Trade Guide on Renewable Energy in Brazil 2002

TRADE GUIDE

on

Renewable Energy in Brazil

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WINROCK INTERNATIONAL
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Foreword

Approximately twenty million Brazilians living in remote communities do not have access to reliable electrical power. While the majority of these underserved reside in Brazil's Northeast, the remainder dwell all over the country -- even in the well-developed states of the South and Southeast regions. These communities rely on small diesel generators to supply power for basic public services like water pumping, communications, lighting for schools, and vaccine storage for health clinics, as well as for small businesses. The Government of Brazil considers universal access to safe, affordable energy a central component in its fight against inequality and rural poverty.

Brazil's untapped potential to employ renewable energy resources such as biomass, solar (photovoltaic and thermal), small hydro and wind for electricity generation is tremendous. Recent economic analyses indicate that these indigenous energy sources can provide cost-effective and environmentally-sound alternatives to fossil fuel-based generation. With a potential $25 billion renewable energy market, business opportunities are limitless. However, government resources alone cannot meet the demand for off-grid energy, and those resources that are currently available support highly-subsidized programs.

The U.S. Agency for International Development (USAID) and its Cooperators undertake activities which demonstrate the catalytic role renewable energy plays in economic growth and promotes the use of commercialized renewable energy technologies in other development sectors (e.g., agriculture, health, and education), creating synergies across programs. USAID also seeks to engage the private sector and local entrepreneurs in the delivery of energy services.

This Trade Guide is the result of a successful partnership between two USAID Programs - the Washington D.C.- funded Global Leader With Associates (LWA) Program and the field Mission-funded Brazil Clean Energy and Energy Efficiency Program (BCEEP) - both implemented under Cooperative Agreement mechanisms with Winrock International. Dissemination of this Guide will provide foreign and local investors a succinct, reliable source of information on renewable energy market development in Brazil and present potential opportunities for business in clean energy.

On behalf of USAID's Brazil energy program, we jointly congratulate Winrock's LWA and BCEEP Teams for the development of this Trade Guide. We anticipate this resource will serve to broaden the use of renewable energy technologies across all development sectors, and further stimulate the renewable energy industry in Brazil.

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List of Acronyms

Acronym	Portuguese	English
ABEER	Associação Brasileira das Empresas Energia Renovável e Eficiência Energética	Renewable Energy and Energy Efficiency Trade Association of Brazil
ABIMAQ	Associação Brasileira das Indústrias de Máquinas	Brazilian Machinery Industries Association
ABRACAVE	Associação Brasileira de Florestas Renováveis	Brazilian Association of Renewable Forestry
ABRAVA	Associação Brasileira de Refrigeração, Ar Condicionado, Ventilação e Aquecimento	Brazilian Association of Refrigeration, Air Conditioning, Ventilation and Heating
ANEEL	Agencia Nacional de Energia Elétrica	National Agency for Electrical Energy (regulator)
APAEB	Associação dos Pequenos Agricultores do Estado da Bahia	Association of Small Farmers of the State of Bahia
APE	Auto Produtor de Energia	Self Producer of Energy
BEN	Balanço Energético Nacional	National Energy Balance
BNB	Banco do Nordeste do Brasil	Bank of the Northeast of Brazil
BNDES	Banco Nacional de Desenvolvimento Econômico e Social	National Bank of Economic and Social Development
CBEE	Comercializadora Brasileira de Energia Emergencial	Brazilian Emergency Power Dealer
CBEE	Centro Brasileiro de Energia Eólica	Brazilian Wind Energy Center
CCC	Conta de Consumo de Combustíveis	Fuel Consumption Account
CCPE	Comitê Coordenador de Planejamento de Expansão de Sistemas Elétricos	Electric Systems Expansion Planning Coordinating Committee
CDE	Conta de Desenvolvimento Energético	Energy Development Account
CEAL	Companhia Energetica de Alagoas	Power Company of Alagoas
CELPA	Centrais Elétricas do Pará S.A	Electricity Company of [the State of] Para
CELPE	Companhia de Energética de Pernambuco	Power Company of [the State of] Pernambuco
CEMAR	Companhia Energética de Maranhão	Power Company of [the State of] Maranhão
CEMAT	Centrais Elétricas Matogrossenses S.A.	Electricity Generators of [the State of] Mato Grosso, Inc.
CEMIG	Companhia de Energética de Minas Gerais	Power Company of [the State of] Minas Gerais
CENBIO	Centro Nacional Referência em Biomassa	National Reference Center for Biomass
CEPEL	Centro de Pesquisas de Energia Elétrica	Electrical Energy Research Center
CEPISA	Companhia Energética do Piauí	Power Company of [the State of] Piauí
CERALPA	Cooperativa de Eletrificação Rural de Alto Pajéu, Ltda.	Alto Pajeu Rural Electrification Cooperative, Ltd.
CERJ	Companhia de Eletricidade do Rio de Janeiro	Power Company of [the State of] Rio de Janeiro
CERON	Centrais Elétricas de Rondônia, S.A.	Electricity Generators of [the State of] Rondônia. S.A.

CERPCH	Centro de Referência para Energia de Pequenas Centrais Hidráulicas	Reference Center for Energy from Small Hydro Plants
CERPEL	Cooperativa de Eletrificação de Petrolina, Ltda.	Petrolina Electrification Cooperative, Ltd.
CERSIL	Cooperativa de Energia, Comunicação e Desenvolvimento do Vale do Sirji, Ltda.	Communications, Energy and Development Cooperative for the Sirji Valley, Ltd.
CESP	Companhia Energética de São Paulo	Power Company of [the State of] São Paulo
CHESF	Companhia Hidro Elétrica do Vale São Francisco	Hydroelectric Company of the São Francisco Valley
CIF		Cost In Freight
CNPE	Conselho Nacional de Política Energética	National Council for Energy Policy
COELBA	Companhia de Eletricidade do Estado da Bahia	Power Company of [the State of] Bahia
COELCE	Companhia Energética de Ceará	Power Company of [the State of] Ceará
CONAMA	Conselho Nacional do Meio Ambiente	National Environmental Council
COPEL	Companhia Paranaense de Energia	Power Company of [the State of] Paraná
COPERSUCAR	Cooperativa dos Produtores de Cana de Açúcar	Association of Sugarcane Producers
CPFL	Companhia Paulista de Força e Luz	Paulista Power and Light Company
CRESESB	Centro de Referência para Energias Solar e Eólica	Reference Center on Solar and Wind Energy
CTEM	Comitê Técnico para Estudos de Mercado	Market Studies Technical Committee
DNAEE	Departamento Nacional de Água e Energia Elétrica	National Department of Water and Electrical Energy (former national regulatory body, now extinct)
DNDE	Departamento Nacional de Desenvolvimento Energético	National Department of Energy Development
EEAF		Environmental Enterprises Assistance Fund
EFEI	Escola Federal de Engenharia de Itajubá	Federal Engineering School of Itajubá
EIA	Estudo de Impacto Ambiental	Environmental Impact Assessment
ELETROACRE	Companhia de Eletricidade do Acre	Electrical Power of [the State of] Acre
ELETROBRÁS	Centrais Elétricas Brasileiras S.A.	Brazilian Electrical Generators (national holding company)
ELETRONORTE	Centrais Elétricas do Norte do Brasil S.A.	Electricity Generators of Northern Brazil, Inc.
ELETROSUL	Centrais Elétricas do Sul do Brasil S.A.	Electricity Generators of Southern Brazil, Inc.
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária	Brazilian Institute for Agricultural and Animal Husbandry Investigation
ENERGIPE	Empresa Energética de Sergipe	Power Company of [the State of] Sergipe
ENERSUL	Empresa de Energia Elétrica do Mato Grosso do Sul	Electrical Energy Companies [of the State] of Mato Grosso do Sul
ESCELSA	Espírito Santo Centrais Elétricas S.A.	Electricity Generators of [the State of] Espírito Santo, Inc.
ESCO		Energy Services Company
EU		European Union
FBDS	Fundação Brasileira de Desenvolvimento Sustentável	Brazilian Foundation for Sustainable Development
FDI		Foreign Direct Investment

FINAME	Agência de Financiamentos para Aquisição de Máquinas e Equipamentos	Agency for the Acquisition of Machines and Equipment
FINEM	Financiadora de Equipamentos e Máquinas	Equipment and Machinery Financing
FINEP	Financiadora de Estudos e Projetos	Agency for the Funding of Projects and Studies
FTV	Fundação Teotonio Vilela	Teotonio Vilela Foundation
FURNAS	Furnas Centrais Elétricas S.A.	Furnas Electrical Generators, Inc.
GCE	Câmara de Gestão da Crise de Energia Elétrica	Energy Crisis Management Council
GCOI	Grupo Coordenador da Operação Interligada	Coordinating Group for Interlinked Operations
GDP		Gross Domestic Product
GEEMF		Global Environment Emerging Markets Funds
GEF		Global Environment Facility
GEF		Global Environment Fund
GTEE	Grupo de Trabalho sobre Energia Eólica	Working Group on Wind Energy
GTES	Grupo de Trabalho sobre Energia Solar	Working Group on Solar Energy
GTZ	Deutshe Gesellschaft für Technisches Zusammenarbeit	German Cooperation Agency
IDB	Banco Interamericano de Desenvolvimento	Interamerican Development Bank
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais	Brazilian Institute for the Environment and Natural Resources
IBGE	Instituto Brasileiro de Geografia e Estatística	Brazilian Institute Geography and Statistic
ICMS	Imposto Sobre Circulação de Mercadorias e Serviços	Merchandise Circulation Tax
IDER	Instituto de Desenvolvimento Sustentável e Energias Renováveis	Institute of Sustainable Development and Renewable Energy
IEE	Instituto de Eletrotécnica e Energia	Energy and Electrotechnical Institute
IEF		International Energy Fund
II	Imposto de Importação	Import Duty
IMF		International Monetary Fund
INPI	Instituto Naçional de Propiedade Industrial	National Institute for Industrial Property
INT	Instituto Nacional de Tecnologia	National Technological Institute
IPAM	Instituto de Pesquisa Ambiental da Amazônia	Institute of Environmental Research in the Amazon
IPI	Imposto Sobre Produtos Industrializados	Industrial Products Tax
IPP	Produtores Independentes de Energia	Independent Power Producers
ISES	Sociedade Internacional de Energia Solar	International Solar Energy Society
MAE	Mercado Atacadista de Energia	Wholesale Energy Market
MCT	Ministério de Ciência e Tecnologia	Ministry of Science and Technology
MERCOSUR	Mercado Comum do Cone Sul	Southern Cone Common Market
MMA	Ministério do Meio Ambiente, dos Recursos Hídricos e da Amazônia Legal	Ministry of the Environment, Hydro Resources and of the Legal Amazon Region
MME	Ministério de Minas e Energia	Ministry of Mines and Energy
NAPER	Núcleo de Apoio a Projetos de Energias Renováveis	Support Center for Renewable Energy Projects
NGO	Organização Não Governamental	Non-Governmental Organization

NREL		National Renewable Energy Laboratory
ONS	Operador Nacional do Sistema Elétrico	National Grid Independent Operator
PESACRE	Grupo de Pesquisa e Extensão em Sistemas Agroflorestais do Acre	Research and Extension Group on Agroforestry of [the State of] Acre
PETROBRÁS	Petróleo do Brasil	Brazilian Petroleum Company
PIA	Produtor Independente Autônomo	Autonomous Independent Producers
PNCE	Programa Nacional de Pequenas Centrais Elétricas	National Program for Small Electricity Generators
PROCEL	Programa de Combate ao Desperdício de Energia Elétrica	National Program for the Conservation of Electrical Energy
PRODEEM	Programa de Desenvolvimento Energético de Estados e Municípios	State and Municipal Program for Energy Development
PROERNE	Programa de Energia Renovável do Nordeste	Renewable Energy Program for the Northeast
PROINFA	Programa de Incentivo às Fontes Alternativas	Incentive Program for Alternative Electric Energy Sources
PROIR	Programa Nacional de Irrigação	National Irrigation Program
PRONABIO	Programa Brasileiro de Biodiversidade	Brazil's Biodiversity Program
PSA	Projeto Saúde Alegria	Health and Happiness Project
Receita Federal	Receita Federal	Brazilian IRS
REEF		IFC Renewable Energy and Efficiency Fund
RENOVE	Rede Nacional de Organizações da Sociedade Civil para as Energias Renováveis	National Network of Organizations of the Civil Society for Renewable Energy
REPSO	Centro de Apoio a Projetos de Energia Renovável	Renewable Energy Project Support Office
RGR	Reserva Global de Reversão	Global Reversion Reserve
SDC		Solar Development Corporation
SECEX	Secretaria de Comercio Exterior	Secretariat of Foreign Trade
SEI		Shell Sustainable Energy Initiative
SELF		Solar Electric Light Fund
SHP	Pequenas Centrais Hidrelétricas	Small Hydro Power
TBC	Taxa Básica do Banco Central	Central Bank Basic Rate
TJLP	Taxa de Juros de Longo Prazo	Long-Term Interest Rate
UFPE	Universidade Federal de Pernambuco	Federal University of [the State of] Pernambuco
UFSC	Universidade Federal de Santa Catarina	Federal University of [the State of] Santa Catarina
UNDP		United Nations Development Program
USP	Universidade de São Paulo	University of [the State of] São Paulo

1. THE BUSINESS ENVIRONMENT IN BRAZIL

Brazil is the fifth largest country in the world, covering an area in excess of 8.5 million km^2. It has a population of 174 million people, of which approximately 79 million are economically active. The per capita gross domestic product has fallen in recent years in dollar terms due to the devaluation of the national currency in 1999, and floats around US$ 3000 (2001). Even at its previous value of approximately US$5000, the relatively low per capita income characterizes Brazil as a developing nation. On the other hand, Brazil's gross national product, which has risen in the last few years, is approximately US$ 600 billion, making Brazil the largest economy in Latin America and the eighth largest in the world. The GDP is distributed as follows: service - 62%, industry - 31%, and agriculture - 7% (2001).

It is important to note that there are drastic economic and social differences between Brazil's geographic regions. The southeastern states of São Paulo, Rio de Janeiro and Minas Gerais are the most prosperous, followed by the southern states, the mid-western, the northeastern and finally, the least economically prosperous northern states. In addition to uneven regional prosperity, income is unevenly distributed among the economic classes: the lowest 10% hold 1% of the national income while the highest 10% hold 47.6% (1996). Although the situation has shown improvements in the last decade, the severe gap between the upper and lower economic classes is a major concern in Brazil's progress towards development.

