plants have not yet become attractive as business opportunities.

In addition to investments in new projects, a great potential exists for investments in SHP through re-sizing currently installed plants end reactivating abandoned units

The majority of SHP plants in Brazil were constructed at a time when hydrologic information was scarce and many plants were consequently under-sized. With the use of more modern and efficient technology, more precise hydrological studies, and investments in automation systems, a considerable increase in installed capacities could be achieved along with significant reductions in operational costs.

Of the 1039 plants in unknown condition, most are located in the southern and southeastern regions, where the electrical grid is easily accessible, presenting opportunities for independent power production. Despite this potential, to date there has been no systematic effort to gather information on the conditions of these SHP plants, nor have the questions of ownership or possibility of their reactivation been addressed.

For windpower energy, the biggest opportunities in Brazil lie in the integration to the connected system of large generation blocks, mainly on the coast of the North and Northeast Regions. The wind regimes were studied by several institutions in the North and Northeast Regions and show a clear situation of supplementing the hydro regime.

3.8.2 Isolated Systems

In Brazil there are many small and medium-sized communities isolated from the urban centers and not connected to the conventional electricity grids, thus, becoming dependent upon fossil fuel for electricity production. However, several of these places have favorable conditions for the use of renewable energy sources, such as photovoltaics, windpower, SHPs, biomass, etc. Given these conditions and the new rules for universalization of electricity services, one expects that in a not too distant future, more generation systems will be installed using local energy sources.

One of the great challenges is to integrate the population who still lives in the dark, without access to electric energy. Just as the GDP represents the level of economic development, the consumption of electric energy is also a social development indicator.

The “Luz Para Todos” program, conducted by the Federal Government, intends to provide energy access to all households in Brazil up to 2008. This program will have how priority alternative energy sources, particularly in the case of North region where are located the most of remote villages in the country that not have energy access from grid.

Considering that the higher lack of energy access is in rural areas, where energy transmission lines are not feasible, renewable energy sources become an excellent means of agricultural electrification. Establishing distributed generation systems can minimize a good part of the energy gap.

Regarding isolated systems one barrier is the strict requirements established by ANEEL. The distribution concessionaires, serving these regions, must guarantee the same service level and quality offered in the interconnected system, such as 24 hour energy supply and a low level of problems.

One of the alternatives for the decentralized generation in isolated regions is the use of *the in natura* vegetable oil Some tests were performed by CENBIO, using a conversion device (kit) to preheat the vegetable oil using the heat of the cooling water system of the engine. The tests and the diary accompanying of the engine show that the system used performs in normally conditions, beyond the improvements that can be expected.

It is necessary to identify, to characterize and to quantify feasible raw materials for the local production of vegetable oils, and to analyze the viability of using *in natura* vegetable oils in stationary engines, with the aim of supplying energy to isolated communities, where the cost of the electricity generated from diesel oil is high.

In the case of generation from biomass residues in small systems, there is higher investment being performed in R&D, mainly to adapt different technologies to the Brazilian reality. The use of biomass residues for electricity generation in isolated systems is specially important and desirable when it substitutes fossil-based generation. It is important to mention that the use of biomass should be done in a sustainable way.

In isolated regions, most of residues from agricultural activities, forest residues (branches, leaves, etc.) and sawmills by-products (sawdust, wood chips etc.) can be used as fuel to generate electricity with the technologies how available in the country, including gasification and small-scale steam cycles.

Electricity generation in small blocks in localities very far from the electric grid has been the ideal niche of photovoltaic cells and small PV systems are installed in remote villages but generation costs are high and the small size of the system does not allow the development of productive activities. Such activities are important to address the sustainable development of the community and the self sustainability of the process. Through these activities, local people can afford the payment of the energy, collaborating to the economic feasibility of the project.

3.8.3 Transportation

Nowadays, the environmental impact of products and processes have taken an important role in the long term sustainability of companies and in their valuation in the market. Investment in fuel technology has been the main factor in the development of environmentally sound vehicles (less pollutant) and it has made the required technological advance possible for production of cleaner fuels.

In order to meet the environmental challenge, the automobile industry has developed prototypes directed towards the optimization of fuel consumption, using modern combustion techniques and modern electronic management (hybrid and fuel cells). It is expected that, in 2020, different technologies will be commercial available and which would change the strategies of oil companies and promote its integration with the vehicle industry.

In the Brazilian market, some aspects are relevant:

- The renewed growth of consumption of hydrated ethanol in light vehicles, due as much to the increased sale of ethanol (UNICA, 2004) cars in the past two years as to the huge success of the vehicles known as "flex-fuel"; (ANFAVEA, 2004)

- The real possibility of the introduction of alcohol in diesel cycles, used for biodiesel production;

The feasibility of biodiesel requires the implementation of an organized structure for production and distribution. Investment is needed in order to guarantee also the supply and quality of biodiesel for automotive uses.

The National Biodiesel Program, launched by the federal government in 2004, represent a good research opportunity, aiming at define, for example, the best ratios of the blends, cost reductions, improvements in the production process and utilization of the residues. The right thing is that these rules were defined before the program lunching but the reality shows that the program was launched without the clear definition of these parameters.