1.1. Recent History of the Brazilian Economy

Historically, inflation has been the most distinctive feature of the Brazilian economy, reaching triple-digit, hyper-inflation stages in the 1980s. Since 1994, when the economic stabilization plan named Real Plan was launched under the Fernando Henrique Cardoso administration, inflation has been under control, and the yearly rates since then have been below 10 %, similar to the yearly rates found in the more developed nations. The price stability created once inflation was controlled benefited society at large: it favored investments as long term risk became more predictable, and it also meant real income gains for the average worker.

Part of the strategy of the Real Plan to control inflation was to slow down the economy through the monetary policy of raising the base interest rates dramatically. In the beginning of the Real Plan the base yearly interest rate reached 45%, today it has dropped significantly but it is still at a high rate of 19%. Table 1.1 below shows the behavior of the base and long term interest rates in the last few years.

Table 1.1 Interest Rates (In Annual %)

Period	Base (SELIC[1])	Long Term (TJLP[2])
Dec/1997	42.04	9.89
Dec/1998	31.24	18.06
Dec/1999	18.99	12.50
Dec/2000	18.94	9.75
Dec/2001	19.05	10.00
Jan/2002	19.05	10.00
Apr/2002	18.38	9.50

Source: Brazil's Central Bank

Foreign exchange was another policy addressed by the Real Plan in 1994, at which time the exchange rate was fixed at a constant nominal value. Following the Russian debt default in August 1998, the economy entered a recession and lost a large volume of exchange reserves. In spite of a US$42 billion assistance package negotiated with the IMF and other lenders, the government was forced to float and devalue the Real in January 1999. Results have been surprisingly positive – the free rate of exchange has been flowing around 30% to 40% with relation to the fixed exchange rate and there has been minimum impact on inflation. Brazil's GDP to debt ratio for 1999 surpassed the IMF target and helped reassure investors that Brazil will maintain tight fiscal and monetary policy even with a floating currency.

Since 1999 the government has also focused on fiscal restraint, highlighted by the passage in May 2000 of the Fiscal Discipline Law, which sets strict limits on government spending at the federal and state levels. While many changes have been implemented, the government needs to continue its economic reform program, specifically tax and pension reform.

Brazil's economic performance in 2000 was solid and stable, with moderate growth (4.4%), relatively low inflation (6%), falling interest rates (15.75% at year-end), fiscal discipline (primary surplus equal to 3% of GDP) and stable external accounts. Foreign direct investment set a record of more than $30 billion. Entering 2001, there were widespread expectations that the economic trends would continue along the same lines. However, the economy has been hampered by several factors, most notably an economic crisis in Argentina, deceleration in the major world economies, and a serious electric power shortage in Brazil. As occurred in nations world-wide, Brazil's economic growth in 2001 was less than previously expected, at 2.2%. The political situation in the year 2002, with presidential elections being held in November, lends a certain instability to the financial environment, in particular with regards to foreign investment.

[1]The Special Settlement and Custody System (SELIC) overnight rate is the average rate weighted by the volume of one-day operations guaranteed by federal government securities. It is the basic rate used as reference for monetary policy.

[2]The TJLP, or long-term interest rate, is fixed for each quarter by the Central Bank, according to the norms of the National Monetary Council.

1.2. Foreign Investment and Commerce

Brazil maintains strong commercial relations with the U.S., the European Community, other European countries and Asia, besides being a leader in the development of MERCOSUR[3]. Bilateral relations with the EU, in particular, have been increasingly strengthened as of the signing, in December 1995, of the EU-MERCOSUR Framework Co-operation Agreement, which has as its objective the preparation of an Inter-regional Association.

Since 1994, and the launching of the Real Plan, investments in telecommunication, the manufacture of cars, the production of electronic equipment, soft drinks and beer, and construction products have been climbing rapidly. Today Brazil is among the countries receiving the largest amount of foreign investments in the world. Table 1.2 below shows the net direct foreign investment in Brazil in the last few years.

Table 1.2 Net Direct Foreign Investments

Period	Direct Investment in the Private Sector	Direct Investment in Privatization	Total US$ billions
1995	4.3	N/A	4.3
1996	7.3	2.6	9.9
1997	11.8	5.2	17.0
1998	20.0	6.1	26.1
1999	21.2	8.8	30.0
2000	N/A	N/A	33.5
2001	N/A	N/A	21.2

Source: Brazil's Central Bank

Since 1995, FDI has increased significantly as inflation came down and as the foreign investment regime started to be liberalized quickly. Since then, the EU has been the main investor in Brazil. European investment (US$30 billion; around 45% of the total, compared to 30% from the US) takes place in areas as diverse as telecommunications, energy, financial services, the automotive industry, the agro-industry and the retailing sector.

In terms of foreign commerce, Brazil has a strong and growing presence on the world market. Its main exports are manufactures, iron ore, soybeans, footwear and coffee. In 2001, total exports amounted to US$ 58.2 billion, representing a 5.7% growth and creating the first trade surplus for Brazil since 1994. In particular, exports to the USA (US$ 14.3 billion) grew by 7.6%, while those to the EU (US$ 14.9 billion) only by 0.5%. Nevertheless, the EU remains Brazil's largest market, purchasing 25.5% of its export products last year, followed by the USA with 24.7%. Remarkably,

[3]MERCOSUR is a common market launched in 1994 between Brazil, Argentina, Paraguay and Uruguay. For more information, visit www.mercosur.org.uy.

exports to MERCOSUR fell by –17.7%, due in part to the financial crisis in Argentina, while those to ALADI[4] grew by 13.6%, to Asia by 11.9% and to Africa by 47.6%. This result represents a diversification of Brazilian exports to new markets, at a time of recession in its more traditional markets (MERCOSUR, EU).

Brazil's principal imports are machinery and equipment, chemical products, oil, and electricity. Electricity is imported from Paraguay, co-owner with Brazil of the Itaipú hydroelectric plant; in 1999, electricity imports totaled 39.86 billion kWh. Total imports in 2001 amounted to US$ 55.6 billion, representing a -0.5% decline. However, imports from the EU showed a strong 5.4% growth going up to US$ 14.8 billion while imports from the USA remained nearly stable at US$ 13 billion. Imports from MERCOSUR (-10.1%) and ALADI (-22%) declined. In importation as well as exportation, Brazil's main trading partners are the EU (26.7% of total imports) and the USA (23.5% of total imports).

In summary, Brazil has a thriving economy with great potential for growth, a large internal consumer market, and has received record high foreign investments in diversified sectors of the economy. The inflation that was always present in Brazilian economic history has been under control and behaving similarly to the more prosperous economies of the world. Stability is allowing for better long-term risk assessment for investors and in some cases wage gains for workers. Interest rates have been high but the trend has been for rates to decrease. Brazilian foreign exchange policy in the last few years has been non-regulated and the currency value has been moderately steady. Many challenges are ahead for the Brazilian economy, but doing business in Brazil continues to be a great opportunity.

1.3. Doing Business in Brazil

There are many sources of information available for those interested in investing in or trading with Brazil. In particular, the Brazilian Trade Bureaus, which function in 52 Brazilian Embassies and Consulate-Generals world-wide, offer assistance in the following areas:

- Providing support for foreign companies interested in importing Brazilian products or in making direct investment in Brazil;
- Providing support for Brazilian businesspersons interested in exporting;
- Disseminating information on trade and investment opportunities;
- Carrying out market and product studies, competitiveness and competition analyses;
- Analyzing potentials for export of selected products from Brazil;
- Identifying any obstacles and restrictions to Brazilian exports and proposing alternatives for overcoming those restrictions.

For further information on the Brazilian Trade Bureaus, visit www.braziltradenet.com.

[4]ALADI is the Latin American Integration Association, formed by Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, Paraguay, Peru, Uruguay and Venezuela.

In addition, the São Paulo American Chamber of Commerce (AMCHAM), a non-governmental, not-for-profit organization, is dedicated the promotion of commerce and investment between the Brazil and the United States. AMCHAM São Paulo, which is the largest American Chamber of Commerce outside the United States, was founded in 1919 and now has approximately 4700 members of the private sector; 70% of these companies are Brazilian, 20% are North American and the remaining 10% are of other nationalities. The organization is present in the cities of Belo Horizonte, Brasília, Campinas, Curitiba, Porto Alegre and Recife and can be contacted through the website www.amcham.org.br.

1.3.1. Import/Export

The Brazilian Ministry of Development's website www.mdic.gov.br contains information on exporting Brazilian products, including procedures, pertinent legislation and incentives, and existing protectionist barriers. Further information can be obtained from the Secretariat of Foreign Trade (SECEX) of the Brazilian Ministry of External Relations www.mre.gov.br. The following excerpts were taken from the U.S. Commercial Service's Country Commercial Guide for Brazil, accessible at www.usatrade.gov.

All the customary import channels exist in Brazil: agents, distributors, import houses, trading companies, subsidiaries and branches of foreign firms, among others.
In 1997 the Brazilian Government established a computerized information system to monitor imports and to facilitate customs clearance known as the Foreign Trade Integrated System (SISCOMEX). The SISCOMEX has facilitated and reduced the amount of paperwork previously required for importing into Brazil, which, however, can still be burdensome. Brazilian importers must be registered in the Foreign Trade Secretariat - SECEX's Export and Import Registry, and receive a password given by Customs to operate the SISCOMEX. The SISCOMEX has a graphic interface for the composition of electronic import documents and transmits information to a central computer.

It is customary for an importer or exporter to retain a customs broker (despachante) to assist in facilitating the process with the SECEX and the customs authority. Despachantes are often quite large organizations providing a wide range of services to anyone wanting to expedite their dealings with the government. Their union controls the customs clearance fees charged by such an organization. Despachantes are employed not only because they can clear goods through customs faster, but also because they eliminate the need for permanent staff in the firm to handle such matters. Numerous custom broker companies exist; several are listed at the website www.global21.com.br/despach.asp.

1.3.2. Joint Ventures/Licensing

Establishment of joint ventures is a common practice in Brazil. A major motivation is to compete in segments of the government procurement market or in other markets subject to government regulation. Formation of a joint venture can be accomplished through a variety of business entities, the most common of which are "sociedades-anônimas" and "limitadas," which are similar to limited partnerships and limited liability companies under U.S. laws.

Licensing agreements are common forms of accessing the Brazilian market. Use of a competent local attorney in structuring such an arrangement is advised. All licensing and technical assistance agreements, including trademark licenses, must be registered with the Brazilian Industrial Property Institute (INPI).

1.3.3. Steps to Establishing an Office

Either setting up a company in Brazil or acquiring an existing entity are options for investing in Brazil. Acquisitions of existing companies are monitored by the Central Bank. Branch offices are difficult to form, whereas corporations (sociedades-anônimas) and limited liability companies (limitadas) are relatively easy to form. Capital registration with the Central Bank is required for access to foreign exchange, capital repatriation, and profit remittance. Brazil's minimum capital requirements are nominal in general.

1.3.4. Taxes

There are three main taxes to which products and/or services are subject in Brazil: (1) Import Duty (known in Brazil as the "II"), (2) the Industrialized Product tax (known in Brazil as the "IPI"), and (3) the Merchandise and Service Circulation tax (known in Brazil as the "ICMS"). Most taxes are calculated on a cumulative basis. In addition to these three taxes, several other taxes and fees may be applicable.

Import Duty (II)

Import duty is a federally mandated product specific tax. After the creation of the MERCOSUR customs union, the four member countries - i.e., Argentina, Brazil, Paraguay and Uruguay - adopted a single import tariff structure known as the "common external tariff" (known in Brazil as the "TEC"). In most cases, Brazilian import duty rates range from 10 to 20 percent.

Industrialized Product Tax (IPI)

The IPI is a federal tax levied on most domestic and imported manufactured products. It is assessed at the point of sale by the manufacturer/processor domestically, and at customs for imports. It is based on the product's c.i.f. (cost including insurance and freight) value, plus duties. The Government of Brazil levies the IPI rate by determining how essential the product may be for the Brazilian end-user. Generally, the IPI tax rate ranges from 0 to 15 percent. As with value-added taxes in Europe, IPI taxes on products that pass through several stages of processing can be adjusted to compensate for IPI taxes paid at each stage. Brazilian exports are exempt from the IPI tax.

Merchandise and Service Circulation Tax (ICMS)

The ICMS is a state tax applicable to both domestic products and imports; most Brazilian exports are exempt. Effectively, the tax is paid only on the value added, as the cost of the tax is generally passed on to the buyer in the price charged for the merchandise. The ICMS tax due to the state government is based on taxes collected on sales, minus those paid in purchasing raw materials and intermediate goods. It is levied on both intrastate and interstate transactions and is assessed on every transfer or movement of merchandise. The rate varies among states, with the predominant rate currently at 17%. On interstate movements, it is assessed at the rate in the state of destination.

1.3.5. Environmental Licensing

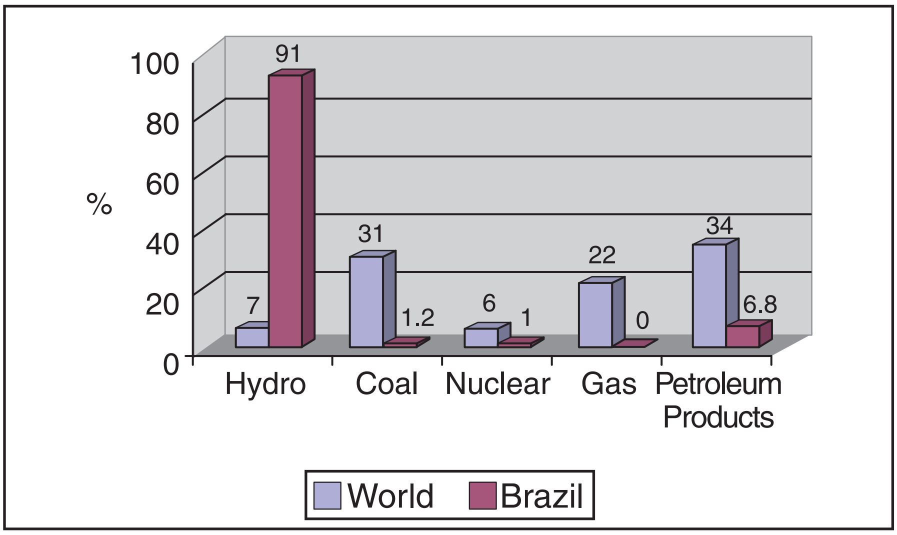
The National Environmental Council (CONAMA), through its resolution no. 001 of 1986, requires that every energy generation project larger than 10MW carry out an environmental impact study (EIA) and submit a respective environmental impact report (RIMA).