A important niche to be considered is fuel cells with ethanol reformer. Fuel cell technology studied in Brazil uses ethanol as the hydrogen source, featuring high energy conversion efficiency and reduction of atmospheric pollution in urban centers.

However, the biggest social benefit of the use of biofuels in developing countries is the job generation in rural areas, in Brazil; the sugar-cane sector is nowadays responsible for 700,000 direct jobs and about 3.5 million indirect jobs.

3.9 Assessment of other experiences

3.9.1 PRODEEM

The Program for Energy Development in State and Municipalities (PRODEEM) is a federal program started in December 1994 and it is coordinated by the MME. The objective of PRODEEM is to reach Brazilian isolated regions, currently unattended by the conventional electricity grid, through locally available renewable sources, thereby fostering self-sustainable social and economic development.

The most important needs achieved under this program are the electrification of schools (Brazil has around 50,000 schools without electricity) and water pumping in areas subject to droughts. Although the program allows for the use of any local, renewable source of energy for this purpose, the program has given, and is likely to continue giving, almost exclusive emphasis to photovoltaic technology.

The program has faced several difficulties, in particular with regards to long-term operation and maintenance structures. The initial concept of working partnerships at the state level, led by public agents, proved to be ineffective in maintaining the systems operational and, as consequence, a follow-up study of Phase I showed high failure rates after just two years of operation.

In order to broaden the reach of PRODEEM, the World Bank proposed financing US$ 110 million to electrify 78,000 rural residences in the states of Minas Gerais, Bahia and Ceará with photovoltaic systems and to develop projects focused on productive end-uses of the electricity. In a joint effort, the Inter-American Development Bank (IDB) and the National Department of Energy Development (DNDE) prepared an Action Plan, making available a grant of up to US$ 9 million to restructure the program, during the years 2003 and 2004. The main goal of the Plan, also having support from USAID Brazil, is threefold: to foster a market of renewable energy service suppliers from the private sector in the rural environment; support the integrated development of micro-regions through production enterprises; and implement a monitoring and evaluation system.

In the beginning of 2003, the Ministry of Mines and Energy decides to restructure the PRODEEM. The restructuring of Prodeem was begun in July 2003 with the consultation of all the involved agents: state governments, research centers, municipal city halls, specialists, ONGs and users. Starting from this mobilization it was created the Plan of Revitalization and Training of PRODEEM. In 2004 it was realized the recovery and the regularization of the patrimonial situation of the equipments already installed in the context of PRODEEM. Finally, in 2005, this program was incorporated to the “Luz para Todos” Program.

3.9.2 Luz no Campo

The Brazilian National Program for Rural Electrification, called *“Luz no Campo” (Light in the Countryside)* for short, aims to contribute to Brazil’s national plan for rural development. While almost 17% of Brazil’s population lives in rural areas, rural production represents just 6% of country’s total GDP. Thousands of municipalities and communities have their economies based on farm production. In order to boost the living standards of this significant share of the population, rural production, productivity and product quality must be raised to levels compatible with the urban centers and the global economy. Provision of rural electricity services stands as an effective inductor of economic development since its multiple effects influence most stages of rural productive chains. Additionally, deploying grid extension to increase rural electricity services is considered an approach compatible with sustainable development, since 95% of the Brazilian electricity is generated by renewable sources.

It is anticipated that increased rural electricity services made possible by *“Luz no Campo”* will significantly contribute to reduce rural-urban migration as well as the pressure on government resources for increased urban infrastructure and social services – which in turn can free up more development resources to rural areas, traditionally poor,. *“Luz no Campo”* finances the implementation of rural electrification infrastructure using the “Global Reserve Fund – GRF” which is constituted by a “levy” charged onto power utilities revenues. Such preferred finance conditions foster a huge number of rural electrification projects implemented by rural cooperatives, power utilities and other qualified agencies.

For the 2001-2004 period, the *“Luz no Campo”* target was to provide grid electricity services to 1 million rural properties and rural homes, a feat that will directly benefit and impact the livelihood of 5 million individuals in the lower stratum of the human development index. In early 2002, federal legislation was enacted that, among other policies, introduces reforms that largely increase specific funding for rural electrification as well as the Eletrobras´ (national power utility whose major shareholder is the federal government) financing role.

Financed by the Ministry of Minas and Energy and for the Government of the State of Bahia, the "Luz no Campo" it was the largest program of rural electrification accomplished already in Latin America, and one of the largest of the world. Considering the total of resources invested in the program, 75% were originating from of the federal and state governments. COELBA (Electricity Company of Bahia's State) participated with 15% and the city halls of the municipal districts benefited with 10%.

Since it was created, the "Luz no Campo" benefited about 500 thousand residents of the rural area of the interior of Bahia's State (one of the poorest regions of Brazil).

Until may 17, 2005, the "Luz no Campo" Program achieved 134,924 consumers, installed 247,867 energy posts and 14,385 energy transformers, and implemented 22,359.96 km of transmission lines in almost all of the municipal districts of Bahia (COELBA, 2005).

As well as PRODEEM, "Luz no Campo" was extinct for the Federal Government (in the middle of 2004) and their goals and objectives were incorporate to the Program "Shines for All" (Light for All), that is today the main government instrument to reach the universal access to the electric energy in Brazil.