For energy generation projects under 10MW, the CONAMA requires that a simplified environmental report (RAS) be carried out. More information with focus on small-scale hydro power plants is presented in Section 4.6. For further information on environmental licensing, visit: www.mma.gov.br/port/conama.

2. THE ELECTRICAL POWER SECTOR

Due to its abundant hydrological resource and decades of focus on the development of its energy infrastructure, Brazil has one of the world's largest hydroelectric capacities. In 2001 the Brazilian electrical power system reached an installed capacity of 72,810 MW, of which 61,555 MW were generated from hydroelectric power plants. This figure represents approximately 90% of the total electrical production in Brazil, and the 10% remaining production derives from several conventional thermal plants and two nuclear plants. Figure 2.1 highlights the difference between Brazil's electrical-energy matrix and that of the rest of the world.

Figure 2.1 Electricity Production
Brazil x World

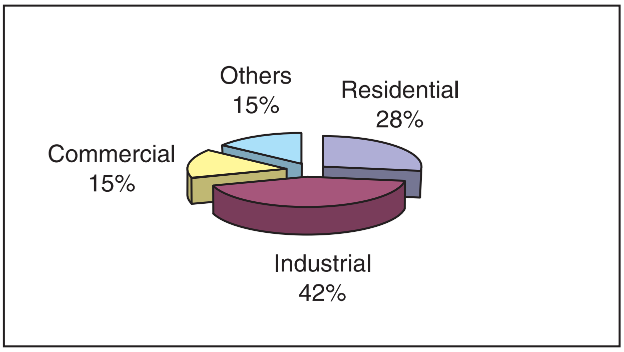


Source: MME, 1999

In 2000, Brazil consumed approximately 332,000 GWh of electric power. The industrial sector has long been the largest consumer, followed by the residential and commercial sectors, as shown in Figure 2.2. As the majority of Brazil's population and industries are located in the southeastern and southern regions, power consumption is concentrated in these areas, as shown by Figure 2.3.

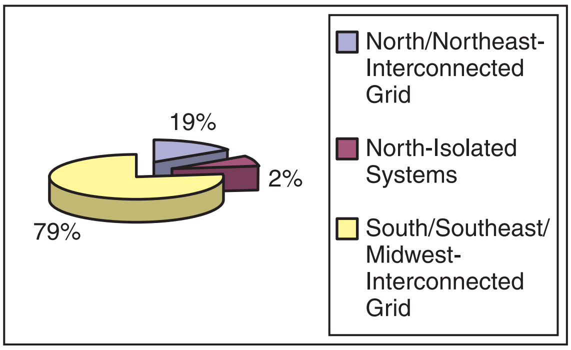
There is still an enormous untapped potential for hydroelectricity in the country. Close to 200,000 MW (mostly in the North) could be added to the existing supply, both to increase the total installed capacity, and to take advantage of the complementary nature of Brazil's hydrological network. This reason is that while the hydrographic systems in the northern and southern regions are experiencing the dry season, the ones in the southeastern, mid-western and northeastern regions are receiving high levels of precipitation, and vice-versa. The planning being carried out for the Brazilian transmission expansion seeks to take advantage of this feature by interconnecting separate but complementary hydrologic systems. Understanding the Brazilian hydrologic regimen is useful for those intending to invest in the grid-connected renewable energy, especially hydro, wind power and biomass, which are significantly affected by seasonal factors.

Figure 2.2 Electricity Consumption by Sector



Source: BEN 2000

Figure 2.3 Electricity Consumption by Region



Source: BEN 1999

Until recently the Brazilian power grid was composed of two major interconnected grids, independent of each other, and several isolated small systems located in the northern part of the country. The southern, southeastern and central states formed the larger of the two interconnected systems, responsible for nearly 80% of the country's power generation and consumption. The other interconnected system served the northeastern states plus the northern state of Pará. In 1999 the two separate networks were linked, making 98% of the electrical market one vast interconnected system.

2.1. Historical Development of the Electrical Power Sector

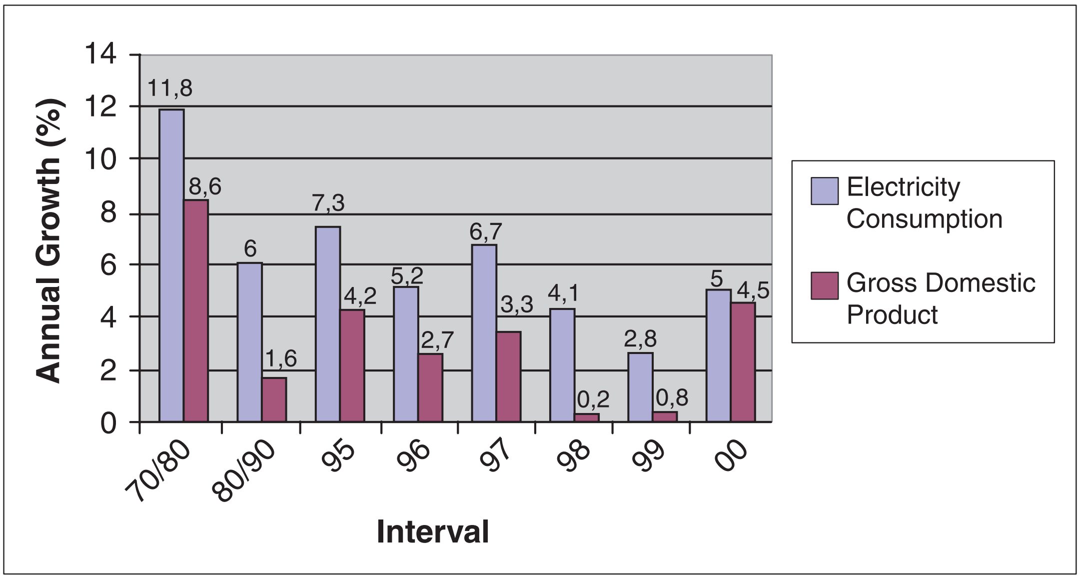
Conversely to the glacial hydrological systems that predominate in the northern hemisphere, the Brazilian one is pluvial and, therefore, bears a certain degree of uncertainty. Accordingly, the system was designed to meet the total demand even in the prolonged absence of precipitation. This was made possible by maintaining large surpluses of water in hydropower reservoirs.

The electric power structure that resulted based on large hydroelectric plants interconnected by a robust transmission and distribution system, required centralized planning and operation, and highly concentrated capital. The ruling paradigm was that a vertical monopoly, directly regulated by the government, would be the most efficient structure. With this objective, Eletrobrás (Centrais Elétricas Brasileiras) was created in 1961, becoming the sector's main financing agency and responsible for developing the plan for expansion and integrated operation of the power sector. Eletrobrás' subsidiaries[5] have been operating throughout the national territory in the areas of construction, generation, transmission and even distribution.

Brazil's demand for electricity has also shown an upward trend, even in periods of economic crisis (See Figure 2.4). In response to this growing demand, the concessionaries increased the supply of electric power without concern as to efficient use of the nation's natural resources. The financial capital necessary for this expansion was drawn from three sources: internal generation of resources from tariff revenues; state funding, and loans obtained on the international financial market.

[5] The six subsidiaries were: Companhia Hidro Elétrica do São Francisco – Chesf; Furnas Centrais Elétricas S.A.; Centrais Elétricas do Sul do Brasil S.A. – Eletrosul; Centrais Elétricas do Norte do Brasil S.A. – Eletronorte, Espírito Santo Centrais Elétricas S.A. – Escelsa; and Light Serviços de Electricidade S.A.

Figure 2.4 Annual Growth of the Economy and Electricity Consumption



Source: CCPE/CTEM

By year 1995, however, the Brazilian power sector found itself in a profound structural crisis, with paralyzed works, out-of-date tariffs and, consequently, lack of incentives for new investments, together with the incapacity on the part of the public sector to invest because of the fiscal crisis in which the country lay. At the same time the Monetary Stabilization Plan (Real Plan) introduced new patterns of consumption in the Brazilian market, significantly increasing the use of electric and electronic appliances by all levels of society. Over the forty years following the birth of Brazil's interconnected utility grid systems, the nation's population more than tripled, and its predominantly agrarian and rural population evolved into an urban and industrial one, now representing 75% of the total.

Re-structuring the power sector became unavoidable and was taken on with the objectives of: diminishing the deficit risk, increasing the competition and efficiency in the system, providing incentives for new investments, especially private ones, ensuring better quality service with fair prices for consumers and diversifying the power generation matrix of the country.

2.2. The Reform of the Electric Power Sector and the Present Scenario

The main characteristics of the former sector model (until the mid-nineties) were:

a) Monopoly, which straddled all segments of the industry, i.e. generation, transmission, distribution, commercialization.

b) State owned, meaning that the vast majority of the assets were properties of the State and the industry was practically closed to private sector participation.

c) Vertical Operations. Industries were allowed to operate in all functions of the sector (Generation, Transmission, Distribution and Commercialization, for instance CESP, CEMIG, COPEL)

d) Completely regulated, meaning that no competition was possible among the sector players.

e) Centralized. The system planning, financing, expansion and operation were, ordinarily, fulfilled by the State, through Eletrobrás, the holding company of the sector, per excellence.

f) Regulation and ownership conflict. The regulatory activities, inspection and auditing were carried out by DNAEE, a governmental autarchy with limited powers that, as such, did not have much of influence over the sector.

g) Equalized tariffs. The tariffs were set up based upon the sector's overall cost of service, covering the utilities' budget, while assuring a premium over the utilities' financial turnover. There was only one tariff matrix for the whole country, along with financial compensation mechanisms, such as CCC[6], RGR[7] etc, in order to compensate for regional inequalities.

In short, the sector was a State-owned monopoly, both at national and regional levels, regulated, supervised and managed by the State itself.

The main characteristics of the proposed model, according to the Coopers&Lybrand[8] recommendations are as follow:

a. Competitive wherever and whenever possible. This means that competition would be immediately promoted in the generation and commercialization segments. Concessions to exploit natural monopolies must be granted through a bid process.

b. Regulated only where necessary, meaning that the natural monopoly in the transmission and distribution must be directly regulated by the State.

c. Segmented, with well-defined technical and accounting boundaries for the sector's segments of generation, transmission, distribution and commercialization.

d. Private sector participation. Instead of blocking private sector participation, the new sector model should welcome private ownership in the industry, mainly through privatization of State assets.

e. Eletrobrás functions diminishing. With the creation of sector's new independent players and without a well-defined role in the sector, there would be a tendency towards eliminating Eletrobrás.

f. Independent players. New strong and independent sector players, namely: National Grid Independent Operator – ONS; Wholesale Power Marketplace – MAE; and a Power System Planning Independent Institute.

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[6] CCC - Fuel Consumption Account (see section 3.5)

[7] RGR - Global Reversion Reserve, managed by Eletrobrás, derive mainly from electric utility companies' quotas and is applied in a number of areas including rural electrification and energy efficiency.

[8] Restructuring of the Brazilian Electricity Sector report (www.mme.gov.br/sen/reseb/resebnovo.html).

g. Independent Regulatory Agency. ANEEL created to be the regulatory, supervising and auditing body with powers to grant concessions and authorizations. ANEEL must have a separate budget, independently funded, and a managing board with guaranteed tenure of office. Those provisions would provide ANEEL with a high degree of independence and autonomy.

h. The sector services would be charged by means of 'tariffs' wherever the sector is regulated (transmission and distribution) and by means of 'free prices', wherever the sector is competitive (generation and commercialization).

i. The matrix of 'tariffs' is freed to reflect each concession area's particularities. The already de-equalized 'tariffs' would be set based upon the marginal cost of expansion, so that economic signaling would stimulate system expansion, both in transmission and distribution. With diverse tariff matrixes over the country, there would be no need for financial compensations, such as CCC and RGR, which would be set to gradually expire.

Therefore, the new sector was designed to be competitive, with emphasis on the private sector participation either in the investments for system expansion and in the management of its assets. At the same time, the sector would be regulated, supervised, planned and operated by independent and strong bodies.

In 1993, the federal government took two decisions to stimulate the participation of private capital in power generation, initiating the process of reform. Decree no. 915 authorized the formation of consortiums of self-producers to build and operate new hydroelectric plants and Decree no. 1.009 made the federally owned transmission lines open to use by private companies, through the creation of the National Electric Power Transmission System – SINTREL. In 1995, the regulation of the sector underwent important changes. The Public Service Concessions Law (no. 8.987) put the concession of public utility services in general up for bidding. In the same year, Law 9.074 established rules for electric power concessionaries, recognizing the role of the independent power producer (IPP), freeing large-scale consumers from the commercial monopoly of the utility and guaranteeing access to the transmission and distribution systems.

The companies controlled by Eletrobrás were included in the National Privatization Program (created in 1990 in the Fernando Collor government, by Law no. 8.031) that required the privatization of the generation and distribution segments of the power sector. The auction of ESCELSA in 1995 inaugurated the new phase of the power sector. At the start of the present government, private participation in the power distribution market was less than 2% of the total; as result of the privatizations carried out, this share now accounts for approximately 60%.

In 1996, through law no. 1.699, a new regulatory and enforcement agency was created, named ANEEL (National Electric Energy Agency), charged with promoting and regulating competition in the sector. In addition, in 1998 the MAE (Wholesale Energy Market) was launched to supervise the buying and selling of electricity. In the same year, the ONS (National Electric System Operator) was created to coordinate and control the plants and basic transmission network of the interconnected systems. The ONS is composed of generating companies, transmission companies, distribution companies, importers and exporters of electricity and the federal government, through the MME, which maintains veto power on issues that conflict with its strategic policies. The National Council on Energy Policy – CNPE was formed in 1997 and restructured in 2001; it is made up of seven technical committees whose objective is to develop policies on a wide range of issues affecting the electric power sector, such as tariffs, expansion of the generating capacity, energy efficiency, environmental impacts of power generation and universal electrification, among others.

The restructuring process divided the power industry into generation companies that compete to sell energy, which is transmitted by high-voltage grids to independent distribution companies and consumers. The industry, in its new form, can be divided in four segments: (1) generation, (2) transmission, (3) distribution and (4) retail. Although the majority of the market continues to be serviced through administrative contracts, the structure is evolving toward greater liberation of electric power as a commodity, and by 2006, bilateral contracts are expected to be the predominant form of concession/consumer relations.

2.3. The Energy Crisis

A combination of factors including recent droughts, rising electricity demand, and long-term lack of investment in power generation catapulted Brazil into its worst energy crisis in fifty years. By May 2001 the main hydropower reservoirs of the Southeast, Midwest and Northeast had became seriously depleted and widespread blackouts seemed imminent. In response, the government focused its efforts on energy rationing, and launched, through Provisional Measure no. 2.152-2 of June 2001, the Emergency Program for Consumption Reduction. Rationing applied to all sectors: residential, commercial, industrial and governmental, and in general consisted of a 20% mandatory reduction in consumption. Overall, the program was effective and succeeded in avoiding the disastrous power outages that would have otherwise resulted. The plan was in place from June 2001 to February 2002 in the Southeast/Mid-West and Northeast regions, and from August 2001 to January 2002 in the North.

The rationing plan was administered by the Energy Crisis Management Council (GCE), created for this purpose by the federal government in May 2001 through Provisional Measure 2147. The council was also responsible for monitoring and evaluating the impacts of the energy crisis, proposing measures to minimize the negative effects of the power shortages, establishing limits on the use and supply of electric power, ordering suspension or interruption of the power supply, proposing changes to taxes and tariffs, and developing a plan to prevent the re-occurrence of a power shortage.

In response to this last task, the Emergency Power Program was created. The objective of this program is to increase the national supply of electric power through the use of thermal power plants with capacity between 10 MW and 350 MW. These plants are to remain on-call, acting as back-up generation for the electric power system. The projected completion date for the integration of these plants into the power grid was July 2002, and the purchase contracts will be in effect for three years, slated to end December 31, 2005. In order to manage the process of purchase of this power from the independent power producers, a new company, controlled by the state, was created through Decree 3.900 of August 2001, called the Brazilian Emergency Power Dealer (CBEE). The CBEE is to execute its role throughout the period of the Emergency Power Program, and be dissolved at the end of 2006. For more information on the Emergency Power Program, visit www.energiabrasil.gov.br.

2.4. Strategic Program for Expansion of Brazil's Power Supply

Although the low precipitation of 2001 was the immediate cause of the energy crisis, climactic events merely aggravated a scenario that was already approaching disaster. The combined effect of increasing consumption and stalled investments in the energy sector, described in section 2.1, was that Brazil's demand for power would soon exceed the supply. With the objective of increasing and diversifying Brazil's electric energy supply, the Ministry of Mines and Energy developed the Strategic Program for Expansion of the Power Supply. This plan covers the period 2001-2004 and foresees the investment of approximately R$43 billion, of which R$34 billion will be furnished by the private sector (Table 2.1). The main focus of these resources will be the construction of new hydroelectric and thermoelectric plants, transmission lines and substations (Tables 2.2 and 2.3).

Table 2.1 Total Investments in the Power Sector (2001-2004)

Undertaking (Units)	Estimated Values (2001-2004) (millions of R$)		
	Private	Public	Total
Hydroelectric Plants (24)	7,882.5	3,355.5	11,238.0
Thermoelectric Plants (38)*	12,395.3	4,371.7	16,767.1
Emergency Plants (58)	2,973.9	--	2,973.9
Importation (5)	1,316.6	--	1,316.6
Transmission Systems (34)	3,769.7	1,167.4	4,937.1
Other energy sources **	5,715.0	480.0	6,195.0
Total	34,053.0	9,374.6	43,427.7
Percent	78.5	21.5	100

US$1.00 = R$ 2.30
(*) Public Investment: mainly Petrobrás in association with private companies
(**) Cogeneration, wind, photovoltaic and small-scale hydro
Source: Energia Brasil

Table 2.2 Expansion of Brazil's Power Supply Capacity (MW)

Installations (Units) 2001	2001 Completed	2002	2003	2004	Total
Hydroelectric (24)	1,397	3,050	2,421	3,122	9,990
Thermoelectric (38)*	1,354	2,530	3,928	3,622	11,434
Emergency Plants (58)	--	2,153	--	--	2,153
Importation (5)	98	1,088	400	800	2,386
SHP	66	134	119	--	319
Cogeneration	125	83	500	--	708
Wind	2	261	394	393	1,050
TOTAL (MW)	3,042	9,299	7,762	7,937	28,040
Transmission Lines	505	1,371	4,350	3,024	9,250
Substations (8)	--	4,347 MVA	900 MVA	1,050 MVA	6,297 MVA

Source: Energia Brasil

Table 2.3 Current and Projected Energy Matrix

Energy Source	Installed Capacity (2001)		Projected Capacity (2004)	
	(MW)	%	(MW)	%
Hydroelectric	61,555	82	69,448	67
Thermoelectric	6,944	9	17,024	17
Nuclear	1,966	3	1,966	2
Alternative Sources (Wind, SHP, Biomass)	2,345	3	5,645	5
SUBTOTAL	72.81	92	94,083	91
Import from Itaipú	5,5	7	6,200	6
Other imports	1,15	1	3,438	3
TOTAL	79.46	100	103,721	100

Source: Energia Brasil

The timeline of these works is being closely followed by the MME and by ANEEL to ensure that deadlines are met. With the completion of these projects, Brazil's energy matrix will be diversified, with the "alternative" energy sources more than doubling their capacity. Overall, however, due to its geographic characteristics and the enormous civil works and investments already in place, Brazil's energy base will remain large-scale hydroelectric power.

2.5. The New Electrical Sector Act – Law n. 10.438/2002

The new Electrical Sector Law modified dispositions of Provisional Measure 14 and added others to the original text, becoming, effectively, a revolutionary legal document of the modern energy sector. Below are the main impacts of the Law with regards to renewable energy, energy efficiency, universal electrification of electric power services and poverty alleviation.

1. The contracting of emergency energy by the Brazilian Emergency Power Dealer (CBEE) was authorized and its costs will be distributed among all consumers, excluding those of low income.
2. The extraordinary tariff readjustment was approved. It will reimburse the distributors for the losses caused by the energy rationing and its costs will be passed to all consumers, except those of low income.
3. The Law establishes a new definition for the "Low Income Consumer," significantly increasing the number of consumers eligible for the social tariff (subsidy); these consumers are also exempt from the additional billing from the energy rationing.
4. The Law created the *Program for Incentive of Alternative Electric Energy Sources* (PROINFA), which aims to increase the participation of wind power sources, biomass sources and small hydropower systems in the supply of the Brazilian grid system through Autonomous Independent Producers (PIA). The Law defines *Autonomous Independent Producer* as a company in which stock control does not belong to any generation, transmission or distribution utility. Equipment producers may participate as Autonomous Independent Producers, as long as the level of nationalization of the equipment is of at least 50% Brazilian.
5. The first phase of PROINFA will add 3300 MW to the system in 24 months through contracts signed between Eletrobrás and the PIAs for wind, biomass and small hydropower projects.
6. The second phase of PROINFA will be developed to ensure that at the end of 20 years wind energy, biomass and small hydropower systems supply 10% of the annual electric power consumption of Brazil. The contracts will be signed with Eletrobrás for 15 years and they will represent at least 15% of the Brazilian electric energy market growth.
7. The costs of PROINFA will be shared among all consumers, including low income.
8. The Energy Development Account (CDE) was created to encourage the utilization of the states' energy potential, specifically wind power, small hydropower systems, biomass, natural gas and national coal. CDE, which will also be destined to promote the extension of electric power services to the entire nation, will last 25 years and will be managed by Eletrobrás. CDE's resources will come from annual payments for the use of public facilities, from the fines levied by ANEEL and from the annual quotas paid by agents who commercialize energy with the final consumer.
9. Universal Electrification will progress according to targets to be established by ANEEL for each utility and permissionaire of the public electric power distribution service. The objectives will define areas, progressively increasing around the distribution networks within which all consumers should be supplied without extra cost. At the same time, the objectives will define areas, progressively decreasing, within which the linkage of new consumers may be delayed for periods previously established by ANEEL. Once the terms are due, the requestors should be supplied without any extra cost.

10. To promote universal electrification, ANEEL may grant concessions, through a bid process, for provision of public electricity services in areas already under concession where concession contracts do not have an exclusivity clause.
11. ANEEL will regulate tariff reductions of at least 50% for access to transmission and distribution systems and for the ventures that produce energy from wind, biomass and qualified co-generation.
12. Producers of power from wind, biomass and qualified co-generation sources connected to the interconnected grid system, are ensured participation in bonuses from the Energy Reallocation Mechanism, which aims to mitigate hydrological risk.
13. Producers of small hydropower, wind, biomass and solar may commercialize energy directly with a consumer or consumer group, whose load is equal or greater than 50 kW within the isolated systems.
14. The Fuels Consumption Account (CCC), which establishes the sharing of diesel fuel costs for isolated systems in the Amazon, will continue for 20 years and generators utilizing small hydropower, wind, solar, biomass and natural gas, are granted access to the subsidy account for projects implemented within the isolated system which substitutes the need for diesel fuel.
15. The resources of the Global Reversion Reserve (RGR) will be available through Eletrobrás, to wind, solar, biomass, small hydro and thermal systems associated with small hydropower projects. The RGR will also be used for the construction of plants of up to 5 MW, destined to the public service of the isolated systems and to energy efficiency projects according to the National Program for Electrical Energy Conservation (PROCEL). In the case of solar power energy, there will be a specific program for the encouragement of photovoltaic panel utilization, in which Eletrobrás will utilize the resources of the RGR to directly contract utilities and permissionaires.

The complete version of the Law is available at www.energiabrasil.gov.br under the option 'Legislação' (legislation).

2.6. The National End-User Average Tariff and the PROINFA

According to the Law 10.438/2002, the Government shall assign economic values to the renewable energy to be purchased by Eletrobrás under the Program for Incentive of Alternative Electric Energy Sources (PROINFA). Those economic values or prices of reference will be established in accordance to each specific technology and energy source. A bottom value is, however, associated to those economic values or prices of reference, which corresponds to 80% of the National End-User Average Tariff.

PROINFA, in its second phase (which will start immediately after the initial target of 3300 MW is achieved), foresees that renewable energy generators shall be entitled to receive a rebate from the Energy Development Account (CDE). This rebate will make up for the difference between the specific technology's economic value, which is at least 80% of the National End-User Average Tariff, and the value received from Eletrobrás (in this case, dictated by the electricity market). Those economic values are yet to be established, but the National End-User Average Tariff can be viewed in Table 2.4, below:

Table 2.4 Average Tariffs by Consumption Category - Regional and National (R$/MWh) From January to April 2002 (without ICMS)

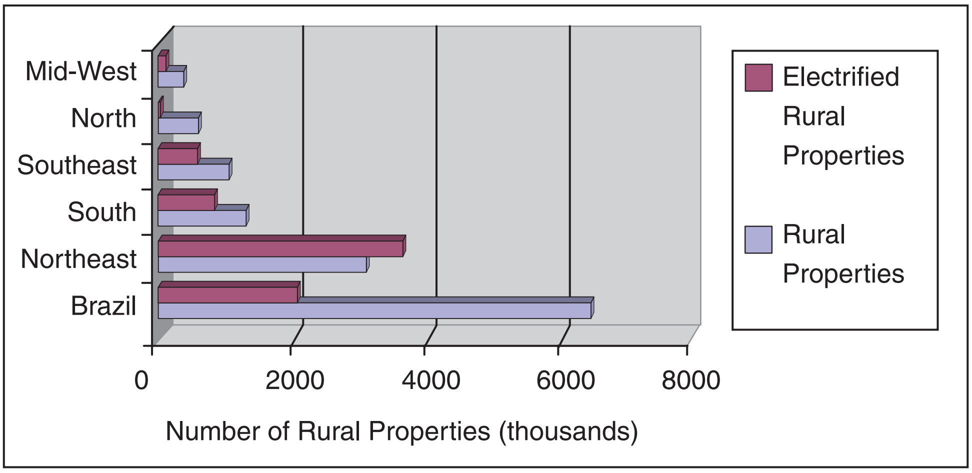
Consumption Category	North	Northeast	Southeast	South	Mid-West	Brazil
Residential	184.46	179.03	213.18	202.55	195.08	**203.44**
Industrial	52.70	71.09	98.77	98.78	99.16	**90.89**
Commercial	167.46	158.25	188.71	169.63	178.29	**179.66**
Rural	126.34	102.77	122.34	99.59	122.35	**109.42**
Public Authorities	172.26	166.88	181.10	174.58	186.52	**177.18**
Public Lighting	107.74	100.40	116.98	102.84	104.55	**109.30**
Public Service	107.00	95.06	101.82	107.30	97.12	**101.26**
Self Consumption	164.36	167.65	83.02	83.56	194.36	**92.94**
Total Average Tariff	**107.86**	**115.38**	**146.32**	**138.14**	**155.13**	**138.18**

Source: ANEEL

2.7. Rural Electrification

While the electric utility service reaches nearly all Brazil's urban population, about 4 million domiciles, or 20 million people, in rural areas do not have access to electricity service (Eletrobrás, 2000), as shown in Figure 2.5. In general, this unattended potential consumer market is spread over isolated and sparsely inhabited areas, presenting little attraction as business opportunities for concessionaries. If the traditional means of electrification were to be carried out, that is, by extension of the grid, the investment required to attend these localities would be enormous compared to the revenue that would be generated by the tariffs on their consumption. Nevertheless, access to electric power is widely recognized as a crucial factor in promoting economic and social development. There is therefore, great potential for independent renewable energy systems to play a role in rural electrification. Photovoltaic systems, in particular, are a very promising means for meeting the low-demand residential energy needs of the rural population, having the dual advantage of using an abundant and wide-spread resource, and being a modular technology that can attend dispersed houses on an individual basis.

Figure 2.5 Rural Electrification in Brazil: Access to the grid or other service provided by the utilities



Source: Eletrobrás

Currently under discussion is a resolution on Universal Electrification, introduced by ANEEL, which will oblige concessionaries, within time frames and means still under negotiation, to make electric power available to all the inhabitants of their concession area.