However, after this phase, decentralized generation will be the only possible option for remote villages, opening an important space for RETs, because grid extension is technically and economically unfeasible for Amazonia conditions.

3.9.3 Luz para Todos

The Brazilian Government has announced in November, 2003 the *Luz para Todos* (Light for All) Program to supply electricity to 12 million people by 2008 throughout Brazil, as yet unconnected to any transmission grid. In fact, it is a fundamental step towards achieving the much longed for dream of universal access to electrical energy services. Only in the State of Rio de Janeiro, near 6,000 households will be electrified.

The first stage of the Program has scheduled investments of US$843 million[i3], funded by the Federal Government (USS 543 million), by 35 concessionaries (US$ 188 million) and by state governments (US$112 million). . In the signature of the contracts, 10% of the value of the contracts was made available to concessionaries. Eletrobras is monitoring all the progress of the work.

In accordance with the Federal Government, the main objective of *Luz para Todos* is social inclusion, through access to electricity supply service. In fact, the relationship between no access to electric energy and poverty is clear in Brazil, as 90% of households without access have an income lower than three minimum salaries.

Since its implantation in 2003, the *Luz para Todos* (Light for All) Program in Brazil has created around 53,000 new jobs, according to a survey by the Ministry of Mines and Energy. The creation of jobs is the result of the economic impact of the program, which has made electricity connections possible for 40 thousand houses per month.

Despite these positive results, the program is still far from its real goal. By 2008 the Light for All Program expects to spend US$ 4.07 (around 9.5 billion reais), US$ 2.91 billion (around 6.8 billion reais) of which will be applied directly by the federal government. The rest will come from state governments and private electricity companies.

The program may generate a total of 300 thousand direct and indirect jobs and extend electric power to 10 million rural residents, if the 2008 goal is achieved.

But, according to data from the Ministry of Mines and Energy, the Federal Government has only spent US$ 267 million of the US$ 1.1 billion (around 2.6 billion reais) set aside for the program. The reason for this is that the companies only receive payment after it is determined that the new connections were installed.

The program, until October 2005, has already reached 1.3 million people in the countryside, approximately 375 thousand families. Another 625 thousand are on the waiting line.

3.9.4 Difficulties in the implementation of some National Programs

3.9.4.1 PCH – COM Program

Launched by Eletrobras on February 22, 2001 and supported by the BNDES (Brazilian Economic and Social Development Bank), the PCH-COM program was created to encourage commercialization of the energy generated by SHPs. The PCH-COM forecast that Eletrobras would purchase the generated energy and that BNDES would finance the enterprise. Eletrobras' goal was to purchase 1.2 thousand MW between 2001 and 2003, about 400 MW a year.

Anyhow, the investors were not interested in the program because of the prices suggested by Eletrobras. Four months after it was launched, PCH-COM hadn't received any proposals.

Since 2004 the Program PCH-COM isn't active.

3.9.4.2 CEANPC Program

In relation to the program that encourages SHPs (the PCH – COM), the government had already tried another solution to attract investors. Resolution No. 169/2001, which establishes the Energy Reallocation Mechanism (MRE), has been changed, reducing the hydrological risk of SHPs. That did not help, and the program did not get good results.

This is not the first SHP incentive program launched by Eletrobras. One of them is the CEANPC, which was part of the National Program for Small Hydropower Plants (PNCE). The CEANPC's function was to advise investors that were interested in the electric energy area, especially in the construction and modernization of SHPs, offering information about legislation, case studies, etc., free-of-charge. However, the CEANPC no longer exists. It was called off when Eletrobras was restructured in 2000.

3.9.4.3 Progedis and PCH-MG Programs

Programs that encourage generation do not come exclusively from the government. The utilities have also shown possibilities of enhancing the national generating system. In relation to SHPs, there are some isolated cases that are waiting for better results, such as the PCH-COM, previously described.

This is the case of the Distributed Generation Program (Progedis) by Copel (Electricity Company of the State of Paraná) and PCH-MG by CEMIG (Energy Company of Minas Gerais). Progedis, launched in December 2000, was created to enable small projects, not only SHPs, to generate up to 980 thousand MWh per year. The program assures the investor that the produced energy will be put into the market with the prices that were previously agreed with Copel. According to Copel (2002), the entrepreneur can look for the necessary resources to finance his/her enterprise within the market with more favorable conditions.

As soon as Progedis was released, protocols of intention for the construction of nine generating plants – five hydroelectric plants and three thermoelectric plants – were signed. However, only Foz do Chopim SHP – 29 MW – is operating and Vitorino SHP – 5.3 MW – is being constructed. The others remain plans and intentions (Copel, 2004).

The PCH-MG, launched in November 2001, was created to improve the SHP potential in Minas Gerais State. Cemig intended to buy 400 MW from the undertaking, but the Program still hasn't reached its original targets.

The main problem related with this kind of initiative is the fact that energy enterprises require intensive use of capital and they are long-term investments. However, aside from the initiative, structural problems and the lack of money may be considered the greatest difficulties.

Nowadays (since 2004), the programs Progedis and PCH-MG aren't active.

3.9.4.4 *Pró-Eólica* Program

The Energy Crisis Management Council, through Resolution No. 24 of July 5, 2001, created the Pró-Eólica emergency wind power program. This Federal Government initiative to improve the use of wind energy in Brazil didn't interest entrepreneurs either and it has been facing the same difficulties as the PCH-COM.