The recently enacted Law 10.438 (approved on April 26, 2002) creates two important opportunities for the application of renewable energy in rural electrification. The law states that unattended consumers can accelerate their own access to electric power by bearing, in part or fully, the associated financial costs of the electrification. These expenditures must be reimbursed by the concessionary after a grace period determined by ANEEL. This creates the opportunity for independent renewable energy systems to provide electric power to off-grid consumers at a cost that would be reimbursed by the utility company. The second opportunity made available by this law is that ANEEL may grant public electric service permissions, through a bidding process, in areas already covered by concessionaries whose contracts are not exclusive. The permissionaire is explicitly allowed to use solar, wind, biomass or SHP technologies for electrification. Concessionaries have historically been unwilling to open their unattended concession areas to service by other companies. This law therefore represents the opening of a large market for companies interested in attending off-grid consumers.

Brazil's main source of financing for rural electrification is the Luz no Campo Program, launched by Eletrobrás in 1999. The goal of the program is to make power accessible to one million properties over three years. By 2001, R$1.96 billion (US$850 million; US$1 = R$2.3) had been spent. Although the program does not exclude electrification through independent renewable energy systems, to date all consumers have been attended through the conventional electrical grid. For more information on Luz no Campo, see Section 3.3.1.

3. RENEWABLE ENERGY DEVELOPMENT ENVIRONMENT

The growing demand for electric power from all consumer sectors in Brazil and the inadequacy of the nation's generating capacity came to a head in 2001 (see Section 2.3). The occurrence of the energy crisis had a dual effect on the progress of renewable energy in the country. On one hand, it was a forceful awakening to the fact that Brazil has nearly all its eggs in the large-scale hydroelectric basket. In this sense, diversifying the energy matrix and increasing efficiency have become top priorities. Faced with rationing of electricity, consumers sought out ways to reduce their electricity bills, often turning to renewable and efficient energy solutions. In the solar water heating and fluorescent lighting industries, for example, sales increased more than three-fold during the first months of the crisis.

On the other hand, the urgency of dealing with the power shortage and avoiding impending blackouts set back the progress of several important legal and financial mechanisms concerning renewable energy which had been under discussion. With the end of the rationing, which occurred March 1, 2002, the emergency situation ended and these issues were taken up once again. With the immediate urgency of the power shortage over, attention is being focused on defining the role that renewable energies can have in diversifying and expanding Brazil's power supply.

3.1. Key Actors

There is currently a large and varied number of groups acting in renewable energy in Brazil, including government, academia, not-for-profit organizations and the private sector.

3.1.1. The Public Sector

Several government organs are involved in the development of renewable energy in the country, most notably the Ministry of Mines and Energy (MME) and the Ministry of the Environment, Water Resources, and the Amazon (MMA) and the National Electric Power Regulatory Agency (ANEEL).

Working in parallel with the public agents, and with a diversified group of participants, is the National Council on Energy Policy (CNPE), which acts as an aid to the president of the nation. The CNPE was created in 1997 and is presided over by the Minister of MME and integrates the heads of several other ministries[9], as well as state, university and general public representatives. Within its goal of promoting the rational use of the energy resources of the country, CNPE is committed to strengthening the role of renewable sources of energy in the nation's power supply (www.mme.gov.br/sen/cnpe/todocnpe.htm).

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[9] Ministry of the Environment; of Planning, Budget and Management; of Science and technology; of Development, Industry and Foreign Commerce; and the Treasury

3.1.2. Not-for-Profit Entities

Reference Centers

Through funding from MME, MCT, ANEEL, ANP and other sponsors, the Small Hydro, the Solar and Wind, the Solar Thermal, and the Biomass Reference Centers (CERPCH, CRESESB/CEPEL, GREENSOLAR and CENBIO, respectively) were created. These organizations promote the development of renewable energy by disseminating information, fostering dialogue between those involved in renewable energy, and supporting studies and projects. Among their strategies are support for centers of excellence, regional development centers, laboratories, and working groups, and establishment of a network between Brazilian universities, technical schools, industries, utilities, and government agencies. The centers' activities are described in more detail in Chapters 4, 5 and 6, respectively.

CRESESB, hosted by CEPEL, manages two working groups on solar and wind (GTES and GTEE, respectively) that are important domestic technical fora for these technologies. They are responsible for generating guidelines and promoting information exchange. Their membership includes universities, government agencies, private companies, research centers, and engineering companies.

Besides the above-mentioned Reference Centers, there are several other expert groups hosted by the universities, primarily the federal ones, working on technology development, demonstration, testing etc. In the following chapters, some of the activities developed by these groups will be outlined.

RENOVE

As of July 2000, a network of NGOs has been in operation under the name of RENOVE (National Network of Civil Society Organizations for Renewable Energy). This network has 16 founding members working primarily on rural and/or environmental protection areas located in the Amazon Forest in the north, the Cerrados Region in central Brazil, and surviving areas of Atlantic Forest scattered along the Brazilian coast. RENOVE supports the commercialization of renewable energy technology through capacity building for energy policy decision-makers, technical assistance for local installations, pre-investment financing, small demonstration projects, and promotion of development models that rely on private/public partnerships. For more information on RENOVE, visit www.renove.org.br.

NGOs

Some non-governmental organizations already play an important role in the dissemination of renewable energy. Eco-Engenho Institute, which arose from Fundação Teotônio Vilela (FTV), is based in Maceió, Alagoas, and works in several northeastern states. In collaboration with BNB, it established programs to finance solar home systems and install community systems. APAEB is an association of small farmers focused on industrialization of the sisal crop, and on diversification of economic activities for the region. They operate a credit cooperative and a revolving fund for financing solar home systems and electric fences. IDER designs, installs, and maintains renewable energy projects. It collaborates with Solar Electric Light Fund (SELF) and manages a revolving fund for solar home systems. IDEAAS is a NGO located in Rio Grande do Sul State that has installed hundreds of solar home systems in rural areas of Brazilian's southern region. Winrock International focuses on rural development, including renewable energy. Its activities are implemented through its RE Program, which supports the commercialization of renewables through capacity building for energy policy decision-makers, technical assistance for local installations, pre-investment financing, small demonstration projects, and promotion of development models that rely on private/public partnerships. It also functions as a bridge between government, private sector, and other NGOs.

Permanent Forum on Renewable Energy

The Forum is a congregation of government agencies, industry, universities, power utilities, and other segments, which aims at promoting the development of renewable energy technologies. The Forum is committed to incorporating renewable energy into Brazilian energy policy and has been very active and successful in bringing the renewable energy theme into the policy decision fronts. More recently, the Forum has slowed down its actions and the last meeting occurred in 1999, in Fortaleza, state of Ceará. The Forum is coordinated by the MCT.

3.1.3. The Private Sector

The private sector, in the form of manufacturers, dealers and installers, is present in the five predominant areas of renewable energy in Brazil, these being small-scale hydro, solar thermal, solar electric, biomass, and wind energy. Two industry associations bring together businesses active in these areas.

Trade Associations

ABRAVA: Brazilian Association of Air Conditioning, Ventilation and Heating was founded in 1956 and currently has approximately 400 members. DASol is the solar water-heating department within ABRAVA; its objective is to foster the development of the sector, interacting with academic and political entities, and with the power sector. In addition, the staff compiles and publishes information on production, sales and developments achieved by solar water heating manufacturers (www.abrava.com.br).

ABEER: Brazilian Association of Renewable Energy Companies. This association is in the process of being reactivated, under the leadership of a new board of directors. Its members include the major photovoltaic companies doing business in Brazil, for which reason ABEER is expected to become the principal source of information on the activities of the private sector in relation to photovoltaic sales and projects (www.abeer.org.br).

APMPE: Brazilian Association of Small and Medium-Size Electric Power Producers. This association convenes nearly 50 companies that are interested, primarily, in the small hydropower sector and has been active in advocating that both PCH-COM and PROINFA start running. No consistent additional information source about the association is available yet. APMPE can be contacted through: Tel: +55 (51) 328-3885, e-mail: apmpe@zaz.com.br.

3.2. Public Policy and Pertinent Legislation

Table 3.1 outlines the main legal mechanisms that are currently in place or proposed which concern renewable energy in Brazil.

Table 3.1 Legal Instruments Concerning Renewable Energy

Legislation	Focus	Date/Status
Law 10.438	Creates the PROINFA incentive program for renewable energy and the Energy Development Account, allows ANEEL to auction certain electric utility concession areas to permissionaires, and covers selected issues on Universal Electrification (see details in 2.5).	Enacted April 26, 2002
Replacement Bill no 2.905/00	Deals with alternative sources in the energy matrix, universal electrification, prolongation of CCC, the Energy Development Account and other topics.	This bill evolved into Law 10.438, outlined above.
GCE Resolution no. 26	Created the Technical Committee for Efficient Energy Use, whose aim is to propose measures for the conservation and wise use of electric power.	July 10, 2001
GCE Resolution no. 24	Created the PROEÓLICA emergency wind power program, with the goal of installing up to 1,050 MW of wind energy by December 2003 and integrating that power into the national interconnected grid.	July 5, 2001
Provisional Measure no. 2.152-2	National electric energy rationing plan applied to all sectors: residential, commercial, industrial and governmental, and from June 2001 to March 1 2002; succeeded in reducing the power consumption by approximately 20%.	June 2001
Decree no. 3.827	Reduced the Manufactured Goods Tax (IPI) to zero for some photovoltaic and wind power system equipment and components until December 31, 2002.	May 31, 2001
ANEEL Resolution 21	Defines minimum efficiencies to qualify cogeneration plants for operation, differentiating by capacity and source. In general, power plants running on renewable energy fuels have a minimum efficiency requirement 10% lower than plants using 25% or more fossil fuel.	January 20, 2000
ANEEL Resolution 371	Regulates the contracting and commercialization of the reserve capacity or self-producers and IPP to supply in full or partially the group of consumers connected to the grid during blackouts or brownouts. Contracts must be for a minimum period of one year and each generating system limited to 30 MW maximum capacity.	December 29, 1999
ANEEL Resolution 261	Requires that concessionaries invest 1% of their annual operational income in research and development and electric energy conservation, which can include renewable energy technologies.	September 3, 1999
ANEEL Resolution 245	Set the terms and conditions for electric power systems that replace thermoelectric fossil fuel systems to benefit from the Fuel Consumption Account.	August 11, 1999
MME Portaria 227	The Ministry of Mines and Energy determined that Eletrobrás would lead a public call for the identification of the excess power available for purchase from cogeneration, as well as establish the mechanisms for its commercialization.	July 2, 1999
ANEEL Resolution 112	Defines criteria for obtaining registration or authorization for installation, expansion or resizing of thermoelectric, wind, photovoltaic and other alternative energy systems selling power	May 18, 1999
ANEEL Resolution 395	Establishes procedures for registration and approval of small hydropower plants studies and designs; authorization for SHP plants and communication of micro and mini hydropower (up to 1000 kW)	December 4, 1998
ANEEL Resolution 394	Defines small hydroelectric power plants as greater than 1000 kW and less than or equal to 30,000 kW, with a reservoir area less than or equal to 3 km^2.	December 4, 1998
Law 9.648/98	Changes devices of several previous laws and authorizes the Executive Power to promote the restructuring of Eletrobrás S.A. and its subsidiaries.	Enacted May 28, 1998.
Decree 2003	Defines Independent Power Producer (IPP), differentiated from Self-producer and guarantees for both unrestricted access to transmission and distribution systems through indemnification of the transportation cost involved, calculated by the regulating agency.	September 10, 1996

Universal Electrification

As stated earlier in section 2.5, according to Eletrobrás, nearly 4 million domiciles in rural areas do not have access to an electric power utility service. Furthermore, according to IBGE, more than 2.5 million domiciles (corresponding to over 10 million people) do not use electricity in any form (neither through an electric power service provider, nor through self-owned means such as batteries, photovoltaic systems and private diesel generators). Aware of the severity of this problem, Brazil's Electric Power Regulatory Agency (ANEEL) has promoted the issue of universal electrification. In October 2000, a draft of the resolution aimed at making electricity accessible to the entire population of Brazil within 5 years was presented at public hearings.

Progress on the resolution on universal electrification was delayed during the energy crisis. During that time, focus was turned away from initiatives involving new grid connections in order to attend the current customers. The negotiations continue, however, and several points of conflict brought up by the concessionaries have been resolved, resulting in changes to the draft resolution. For current information on universal electrification, please visit www.aneel.gov.br.

Preliminary studies indicate that a significant share of the market can be served through decentralized supply options. Photovoltaic systems, for example, have proven adequate for the typical household and rural property needs in Brazil's North and Northeast, where the rural electrification indices are the lowest.

3.3. Programs

At both the federal and state level, Brazil has selected programs that can become channels for the dissemination of renewable energy applications.

3.3.1. Light in the Countryside (Luz no Campo) Program

This federal program, with financial and technical support from Eletrobrás, is Brazil's largest rural electrification effort. The goal of the program is to make electricity available to one million rural homes and properties, benefiting nearly five million inhabitants, with the aim of helping to bring solutions to the profound socio-economic problems of the rural sector. A line of credit is available to assist exclusively concessionaries and permissionaires. Eletrobrás will contribute approximately R$2 billion with resources from the Global Reversion Reserve (RGR). Although the program is open to the use of renewable energy, to date all rural electrification through Luz no Campo has been by way of conventional grid extension. Efforts are being made by several key actors to increase the amount of renewable energy projects within the program. For further information visit (www.eletrobras.gov.br or www.mme.gov.br).

3.3.2. PRODEEM

The Program for State and Municipalities Energy Development (PRODEEM) is a federal program instituted in December of 1994 by presidential decree and coordinated by the MME. The objective of PRODEEM is to reach Brazil's isolated regions, unserved by the conventional electric grid, through locally available renewable sources, thereby fostering self-sustainable social and economic development. For further information see Section 6.3, Table 6.3.2, or visit www.mme.gov.br/prodeem.

3.3.3. PCH-COM

With the objective of encouraging grid-connected small-scale hydropower generation, Eletrobrás launched the Small Hydro Power Development and Commercialization Program (PCH-COM), in partnership with BNDES, on February 2, 2001. This program was created to increase the feasibility of installation and re-activation of SHP stations by guaranteeing the purchase of the power generated and by offering financing for the enterprises. The goal of the program is to select up to 1200 MW over the course of three years (2001-2003), in blocks of 400 MW per year, to benefit from the program. For more detail, refer to Section 4.5.1 or visit www.eletrobras.gov.br.

3.3.4. PROEOLICA

The Energy Crisis Management Council, through resolution no. 24 of July 5, 2001, created the PROEOLICA emergency wind power program. The goal of the program is to install up to 1,050 MW of wind energy by December 2003 and integrating that power into the national interconnected grid. For more detail, refer to Section 7.0. This program was somewhat incorporated in PROINFA, described below.

3.3.5. PROINFA

Through law 10.438, enacted on April 26, 2002 the Incentive Program for Alternative Sources of Electrical Energy was created to increase the participation of wind, biomass and small-scale hydro produced by Independent Autonomous Producers for the nation's grid-connected energy matrix. During the first phase, Eletrobrás is to sign contracts for the implementation of 3,300 MW from these RE sources for the duration of 15 years. In the second phase, the contribution of these RE sources is to increase, supplying 10% of the nation's annual electricity consumption within 20 years.

3.4. Taxes

Table 3.2 outlines the taxes to which selected renewable energy equipment is subject. In order to make renewables more competitive relative to conventional energy sources, recent tax exemptions have been granted to selected products. See Section 1.3.4 for an explanation of each these taxes.

Table 3.2 Taxes on RE Equipment

Product	Import Tax (%)	IPI Tax (%)	ICMS Tax (%)
Photovoltaic and Wind			
Solar Module	21	0	0
Solar Cell	17	0	0
Water Pump	21	0	0
Charge Controller	21	7	12
Inverter	20	7	12
Wind Generator	21	0	0
Battery	21	15	18
Micro Hydro			
Turbines & Water Wheels under 10MW	20	5	12
Parts of the Hydropower Turbines	20	5	18
Biomass Generation			
Boiler	20	0	18
Auxiliary equipment	20	0	18
Gasifier	20	0	18
Turbine	20	0	18
Electric Motor (> 337,5 kW)	0	5	18
Other Motors	20	0	18
Generator (750W > 75kW)	21	0	18
Solar Water Heating			
Collector and Tank	30	0	0

3.5. Lines of Credit

A number of financing options that target renewable energy projects have become available. Table 3.3 outlines the major lines of credit and describes the terms of the loans. Other information about credit lines can be found in the following chapters for each considered technology.

Table 3.3 Main Domestic Lines of Credit

Institution/Program	Focus	Limit	Term	Grace Period	Interest Rate[11]
Banco do Nordeste (BNB): FNE Verde	Renewable energy and environmental protection in the Northeast	Determined for each case	Up to 12 years	Up to 4 years	6 – 14% annual depending on scale and location
Eco-Engenho[12] / BNB	Renewable Energy	BNB: US$ 23k Eco-Engenho: US$ 18k	BNB: 8 years Eco-Engenho: 2 yrs for 15% 5 years for 85%	6 months for BNB funds	BNB: 60% of TJLP + 6%; Eco-Engenho: 11%
Eletrobrás credit line (Luz no Campo[13])	Rural Electrification	Up to 75% of total investment	variable	variable	variable
Eletrobrás PNCE credit line	Hydropower Systems < 10 MW (IPP/SP)	Grid-connected: up to 30% of total investment; Off-grid: up to 70%	10 years	variable	5% + 1% of charges + RGR
PCH-COM (Eletrobrás/BNDES)	Grid Connected Small Hydro Power	Up to 80% of total investment	10 yearsr	6 months from start-up --	TJLP + basic spread (2.5%) + risk spread (0.5-2.5%) or financial agent spread (negotiable)
Caixa Econômica FGTS (families with monthly income up to R$2160)	Solar Water Heating[14]		60 months	--	8% + TR
Caixa Econômica Construcard	Solar Water Heating[14]		24 months	--	1.9% monthly
Banco Real	Solar Water Heating[14]	Equal to customer's CDC limit	24 months		2.9% monthly

[11] TJLP: Long-Term Interest Rate is fixed for each quarter by the Central Bank, according to the norms of the National Monetary Council. See Table 1.1, Section 1.1 for values.
TR: Reference Rate is disclosed daily by the Central Bank and is calculated based on the average monthly return of the Certificates of Deposit and Receipts of Deposits emitted by the thirty largest financial institutions of the country. Over the year 2001, the TR varied from a low of 0,03 to a high of 0,39% monthly. For a record of TR values since 1993, visit www.estadao.com.br/ext/economia/financas/cotacoes/descritivo/historico.htm
IGP-M: General Index of Market Prices is calculated and disclosed monthly by the Getúlio Vargas Foundation, based on three indices: Wholesale Price Index (IPA), Consumer Price Index (IPC) and National Construction Cost Index (INCC), representing 60%, 30% and 10% respectively of the IGP-M. The IGP-Mrate during 2001 varied between 0,22% and 1,48% monthly. For a record of IGP-M values since 1991 visit wwww.estadao.com.br/ext/economia/financas/cotacoes/descritivo/historico.htm
[12] Program previously directed by the Teotonio Vilela Foundation.
[13] Exclusively for concessionaries and permissionaires.
[14] Equipment to be purchased must be certified by INMETRO (Brazil's Technological Inspection and Certification Institute)

In addition, several lines of credit exist which focus on other related areas, such as: purchase of equipment (FINEM, FINAME), regional development (through Banco do Brasil and Banco da Amazonas) and technological development (through BNB). In many cases renewable energy projects can be financed through these options, depending on the context of the application.

Financial Incentive: CCC

The Conta de Consumo de Combustiveis, or Fuel Consumption Account (CCC) is a fund used to subsidize costs for fossil fuel-based generation systems where they are needed, both interconnected or isolated. In the case of isolated systems it also helps minimizing the difference between grid-connected and off-grid electricity rates paid by consumers. This incentive, which is effective until 2022 for isolated systems, can now also benefit isolated renewable electric power systems replacing thermoelectric systems which use fuels derived from petroleum. In 2002, CCC amounted to R$ 2,053 million[15].
Three renewable energy projects already benefit from the CCC subsidy: a 4MW hydropower plant in Monte Belo, state of Rondonia; a 1.1MW hydropower plant in Parecis, Rondonia; and a 9MW wood residue thermal power plant in Itacoatiara, state of Amazonas.

3.6. International Financing and Support

Numerous sources of international funding and financing for renewable energy are available in Brazil. Several of these entities are described below.

E+Co

This company of entrepreneurs, investors, strategists and mediators was established in 1994 to provide enterprise development services seed capital and equity investment to viable local companies working with renewable and/or efficient energy. E+Co is present in 15 countries worldwide and has recently initiated activities in Brazil through the Brazil Renewable Energy Enterprise Development (B-REED) program, launched in May 2002. www.energyhouse.com

Clean Tech Fund

The Clean Tech Fund, an equity fund directed by A2R Investment Company, is expected to be launched this year. The initial goal is to leverage US$20 million from international investors to be applied in the development of recycling projects and alternative energy generation. The fund was structured in Brazil to accept projects in Latin America and is in the final phase of capitalization. www.a2r.com.br

[15] Resolution ANEEL 325/2002. It must be noted that most of this amount goes to the interconnected units and that the incentive for renewables only applies for isolates plants.

Renewable Energy and Energy Efficiency Fund (REEF)

REEF was established by the International Finance Corporation to invest in renewable energy and energy efficiency projects in developing countries. The principal fund manager is Energy Investors Fund (EIF). The REEF, with US$100 million in equity and US$100 million in debt, will consider investment in projects with total capitalization requirements of between US$ 1 million and US$100 million. www.reef.org

Global Environment Fund

This is a venture capital fund manager with over US$250 million under management in four funds and private asset accounts focused on public and private equity investments in emerging markets. Two of its funds, Emerging Markets Funds I and II, invest in renewable energy, among other environmentally oriented projects. www.globalenvironmentfund.com

The Interamerican Development Bank (IDB)

IDB intends to finance wind, solar, small hydro and biomass cogeneration power projects. The resources will be directed to projects that demand US$30 million minimum investment. IDB will work in two different ways to finance the enterprises: creating a fund to reduce the operational costs and financing a group of projects that belongs to a single shareholder. www.iadb.org

Solar Development Group (SDG)

The group consists of a private investment fund and a foundation whose common purpose is to accelerate the delivery of off-grid PV and other renewable energy sources to rural areas of developing countries. It was established with core funding and investment capital from the World Bank, IFC, Global Environment Facility (GEF), charitable US foundations and other multilateral and private investors. SDG has a target capitalization of US$ 50 million divided between an investment fund and grants, and will make equity or quasi-equity investments in local off-grid energy companies and provide financing to local financial institutions that serve such companies. www.solardevelopment.org

IFC Small and Medium Enterprise Program (SME)

The program was established by the IFC and capitalized by the GEF; it provides debt to "intermediary organizations" in developing countries that either implement environmentally beneficial projects or on-lend to other enterprises that implement such projects. Following a pilot phase, the SME Fund was capitalized by the GEF at US$16.5 million, and act in policy making, provide technical assistance, capacity building and access to capital and information technology. www.ifc.org

EcoC Energy and Carbon Fund

Managed by Ecoinvest Assessoria, an investment company focused on socially and environmentally-oriented projects, EcoC Energy and Carbon Fund will invest in renewable energy generation and energy efficiency projects. Based on the expectation of carbon market growth and consolidation, EcoC Fund will direct efforts on the identification of high potential carbon credit projects. The fund will operate with US$35 million dollars converted to local currency and is designed to function for 11 years. With an aggressive profile, EcoC Fund will charge a 3% administration fee and will seek for 26% IRR. After having been structured, the fund is now in the process of gathering resources.

4. SMALL HYDRO POWER

4.1. Brazil's Hydrological Resource

Brazil's vast hydrological resource makes up 8% of the world's fresh water and has an estimated potential for electrical power generation of 262,000 MW. Currently however, only 24% of the total – 62,000 MW – is being explored.

The country has an extensive metering network made up of 7681 fluviometric stations and 3429 pluviometric stations. Of these, 423 also monitor water quality and 170 are telemetrized. By ANEEL's Resolution no. 396/98, all hydroelectric plants, including SHP, must install and maintain fluvial and pluviometer stations, thus increasing the hydrological data available in the country. This information is available in electronic format and can be obtained through the site www.inmet.gov.br.

SHP plants are distributed within Brazil as follows: those with the largest capacities are found in the South and Southeast; the greatest number of new undertakings, in the phases of studies, design projects and authorizations, are in the Midwest; while the Northeast, being a semi-arid region has few new enterprises. Although the North has plentiful hydrologic resources, the extremely low population density (2.92 inhabitants per km^2), generally flat landscape and dense forest vegetation present obstacles for exploitation. In this region diesel generators are the most commonly used means of providing power to the populations. However, certain states, such as Rondônia and Acre, offer promising sites for the installation of SHP stations.

Table 4.1 – Brazil's Hydroelectric Potential

Hydroelectric Potential	Capacity (GW)
In operation or construction	62.4
Available, inventoried	99.9
Available, non-inventoried, estimated	99.7
Total	262.0

Source: CERPCH, 2001

4.2. Classification of Small-Scale Hydropower

In Brazil, SHP is classified by the following criteria[16]:

- Operating under open flow conditions or, at most, with daily flow adjustment
- 10 m maximum height of dam
- Not involving tunnels
- 20 m^3/s maximum flow rate
- Using generating units of 5000 kW maximum each
- 30,000 kW maximum installed capacity
- 3 km^2 maximum flooded area

[16] As defined by Portaria 109 of 1982, modified by Law 9648 of 1998.

Small-scale hydropower is classified in three categories: micro, mini and small, according to power generation capacity, as shown in Table 4.2

Table 4.2 SHP Classification by Capacity

Category	Installed Capacity (kW)
Micro	Micro Up to 100
Mini	Mini 100 to 1,000
Small	Small 1,000 to 30,000

4.3. Market Development

SHP has been a part of Brazil's energy matrix since the late 19th century and has played an important role in regional economic and social development. Originally, SHP plants were installed with the purpose of supplying electricity for industrial activities of private entrepreneurs. Later on, as the municipalities developed and demand for electric power grew, SHP became a means for townships to meet the lighting and residential needs of their populations. Unconfirmed information points to the existence of over a thousand mini and micro hydropower installations, with an average capacity near 300 kW, including many under 100 kW, the state of operation and conservation of which is unknown. Many of these plants continue to meet the needs of agro industries, farms and isolated communities, principally in the North and Mid-west of Brazil.

These applications prospered until the 1960s, at which time the economic scenario became favorable to large state and federal companies. The small power generation companies of decentralized systems were acquired by these public entities, and evolved into large grid-intertied systems. During that period, small hydropower gave way to the large-scale enterprises, such as Itaipú (at 12,600 MW, the world's largest hydroelectric plant) that today provide Brazil with nearly 90% of its electric power.

There is currently 1,633.8 MW of installed capacity in mini and small hydropower plants across the country, with another 1,023.4 MW in projects in development as of 2001. The number and status of existing SHP stations was determined through an investigation carried out in 1999 by the National Electric Power Regulation Agency (ANEEL), shown in Table 4.3. SHP projects currently being developed are outlined in Table 4.4.

Table 4.3 Existing Mini and Small Hydropower Plants—1999

Status	Quantity	Total Installed Capacity (MW)	Average Installed Capacity (MW)
Operation	329	1,472.2	4.47
Re-dimensioning	3	20.9	6.96
Reactivation	14	20.9	1.49
Deactivated	164	119.8	0.73
Total	510	1,633.8	3.20

Source: ANEEL

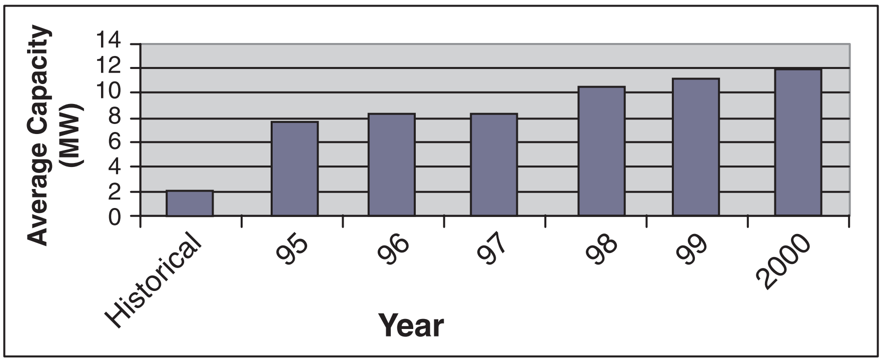
Table 4.4 SHP Projects Underway in 2001

Status	Quantity	Total Installed Capacity (MW)	Average Installed Capacity (MW)
Preliminary study	67	812.5	12.13
Design Phase	3	38.8	12.82
In Construction	15	172.1	11.47
Total	85	1,023.4	12.04

Source: ANEEL, 2001

An important tendency to note is the increase in size of the SHP plants: 3.20 MW average of existing plants, compared to 12.04 MW for new undertakings. Figure 4.1 shows the evolution of the capacity of SHP plants.