The Pró-Eólica Program foresees that ELETROBRAS buys the electricity generated by the participating plants at higher prices (US$ 47.63 per MWh, for fifteen years) than that of hydroelectric power stations (US$ 30.62 per MWh).

The initial focus of the Pró-Eólica Program was the implementation of 1,050 MW of wind energy in Brazil over three years (2001-2004). This target was achieved and in a restructuring process, the Pró-Eólica Program was definitively incorporated in PROINFA Program, in December 2004.

3.10. Overall assessment and Identification of problems

3.10.1 Institutional Barriers

With regard to political and institutional barriers, the main drawback is the lack of means for long-term energy policies, a constraint that is even larger when dealing with renewables. Energy policy, planning and regulation are still almost completely detached from each other, even though some efforts in this direction exist. Regarding renewable electricity, the Ministry of Mines and Energy and the National Electric Energy Regulatory Agency have proposed and implemented their own programs, but their actions are not coordinated and synergic effects are not clearly identified.

In general, regulatory actions by ANEEL address important points but there are many doubts concerning their effectiveness as tools for fostering renewable electricity in Brazil. Probably because of the hydroelectric culture and sector interests that remain strong in the country, it seems that regulation concerning renewables is carried out like a duty, without a real purpose to implement these energy sources.

Law No. 9648/98 extended to renewable sources in isolated communities the subsidies already existing for diesel thermoelectric generation in the North of Brazil, through the Fuel

Consumption Account (*Conta de Consumo de Combustível -CCC*). This account is funded by special taxes paid by final consumers. ANEEL Resolution No. 245/99 determined conditions and timeframes for using CCC for projects in isolated electric systems that replace fully or partially oil fired thermoelectric generation or those that supply new loads from market expansion. This scheme is applicable until May 2013.

In the interlinked system, special status was accorded to renewable energy sources through the 2002 approved Law No. 10438 that created the Incentive Program for Alternative Electric Generation Sources (PROINFA – *Programa de Incentivo a Fontes Alternativas*).

The PROINFA plan is divided into two phases. In the first phase within the first 24 months after the Law was enacted, long-term contracts (15 years) are supposed to be made over 3,300 MW by Eletrobras (Holding of the Brazilian Power System). The fixed amount is supposed to be achieved equally by the following energy sources: wind power, small hydropower projects and biomass. Acquisition of this energy will be defined by the economic value for each specific technology. This value is calculated by the executing body, in this case, the Ministry of Mines and Energy, but it has to represent at least 80% of the average national tariff for the end user.

After the implementation of the first 3,300 MW, the second phase will begin. The program is designed so that wind energy, small hydropower and biomass will achieve 10% of the Brazilian power production. This goal is supposed to be reached within the next 20 years, as in the first phase with contracts over 15 years. The price of the purchased energy is determined by the economic value of the referential competing energy source, defined by the average costs of power production by new hydropower projects with an installed capacity of over 30 MW and new gas power stations. The Ministry of Mines and Energy again determined the price, as follows:

Table 19: Electricity purchase prices

RET	**R$/MWh**
Small hydropower plant	117.02
Wind energy	180.18 – 204.35
Biomass	
Sugarcane	93.77
Wood residues	103.20
Rice husks	101.35
Landfill biogas	169.08

Source: Ministry of Mines and Energy – Directive No. 45, March 30, 2004 (http://www.mme.gov.br/Proinfa/Portaria/Portaria_MME_n_45-2004.pdf)

This program is only applicable to the interconnected system, as mentioned.

This program can be the first step in the implementation of a more diversified energy matrix, collaborating to reorganize the generation system, as well as the transmission and the distribution of energy in the country, so that in the future, the country will not be exposed to new energy shortages like the ones that occurred recently.

According to estimates of MME, the Program could generate 150,000 jobs during the construction period and afterwards, during the operation of the power units.

A government investment of R$ 4 billion will be required for the production and supply of plants and materials in Brazil for the renewable industry. Also, it will be necessary a private investment of about R$ 8.6 billion.

The strategic aspect of PROINFA is to create complementarily between hydropower and wind energy in the North and hydropower and biomass in other areas. For each 100 MW produced by wind energy parks, 40 cubic meters per second of water are saved in the waterfall of the São Francisco River.

The implementation of the PROINFA project would prevent the emission of 2.5 million tonnes of CO_2 per annum and would create an environment for business that will ensure the reduction of carbon emissions in terms of the Kyoto Protocol.

An indirect barrier to the implementation of renewables is the current environmental legislation for stationary sources. Nowadays the legislation for these sources establishes limits only for SO_2 and specific particulate emissions, not for NO_x emissions, especially in natural gas power plants where NO_x emissions must be controlled. Otherwise, a conversion system will be installed with no emissions reduction, with lower installations costs. Consequently, this appears to be an indirect subsidy to fossil fuels, mainly outside São Paulo State, since it is the only State which has restrict environmental legislation to control these emissions.

3.10.2 Technological Barriers

Technological barriers for PV, wind and small hydro are not significant nowadays.

Small-scale electricity generation using biomass, which is important for isolated communities, still presents some specific technical barriers in Brazil.