Figure 4.1 Evolution of SHP Size



Source: CERPCH, 2001

4.4. Market Opportunities

The current re-structuring of the national power sector, and the more recent energy crisis, have begun to attract private investments in independent power generation. In comparison with other energy sources used in Brazil, both renewable and conventional, SHP offers 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.

Between January 2000 and the first semester of 2001, ANEEL authorized the construction of a record 71 SHP plants in the country. This amount, twice that registered in 1998 and 1999, shows a resurgence of investments in projects with capacities between 1 and 30 MW. By 2003, the investments in SHP will likely reach US$1 billion.

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

4.5. The majority of SHP stations 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.

Table 4.5 – Small Hydropower Plants with Potential to be Re-sized or Reactivated

Plant Status	Number	Potential Contribution (MW)
Under-dimensioned[17]	347	216
Deactivated	427	156
Unknown	1039	328
Total	1813	700

Source: CERPCH

Of the 1039 plants in unknown condition, the majority is 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 stations, nor have the questions of property or possibility of their reactivation been addressed.

4.5. Barriers and Incentives

Changes in the legislation have created an extremely favorable environment for new undertakings in decentralized generation. Applied to small-scale hydropower projects, ANEEL's resolutions have led to the following benefits:

- Installation requires only authorization by ANEEL, as opposed to hydropower plants above 30 MW, which must go through a bidding process;
- Exemption from the water resource use tax;
- Exemption from the tariffs on use of transmission and distribution systems for enterprises in operation before 2003 and minimum of 50% reduction of these tariffs for those entering after 2003;
- Possibility for immediate sale to customers whose demand is greater or equal to 500 kW for interconnected plants and 50 kW for isolated ones;
- Guaranteed participation in the technical and economic advantages of operation in the intertied system;
- Use of the resources proceeding from the Fuel Consumption Account (CCC)[18] in the case of substitution of thermoelectric generation.

[17] Three of these plants are currently being re-sized.
[18] CCC is a fund used to subsidize costs for isolated diesel generation systems with the intention of minimizing the difference between grid-connected and off-grid electricity rates paid by consumers. These resources are now open to selected renewable energy plants.

4.5.1. PCH-COM

An important tool for the advancement of mini and small hydropower plants became available as of February 2, 2001 with the creation of the Small Hydro Power Development and Commercialization Program (PCH-COM). The objective of this program, created by Eletrobrás in partnership with BNDES, is to stimulate the installation and reactivation of grid-intertied SHP by private entities. The program offers financial and technical incentives to the installation of up to 1,200 MW of small hydropower generation over the course of three years (2001-2003), in blocks of 400 MW per year. The main incentives offered by PCH-COM are:

- Guaranteed revenue for meeting BNDES financing payments;
- Possibility of immediate commercialization of the energy produced by SHP;
- Cost reduction due to Eletrobrás acting as representative of the enterprise in the Wholesale Power Market (MAE);
- Participation in the allotment of PCH-COM fund surplus;
- Eletrobrás technical support during plant installation;
- Eletrobrás support during plant operation and maintenance;
- Guarantee by Eletrobrás of project quality in regards to engineering and environmental issues;
- Option of withdrawal from program and commercialization of own energy.

The terms for financing are outlined in Table 4.6, Section 4.5.2. The main concern of most entrepreneurs is the relatively low energy purchase price set for the program of R$67/MWh, being that at this price, most of the projects become unattractive. Another difficulty is obtaining collateral. BNDES is dealing with several insurance companies to assume the project pre-operational risks. The cost of the insurance would be from 0.3% to 1.5% of the enterprise and would also be financed by the bank. For more information on the workings of PCH-COM please visit www.bndes.gov.br.

4.5.2. Financing

The government's interest in increasing the role of small-scale hydropower in Brazil's energy matrix has been backed by concrete financial action. The 1999-2008 Eletrobrás Power Expansion Plan, for example, shows five projects that were awarded by Eletrobrás financing to generate a total of 16 MW. Other projects under analysis by Eletrobrás amount to 80 MW. Companies requesting financing include COPEL (in Paraná), CEAM (Amazon), and CELTINS. Several industries (Samarco, Valesul Aluminio, Acesita) and power utilities (i.e. Cataguazes-Leopoldina, CELTINS, CERJ, CEMAT, ESCELSA) have submitted feasibility and basic project studies for ANEEL's approval. The list adds up to 370 MW of planned SHP. Cataguazes Leopoldina alone plans to build 10 SHP plants.

There are currently three lines of credit available for SHP enterprises in Brazil, as outlined in Table 4.6.

Table 4.6 Financing for SHP

ITEM	ELETROBRÁS	BNDES (PCH COM)	FINEP
Financial Cost	IInterest = 5% yearly + (management fee) 1 % yearly	Interest = TJLP + basic spread (2,5% yearly.) + risk spread (0,5 a 2,5% a.a.) or financial agent spread (negotiable). The basic spread can be reduced to 1% if the project is located in areas targeted by regional development programs	Interest=TJLP+ 6% yearly
Grace Period	2 to 3 years	Up to 6 months after plant becomes fully operational	2 years
Amortization	10 years after grace period	10 years after grace period	3 years
Participation	Isolated Systems: 70% Grid-intertied systems: 30%	Up to 80% of the eligible items (according to operational policies at the time)	
Beneficiaries	• Utility Companies • Consortia, including Utility Companies	Private entities in general.	Private and public entities
Inclusion	Construction, re-sizing and/or reactivation of SHP, covering: studies, project design, equipments, additional parts and installation	Equipments and services for installation of the plant	Contracting consulting companies to carry out studies and project designs of interest to the electric power sector, encompassing: survey, planning studies, feasibility studies, basic project design and financial cost outline

Source: Paulon, 2000.

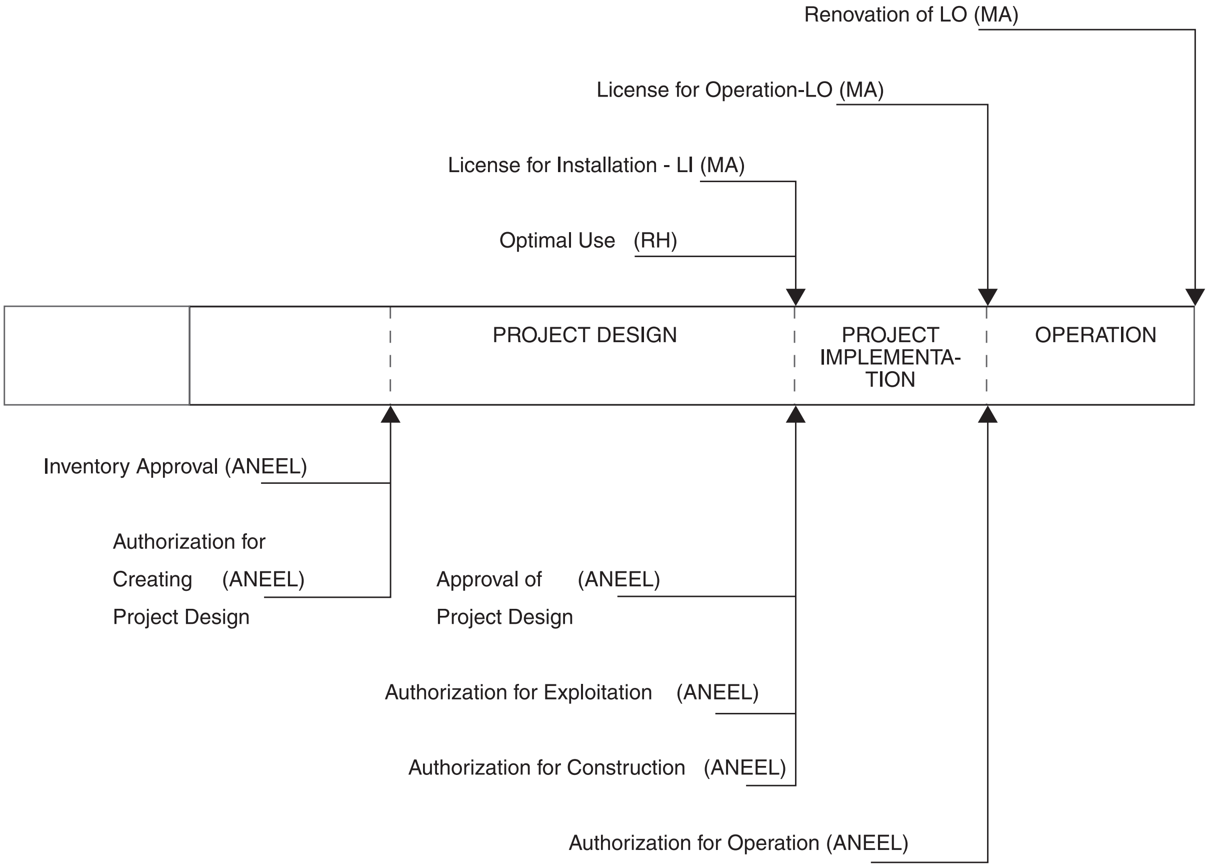
4.6. Institutional Procedures for Implementation of SHP Projects

The use of surface and subterranean waters requires authorization by an accredited federal or state organ in order to ensure compliance with the water use priorities, defined in the Watershed Management Plan. This authorization, or approval ("outorga") is a document that guarantees the right to the use of water, and specifies the location, the source, the volumetric flow during a determined period, and the end use of the water. The types of approvals are:

- Permission, in the case of private use and low volumetric flow;
- Authorization, in the case of private use with significant volumetric flow;
- Concession, in the case of water use for public utility.

Figure 4.2 below outlines the steps and corresponding approvals and licenses required in SHP enterprises.

Figure 4.2 – Steps for Implementation of SHP Project[19]



Source: Nascimento, 1997

4.7. State of the Industry

The components for the vast range of small-scale hydroelectric plants can all be found in Brazil. In general, the larger manufacturers have access to foreign technology and supply equipment for the 1 MW and higher range. For lower capacities, the market is served by small Brazilian companies. Traditionally, manufacturers using 100% Brazilian technology have been capable of producing the range of necessary mechanical and electrical equipment including sluices, conduits, valves, turbines, generators, speed controllers and other electrical components. However, the sector has evolved very little over the past decades. Due both to the lack of pressure for improvement from the market and to the lack of more advanced technology, manufacturers continued to produce equipment based on old project designs.

A few large domestic manufacturers are meeting the challenge of modernizing their operations and becoming competitive in the new market of SHP. The advances in technology have permitted

[19] MA – Environment Agency
RH – Hydro Resource Agency

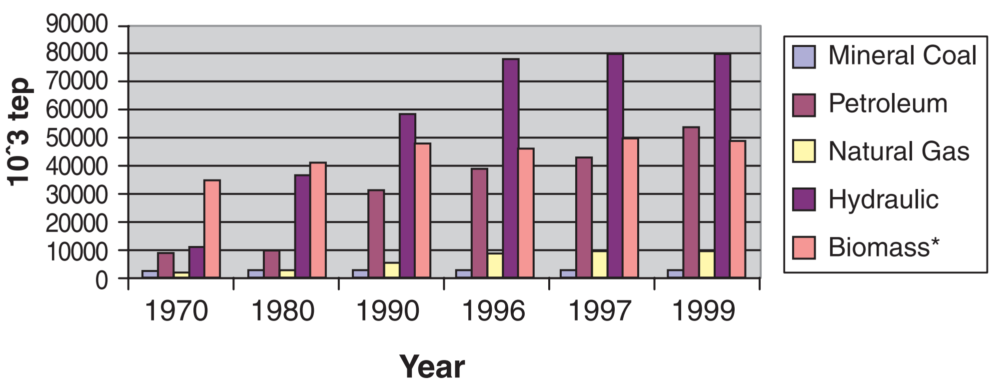
much higher efficiencies than what is offered by the traditional national companies. Because of the higher operational costs and the technology involved, however, the price of these top technology options becomes prohibitive for capacities under 1 MW operating in connection with the grid. In this lower range, private clients generally opt for conventional domestic equipment, sacrificing efficiency in favor of the lower initial investment. Small systems normally operate isolated competing with higher generation cost options, such as diesel generators.

In June 2000 the APMPE (Brazilian Association of Small and Medium-Size Electric Power Producers) was formed, with nearly 50 members including cooperatives and independent producers, willing to make investments in the area (see section 3.1.3).

5. BIOMASS

Biomass, in the form of wood products, is one of the oldest and most widely exploited sources of energy in Brazil. It was not until the late 1980s that it gave way to hydropower as the largest source of primary energy in the country (see Figure 5.1). Although traditional, informal uses of biomass, such as firewood for heating and cooking, are becoming less significant, large-scale, industrial applications have the potential to regain the importance of biomass in Brazil's energy matrix. Several factors have created a favorable environment for this development: the recent 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.

Figure 5,1 Primary Energy Production in Brazil by Source



1MWh = 3132 Mcal = 0,29 tep

* Biomass sources include wood, lye, bagasse, charcoal, alcohol and other residues.

Source: BEN, 2000

The term biomass refers to a wide variety of material that can be transformed into fuels such as: alcohol, bagasse, black liquor, vegetable oils, charcoal and biogases. Each fuel is appropriate for certain applications, requires specific technology for production and use, and faces different barriers. The strongest developments by far in biomass energy are taking place within the sugarcane industry, in two areas: alcohol fuel for transportation and cogeneration using bagasse. The technology in both these cases is well developed, and barriers to progress are financial: investments are high while returns remain uncertain. On a smaller scale, but nonetheless significant, is the opportunity for vegetable oils to replace diesel in generating electricity for isolated, off-grid communities. Other opportunities, such as biogas production from urban and agroindustrial wastes through anaerobic digestion, or from wood residues through gasification, are promising, but the immediate barriers are of a technical nature: lack of know-how and domestic equipment hinder the development of successful projects in these areas. Despite these challenges, Brazil's abundant biomass resources offer the potential for meeting a significant share of the nation's energy demand with cleaner-burning fuels produced from local, renewable sources.