- Small-scale steam cycles (minimum 200 kW): No small size steam cycles are commercially available. The few ones existing is Brazil have high generation costs. However, there are positive perspectives as in 2003 the development of small-scale projects begun, and they could be installed in the near future.

- Small-scale gasification systems: this technology presents low conversion efficiency and high levels of tar emissions. In Brazil, this technology is used only for thermal purposes; projects to adapt Indian systems to Brazilian conditions are under development (CENBIO, 2004).

- Biogas and vegetable oil engines: such engines are not available in Brazil, but are commercially available in the USA and Europe. In addition, projects to adapt existing conventional engines to biogas are under development (CENBIO, 2004).

3.10.3 Political Barriers

Today, 20 million people in the country still have no access to electricity, one third of the rural population. This is especially true in isolated rural Amazon communities and urban area outskirts. It is clearly necessary to give attention to these communities' needs and renewable energy can collaborate to achieve this goal (Goldemberg *et al*, 2003). In Brazil, some policies already being implemented to achieve this goal such as special tariffs to low income consumer and the Luz para Todos program.

The National Electric Energy Regulatory Agency - ANEEL has introduced several measures to stimulate renewables, simplifying authorization procedures and establishing flexible commercialization prices.

Considering the needs for special policies to implement renewable energy in rural and isolated communities, a program similar to PROINFA could be implemented, establishing the mandatory purchase of electricity from renewable sources also for the isolated systems.

This could be a strong incentive policy for renewables, considering that there are local utilities in these regions and most energy supplied comes from diesel engines. This policy, together with the existing CCC (already expanded for renewables, as mentioned before), could in fact contribute to the expansion of renewables and, consequently, reduce their production costs, as discussed in Goldemberg *et al*, 2003.

It is well known that the strongest argument against renewables in general is their high cost and ensuing lack of competitiveness with conventional fuels - a common characteristic of new products and infant industries. This was indeed the case in the past but, as consumption of renewable energy increases, its cost will fall, as is the case for most products (Goldemberg *et al*, 2003)

4.0 Policy Outlines

4.1 Objectives and policies outlines

In Brazil, the definition of a comprehensive national strategy for universal energy access is still needed. This national strategy to be established by the Ministry of Mines and Energy must include the definition of the volume of available resources from RGR and CDE funds, the deadline for universal access in the whole country and the maximum impact that would be acceptable on the tariffs, and how those available funds would minimize this impact.

An effort to coordinate the actions of different institutions and programs, articulating income generation, poverty alleviation, infrastructure provision and rural electrification programs complete the list of the most urgent actions to promote such full coverage. This concerted action should take into consideration the different initiatives, like Luz no Campo, Prodeem, Ministry of Agriculture's funds to RE through annual national budget, Program of Poverty Alleviation, Northeast Development Bank credit line to micro-entrepreneurs, etc. This strategy should try to optimize the allocation of the public resources, which must be used to leverage the private funds raised by the concessionaires and new agents.

In the case of rural areas, existing programs should create conditions to make feasible the conversion of some rural electrification cooperatives into multi-service entities (electricity, telephone and water), e.g. through a specific credit line and capacity building efforts, including coordinated regulation and tariff definition. This is a model with strong potential for replication, and it could make permissionaires more viable. Also, local sustainable activities must be developed aiming to make all these programs self sustainable.

Brazil is a large market for both grid extension and distributed electricity production from renewable energy technologies. However existing information on market (mainly for rural areas) is very inaccurate. A definitive quantifying census that would include sample surveys to more precisely define how the market could be split between these alternatives is vital. This would certainly reduce uncertainties and attract private investors.

In this context, this chapter aims to discuss the main existing policies and proposes changes when necessary to keep making these policies feasible.

- Isolated System

There are two distinct scenarios on electricity supplying in Brazil. One of them is composed by the interconnected system (grid) and the other by isolated systems.

In the grid system, that covers the majority of the states in the country, the electricity is produced mostly by hydroelectric power plants (85%) and distributed to the public through distribution lines. The scenario is not the same in the isolated systems, which are located mostly in the North part of the country.

The fact that consumers in this region are spread in a vast geographic area with a low demand makes the replication of the grid system energy supply model impracticable. In this peculiar case, the decentralized energy production represents a solution being the electric power produced and consumed locally or in micro regions.

The specific conditions on isolated systems require adequate policies to the use and expansion of renewable energies which would take in consideration the local reality.

From these specific scenarios the CCC (Fuel Consumption Fund) was implemented in Brazil, aiming the reduction of the cost differences between the two systems (grid and isolated). Through the CCC part of the financial resources collected from the energy supply in the grid system is utilized to reduce the cost differences in the energy production in isolated systems, allowing a fair cost to the final consumers which do not have access to a cheaper energy produced in the grid system.

The benefits of the CCC were expanded to renewable sources through the law 9648/98. However the legislation says that only generators which have a concession or authorization of the Energy National Agency (ANEEL) are qualified to receive CCC benefits. These authorizations and concessions are required only to hydropower plants of minimum 1 MW and thermal power plants of minimum 5 MW. It is a barrier to the development of small-scale projects in isolated communities, as the projects presented previously (section 3.6).

For an effective contribution to the expansion of renewable sources some alterations will be necessary.

A correction about the article 8 of the law 10.848 of March, 15th of 2004: “Art.8: It is extended to all suppliers concessionaries a cost share of fuel consumption (CCC), including the biodiesel to produce electric power in the isolated systems, without loss of what is writhen in the third paragraph of the article 11 of law 9648 of May 27th of 1998.

Aiming to enlarge the use of CCC, biodiesel was included as a potential fuel replace diesel. However, electricity production using biodiesel does not meet the necessities of the isolated communities. Biodiesel is an industrial product from the transesterification of a vegetable oil with an alcohol. The final products are biodiesel and glycerin that must be very well separated. The alcohol can be ethanol or methanol. In case of using methanol, which is a petroleum derivative, it must be transported to the community in a region with severe logistic restrictions due to the vast territorial extension, weather adversities and the need of a fluvial transportation.

In case of using ethanol, the whole production chain would have to be implemented, since the a sugar cane plantation and an installation of alcohol distillery to obtain the desired product, another possibility shall be transportation of ethanol to the communities. The both possibilities are not economically feasible.

In both cases it is possible to observe the difficulties on the biodiesel production in remote localities. That is why the in natura vegetable oil utilization is a more viable alternative to produce energy in isolated systems than biodiesel. The energy production from in nature vegetable oil dismiss the transformation of the vegetable oil and consequently all processes and products linked to it, been the most indicated alternative considering the regional conditions.

So, it is necessary to change the referred law, allowing the utilization of in nature vegetable oil as fuel in CCC issues. It is suggested the use of the term “biofuel” instead of biodiesel.

Another distortion of the law concerning the CCC is related with the supplying standards. The same supplying standards utilized by the grid system were adopted. These standards are bond to the energy supplying period to met and therefore comply with CCC norms, which impose, for instance, that the installed remote systems supply electric power 24 hours a day to all the consumers.

This situation brings along operational and infrastructure requirements that will burden the operation of local production systems, consequently imposing difficulties to electricity production from renewable sources. In the communities with no electricity supply, the installation of a power system that supplies energy in specific periods of the day is already a remarkable improvement. Lowering the period of energy supply reduces installation and operation costs and contributes to the feasibility of such power systems. More flexible supply standards are being proposed just for power systems based on renewable energy sources because these systems are starting to be implemented and can not afford to follow more strict rules.

Regarding the current energy supply policy to isolated communities another important issue is related to the implementation. The current systems of electric power supply are designed based on the community’s size and on the energy consumption of each community member. Generally the socio-economic characteristics are not analyzed in the process planning.

Energy supply must be related to the promotion of the income improvement, mainly where the inhabitant’s income is low.

So, the system's scale must be done using as a reference the energy demand aiming to aggregate value to the local economic activities, contributing to the improvement of the local people income, raising the economic viability of the systems.

In general, remote villages have extractivism as their main economic activities, together with fishing and agriculture. For fishing based communities, the lack of energy compels the fishermen to sell their production during the season when the price is low (the dry season, when all suffer with the same refrigeration problems). In this case, the capacity of these communities power systems should be defined based on their refrigeration demand fulfillment. In this scenario it is possible to estimate a possible local income improvement and, consequently, the economic improvement.

In the case of fruit harvesting communities, a common activity in the region, the same problem is experienced. With a vigorous planning associated with the productive chain it is possible, depending on the treatment method to the fruits, to define not only the amount of the necessary electric power as well the renewable power technology method that will be utilized. If, for example, during the treatment, a source of heat becomes necessary, the gasification can be utilized to supply these demand and generate electrical power as an appropriate alternative to produce heat for the process.

In this scenario the suggestion is that the sizing of the electric power systems for isolated systems is to be done in an integrated method. This requires the involvement of many local institutions. The National Institute of Land Distribution (INCRA), the Agriculture Agency, the National Enterprise of Farming Research (EMBRAPA), local associations and concessionaries could determine the most efficient way to aggregate value to the local production through the electric power produced in the communities with an interaction among themselves.

It would be interesting the development of a social organization such as agricultural association or cooperative that would aggregate these agents to make possible a centralized development of the process.

- Interlinked System

In the Brazilian interlinked system the main barriers to the use of renewable energy are not related to technology availability. The main difficulties are related to the lack of adequate policies to promote this type of technology, making it attractive to the private sector.

Federal government has been trying to develop mechanisms to change this situation, but its necessary to establish a better agreement between the entrepreneurs and the government regarding tariffs for electricity purchase.

The electricity production from renewable sources in the interlinked system faces difficulties to get rid of the continuous condition of promise. In Brazil, the Program of Incentive to the Alternative Sources of Electric Energy (Proinfa) was created last year with the goal of stimulating cleaner energy sources, but it has been put into practice very slowly.

There are two reasons why the adhesion did not come up to expectations, according to the biomass sector: the prices determined by the federal government for the purchase of energy to be produced are not attractive; and the period of the contracts, of 20 years, is too long for the low tariff offered by Government. Entrepreneurs would like to have more freedom to enjoy, in the future, higher prices eventually paid for the electricity, in case the forecasts of shortages are confirmed in the medium term.

Some concerns had been highlighted by federal government related to the delay on environmental licensing but, in fact, all those licenses had been emitted by environmental agencies, with any delay. The lack of interest from investors was indeed due to those economic aspects.

Among the entrepreneurs of SHP that had filled the share of 1.100 MW, there are stalemates viability of the projects, but in another aspect. From 27 enterprises conducted for the Brazilian Development Bank (BNDES), only one received the necessary financing, until now. In general, the projects about infrastructure have bumped into the delay of the bank procedures. In the case of the SHP projects, there is an extra ingredient: the lack of enough guarantees to be offered to the bank for some entrepreneurs, several of them without tradition in the energy sector.

The Federal government decision, by the end of 2004, to postpone to December 2008 the deadline for the beginning of Proinfa projects operation, previously scheduled to December 2006, still brought the diffidence, among some experts of the sector, that the program might take longer to be made viable than initially foreseen.

For these experts, the energy supply should match the demand from 2007 on. Without the 3,300 MW of Proinfa, however, there is the expectation that the supply might get tighter.

In fact, if federal government wants to improve the number of biomass projects under Proinfa it is necessary to take some measures to call entrepreneurs’ attention (like better prices for the energy sold), other actions being recommended to develop the enormous potential on biomass in the country though in sugarcane sector this type of generation is already a reality.

4.2 Stakeholders reactions

Table 20: Stakeholders Reaction

Specific objective	Extend the same subsidies to the diesel fuel for electricity production in isolated areas to renewable fuel in general.		
Strategic outlines **Stakeholders**	*Developing economic incentives*	Developing political incentives	Social awareness
1. Ministry of Mines and Energy	*S*	S	S
2. Economy Ministry	*O*	S	A
3. Regulatory Agency	*CS*	S	S
4. Environment Ministry	A	S	S
5. Legislative representatives	CS	CS	CS
6. Political parties	CS	CS	CS
7. Local Government	S	S – CS	S
8. Rural organizations	A	A	S
9. Indigenous organizations	I	I	CS
10. Industrial enterprises	CS	A	S
11. Investors	A	A	CS
12. Multilateral banking	I	CS	A
13. Commercial banking	I	I	A
14. Cooperation Agencies	A	S	S
15. Project developers	S	S	S
16. Power Utilities	A – CS	S	CS
17. Oil companies	O	O	I
18. Professional associations	A	I	S
19. Transmission companies	CS	A- I	I
20. Distribution companies	*CS*	CS	S
21. Climate Change Office	S	S	S
22. Environmental NGOs	S	S	S
23. Potential users	A	A	A
24. Church	I	I	S

S = support; A = acceptance; CS = conditioned support; O = opposition; I = indifference

Specific objective	Adapt the operational and infra structure requirements of energy supply to the isolated regions reality.			
Strategic outlines **Stakeholders**	*Developing economic incentives*	Developing political incentives	Developing Technologies solutions	Improvement private utilities interest
1. Ministry of Mines and Energy	*S*	S	S	S
2. Economy Ministry	*O*	CS	S	A
3. Regulatory Agency	*CS* - I	S	S	S
4. Environment Ministry	A	S	S	S
5. Legislative representatives	CS	CS	CS	CS
6. Political parties	CS	CS	CS	CS
7. Local Government	CS	S - CS	CS	S
8. Rural organizations	A	A	A	S
9. Indigenous organizations	I	I	I	CS
10. Industrial enterprises	CS	A	S	S
11. Investors	A	A	CS	CS
12. Multilateral banking	*CS*	CS	CS	A
13. Commercial banking	*I*	I	I	A
14. Cooperation Agencies	*CS*	S	S	S
15. Project developers	*A*	S	S	S
16. Power Utilities	*A – CS*	S	S	CS
17. Oil companies	*O*	O	CS	I
18. Professional associations	*A*	I	A	S
19. Transmission companies	A – I	A- I	A	I
20. Distribution companies	*CS*	CS	A	CS
21. Climate Change Office	S	S	CS	S
22. Environmental NGOs	S	S	CS	S
23. Potential users	A - I	A	CS	A
24. Church	I	I	I	CS

Specific objective	The systems of electric power supply in isolated areas needs to be dimensioned based in the community's socio-economics characteristics.			
Strategic outlines **Stakeholders**	Improvement private utilities interest	Developing political incentives	*To become more reliable the regional information*	*Incentives RETs project research in isolated villages*
1. Ministry of Mines and Energy	*S*	S	S	S
2. Economy Ministry	*O*	S	S	A
3. Regulatory Agency	*CS* – I	S	S	S
4. Environment Ministry	A	S	S	S
5. Legislative representatives	CS	CS	CS	CS
6. Political parties		CS	CS	CS
7. Local Government	CS	S – CS	CS	S
8. Rural organizations	A	A	A	S

9. Indigenous organizations	I	I	A	CS
10. Industrial enterprises	CS	A	S	S
11. Investors	A	A	CS	CS
12. Multilateral banking	CS	CS	CS	CS
13. Commercial banking	I	I	I	A
14. Cooperation Agencies	S	S	S	S
15. Project developers	A	S	S	S
16. Power Utilities	A – CS	S	S	CS
17. Oil companies	O	O	CS	I
18. Professional associations	A	I	A	S
19. Transmission companies	A – I	A- I	A	CS
20. Distribution companies	*CS*	CS	A	CS
21. Climate Change Office	S	S	CS	S
22. Environmental NGOs	S	S	CS	S
23. Potential users	A - I	A	CS	A
24. Church	I	I	I	I

Specific objective	The systems of electric power supply needs to be related to the promotion of the income improvement and aggregate to the local economic values, raising the economic viability of the systems and absorbing the benefits associated to the electric power supplying.			
Strategic outlines **Stakeholders**	*Developing economic incentives*	Developing political incentives	Developing Technologies solutions	Developing local population awareness
1. Ministry of Mines and Energy	*S*	S	S	S
2. Economy Ministry	*CS*	S	S	A
3. Regulatory Agency	*CS* - I	S	S	S
4. Environment Ministry	S	S	S	S
5. Legislative representatives	CS	CS	CS	CS
6. Political parties	CS	CS	CS	CS
7. Local Government	CS	S – CS	CS	S
8. Rural organizations	A	A	A	S
9. Indigenous organizations	I	I	I	CS
10. Industrial enterprises	CS	A	S	S
11. Investors	A	A	CS	CS
12. Multilateral banking	CS	CS	CS	A
13. Commercial banking	I	I	I	A
14. Cooperation Agencies		S	S	S
15. Project developers	A	S	S	S
16. Power Utilities	A – CS	S	S	CS
17. Oil companies	O	O	CS	I
18. Professional associations	A	I	A	S
19. Transmission companies	A – I	A- I	A	I
20. Distribution companies	*CS*	CS	A	CS

21. Climate Change Office	S	S	CS	S
22. Environmental NGOs	S	S	CS	S
23. Potential users	A - I	A	CS	CS
24. Church	I	I	I	CS

Specific objective	To take some governmental measures to attract the biomass entrepreneurs concern (like better prices for the energy sold) and don´t fritter the enormous potential on biomass in the country.		
Strategic outlines **Stakeholders**	*Developing economic incentives*	Developing political incentives	Improvement private industries interest
1. Ministry of Mines and Energy	*S*	S	S
2. Economy Ministry	*CS*	A	CS
3. Regulatory Agency	*CS* - I	S	S
4. Environment Ministry	CS	S	S
5. Legislative representatives	CS	CS	CS
6. Political parties	CS	CS	CS
7. Local Government	CS	S – CS	CS
8. Rural organizations	A	A	S
9. Indigenous organizations	I	I	I
10. Industrial enterprises	CS	A	CS
11. Investors	A	A	CS
12. Multilateral banking	CS	CS	CS
13. Commercial banking	I	I	I
14. Cooperation Agencies	A	S	S
15. Project developers	A	S	S
16. Power Utilities	A – CS	S	S
17. Oil companies	O	O	CS
18. Professional associations	A	I	A
19. Transmission companies	A – I	A- I	A
20. Distribution companies	*CS*	CS	A
21. Climate Change Office	S	S	S
22. Environmental NGOs	S	S	CS
23. Potential users	A - I	A	CS
24. Church	I	I	I

5.0 Summary of key findings and recommendations

Renewable energy sources are a real option for energy production in Brazil, not only for electricity production in the interlinked systems but also in the isolated ones.

In the interlinked system, biomass (mainly sugarcane bagasse), SHP and wind appear to be the most feasible options. The existing Proinfa Program only needs some adjustments (mainly for biomass) regarding purchase tariffs for long terms contracts.

On the other hand, on the isolated systems (remote villages), biomass and SHP are the main options. Photo Voltaic systems, due to the high cost, are only feasible in some specific cases, such as for schools and community centers, when any others sources are not available.

In these villages, biomass based power systems can use locally available agricultural residues (like fruit shells or wood residues from small sawmills) or vegetable oils, which can be produced by the community itself. The advantage of this process is that it allows simultaneously the sustainable development of the community and electricity production, making economically feasible the energy conversion process. Differently from PV systems (that allows only a very small installed power for lighting, water pumping, etc), such biomass systems allow the sustainable development of economic activities in these remote areas.

However, better support for demonstration pilot units are needed, not only to disseminate information on small scale Projects (CENBIO, USP, CEPEL etc) but also to attract local utilities to be involved in the process. Once participating on this process, these utilities could be responsible for O&M.

However, as discussed, changes on CCC laws and CCC regulations by ANEEL are strongly need, otherwise these RE systems will not become economically competitive to diesel engines. It must be considered that opportunities from Kyoto Protocol carbon credits eventually received are not enough to make these projects feasible due to the high subsidies existing only for the diesel generation.

6.0 Suggestions for future actions

Considering the huge opportunity for RE (mainly biomass) in rural areas (remote villages) the dissemination of adequate technologies conversion among developing countries is fundamental. Existing examples of such collaboration (South–South collaboration) already exists in Brazil (Brazil – India, CENBIO/USP – IIS) and could be expanded, with social, economic and environmental advantages.

Previous preliminary studies have aimed to reach this objective (ECN – Energy Research Center of the Netherlands), but there were no follow-up due to the lack of funds.

Also, it is important the adequate coordination of such studies, avoiding the waste of funds and efforts. More and deeps studies on this issue, as well as international networks to exchange information and discuss adequate RE technologies for rural areas (economically affordable) can be interesting option, not only in Brazil but for all developing countries.

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[i] In June 21st exchange rate was US$1 = R$3.131.