5.1 Brazil's Biomass Resource

Brazil's intense solar radiation and plentiful rainfall favor biomass cultivation. Furthermore, large tracts of sparsely populated territory and high unemployment create conditions auspicious for development of an ambitious program. An estimated 100 million hectares could be dedicated to raise energy crops. According to USEPRI, the use of half of this area could generate US$ 12 billion annually for rural producers. Table 5.1 shows the theoretical potential in MW for all Brazilian regions of electricity generation from sugarcane, agricultural residues and wood residues.

Table 5.1 Theoretical Potential in Brazil for Electric Power Generation from Biomass

	Technology	Theoretical Potential (MW)		
Region	Biomass	Low Yield	Medium Yield	High Yield
Mid-West	Sugarcane	158	306	611
	Wood residues	70	94	140
	Agricultural residues	1,561	2,082	3,122
Southeast	Sugarcane	1,362	2,633	5,267
	Wood residues	135	180	270
	Agricultural residues	1,449	1,932	2,899
South	Sugarcane	151	584	584
	Wood residues	67	89	133
	Agricultural residues	4,664	6,216	9,328
Northeast	Sugarcane	367	513	1,026
	Wood residues	56	74	111
	Agricultural residues	593	791	1,187
North	Sugarcane	4	4	8
	Wood residues	103	137	205
	Agricultural residues	1,035	1,379	2,069
All Regions	Sugarcane	2,042	3,748	7,496
	Wood residues	431	574	859
	Agricultural residues	9,302	12,400	18,605
	TOTAL	11,774	16,722	26,961

Source: CENBIO

In the case of sugarcane, the assessment is based on bagasse availability in the plant, taking the 1998/1999 harvest season (production of approximately 295 million tons) as the base year (UNICA). Bagasse production was taken as 0.3 t/t of cane (tc) with 50% water content. Low yield technology means 30 kWh/tc - power generation during the harvest season, medium yield technology: 100 kWh/tc - power generation during/between harvest season, and high yield technology: 200 kWh/tc - gasifier/gas turbine - power generation during/between harvest season.

For agricultural residues, the potential assessment is based on residues available in the field after harvest. Base year for the agricultural production is 1995 and for the harvest coefficient, it is 1996 (IBGE). Low yield technology means small size steam cycles, medium yield technology: gasifier/engine systems, and high yield technology: medium size steam cycles. In all situations, a plant load factor of 70% was fixed.

For wood, Amazon wood residues processed in the regions were considered. Base year is 1997 (IMAFLORA/Friends of Earth/IMAZON, 1999). Low yield technology means small size steam cycles, medium yield technology: gasifier/engine systems, and high yield technology: medium size steam cycles with plant load factor of 70%.

5.1.1. Sugarcane Bagasse

Total bagasse production in 1999 was 82.3 million tons (50% moisture content), or approximately 41 million dry tons, of which 3.9 million was used for electricity production and 78.4 million for steam power applications (BEN, 2000). Leaves and tops, which are generally burned before harvesting, have been estimated to add another 70 million dry tons of biomass; even if 30% of this amount were to remain in the field for soil protection, over 40 million additional dry tons of biomass would become available. The use of leaves and tops is limited to situations in which the green cane is harvested mechanically and in which there is an existing infrastructure for its removal and storage. Today, the vast majority of harvesting is carried out manually; São Paulo state is at the forefront of mechanized harvesting, used for 25% of its production. Considering the use of leaves, tops and bagasse, it would be possible to generate 280–600 kWh/ton of sugarcane using the experimental biomass gasifier/steam injected gas turbine, which optimizes combustion (Williams & Larson).

5.1.2. Agroforestry

The silvicultural skills required to produce energy crops exist to a degree, mainly within the cellulose and charcoal industries. Good results have come from short-rotation forests. Recent studies, such as the Floram Project in Santa Catarina state, have examined the potential supply of energy crops. Winrock International published a report in collaboration with the Instituto de Pesquisas e Estudos Florestais and the Sociedade de Investigações Florestais on production of Eucalyptus. Some reference values for agro-forestry productivity in Brazil are presented in Table 5.2.

Table 5.2 Biomass Volume Available by Species

Genus	Apparent volume with bark (m3/ha/year)
Eucalyptus	47
Pinus	34
Taxi-branco	32.8
Acácia	30
Araucaria	14

Source: ANFPC, 2000

5.1.3. Municipal Solid Waste

At an average daily production of 0.5 kg/inhabitant, over 20 million tons of municipal solid waste (MSW) are generated in Brazil annually. The use of this for the production of electric power could provide 50 million MWh/year, equivalent to over 15% of the total electricity produced in the country. 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 Metro 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 adequate landfills. Regarding liquid effluents, figures from SABESP (São Paulo city's water supply and sewage treatment company) indicate that the São Paulo Metropolitan Area produces 50 m3/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 is stalled at the first step—collection, and the governments' primary effort has been on extending the garbage collection service to the unattended 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. São Paulo has plans underway for landfill gas use, as described in Section 5.2.5.

5.1.4. Animal Waste

In the case of energy generation from animal waste, there is a considerable lack of information available as to type and quantity of material available, as well as about technically and financially feasible systems. There are a few studies being developed, mainly from UNESP, ESALQ/USP and other universities in São Paulo State on the subject. 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; 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 toward 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.

5.1.5. Sources of Biomass Data

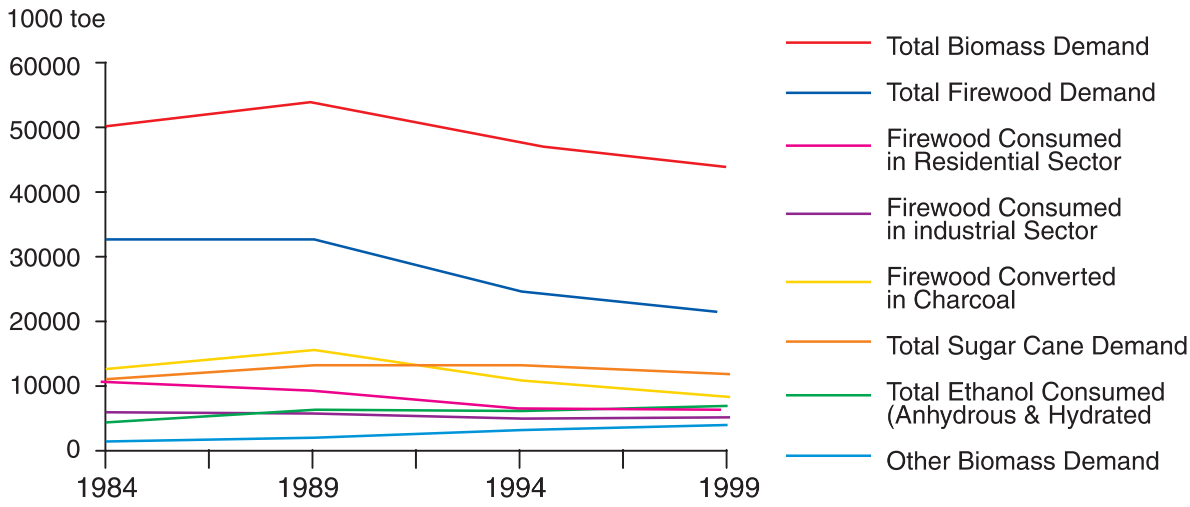
National Biomass Reference Center (CENBIO)
The Centro Nacional de Referência em Biomassa is located within the University of São Paulo, and receives support from MCT, IEE/USP, ANEEL, ANP, SEE-SP, and BUN. Its mission is to study and promote the sustainable use of biomass nation-wide.
Address: Av. Prof. Luciano Gualberto, 1289
Cidade Universitária – São Paulo, SP 05508-010
Telephone: 55 11 3818-4912 ext. 425 / Fax: 55 11 3818-4912 ext. 418
www.cenbio.org.br.

Agroindustrial Sugarcane Union of São Paulo (ÚNICA)
The União da Agroindústria Canavieira de São Paulo collects and publishes information concerning the sugarcane industry in Brazil.
Address: Av Brig Faria Lima 2179, 9th floor
São Paulo, SP 01452-000
Telephone: 55 11 3812 2100 / Fax: 55 11 3812 1416
www.unica.com.br

5.2. Market Development and Opportunities

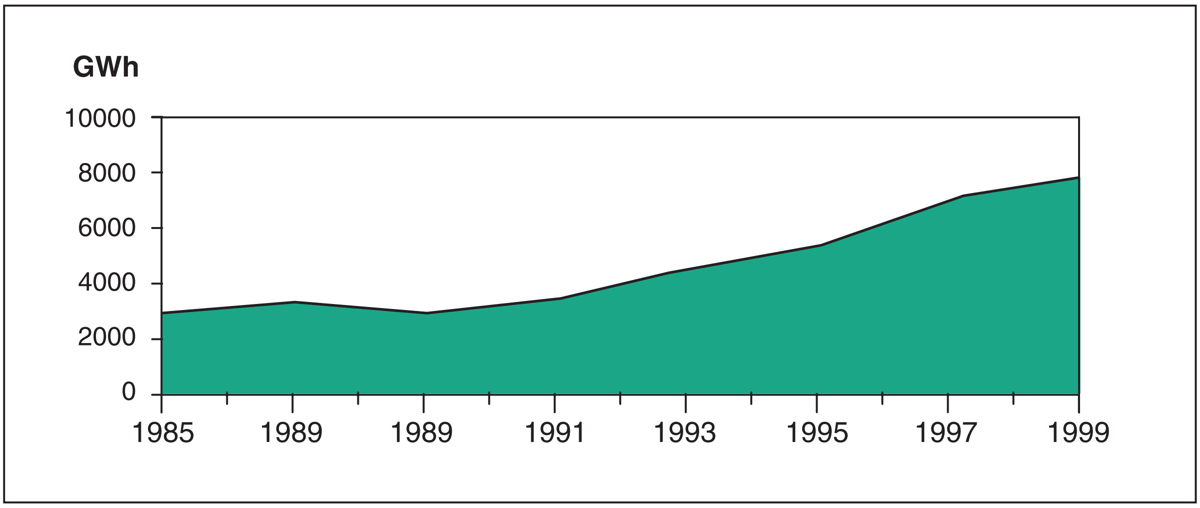
Over the past 50 years, Brazil has shifted from a rural, agrarian economy to an urban, industrial one. In the 1940s, wood accounted for 77% of primary energy consumption. By the 1990s, however, hydropower and petroleum had largely displaced biomass. Nonetheless, biomass is still significant. The use of sugarcane products such as alcohol and bagasse has grown, at the same time that consumption of biomass residues has risen, especially in the pulp and paper industries. Gradually, the use of biomass resources has grown in modern sectors like transportation and electricity (Figure 5.2). Electricity production from biomass is expanding (see Figure 5.3). According to the National Energy Balance (BEN), in 1999, biomass power accounted for 2.3% of total production.

Figure 5.2 Biomass Demand in Brazil



Source: DNDE/SEN/MME, 2000

Figure 5.3 Electricity Production from Biomass



Source: DNDE/SEN/MME, 2000

5.2.1. Cogeneration

Cogeneration is appropriate in situations where a demand for electric and mechanical power coexist. Within the sugarcane and cellulose plants, there is both demand and residual fuel, creating a favorable scenario for this technology, which has long been applied within these industries. In fact, of the 7500 GWh produced from biomass in 1999, 90% came from cogeneration in sugarcane and pulp and paper plants (BEN, 1999).

5.2.1.1. Sugarcane

With production at 264 million tons for the 1999-2000 season, excluding the North and Northeast regions, Brazil is the world's leading grower of sugarcane. As such, cogeneration of electricity and process heat in sugar refineries and alcohol plants using cane bagasse has been common for many years. Nowadays almost all sugar/alcohol industries in the state of São Paulo - and in many other regions - are self-sufficient, and some of them sell excess electric power to the grid (see Table 5.3). On average, 20 to 30 kWh of electricity are produced per ton of ground cane, used mostly to run electrical equipment in the factory. A larger portion of the energy produced is in the form of medium and low-pressure steam, used to operate mechanical drives and evaporative processes in the sugar factory, refinery or distillery. Almost all of the power (90%) is used in producing sugar; 5% is also accounted for by the orange juice industry (COPERSUCAR, 1995). Local project developers are predominantly mill owners, turnkey contractors and specialized energy service companies.

Table 5.3 Cane Electricity Cogeneration of Selected States for the 00/01 season.

State	Cane (t)	Installed Capacity for Electric Power Generation (MW)	Surplus (MW)
Goiás	7,207,646	50.37	4.50
Mato Grosso	8,233,354	61.43	5.50
Minas Gerais	10,698,635	50.16	4.50
Paraná	18,679,151	90.97	0.24
Pernambuco	13,411,905	101.74	0.23
Piauí	218,022	5.60	7.20
São Paulo	148,232,537	850.98	110.20
TOTAL	206,681,250	1211.12	132.37

Source: Cenbio, 2001

The upgrade of current systems and the production of electricity surpluses within the sugarcane industry have only recently become attractive. Prior to that, centralized decision-making in the electrical sector, the almost exclusive focus on hydro, and the lack of interest from the sugar and alcohol industry due to low supply tariffs, discouraged investments.

Tariff reform and a forecasted energy shortage are the main factors driving modernization of cogeneration systems. Presently, not only do they tend to fulfill in-plant power needs but also produce small surplus margins for export.

The Technology

The most prevalent technology consists of back-pressure steam turbines, operating with live steam at pressure values typically around 21 bar. Usually this meets only part of the power demand. However, by increasing boiler pressure and turbine efficiency, the yield may exceed 120-250 kWh per ton of ground cane, and to about 500 kWh per ton of crushed cane with the use of a Biomass Integrated Gasifier-Steam Injected Gas Turbine (BIG-STIG) system, although this technology is yet to be proven commercially. Even this value can be outdone if the leaves and cane tops left in the field during harvest are also used. Moreover, ethanol and sugar processing require little electricity (~14 kWh/t of cane processed) and a large amount of low-pressure steam (450–500 kg/t of cane) for distillation.

For the new investments started in 2001, the 42 bar boilers are the current technology chosen and a small number of 60 bar boilers have been commissioned. High-pressure boilers are the most efficient technology but they require high investments. Currently the price paid for the electricity by utilities is not attractive enough to justify the use 60 bar boilers instead of lower pressure ones.

Regional Disparities

In evaluating cogeneration potential in the sugar and alcohol industry in Brazil, one should consider the different realities found in the Northeast and Southeast. The principal region for the industry is São Paulo state in the Southeast, which accounts for 63% of national sugar cane production (UNICA, 2000). The state has over 850 MW of installed power based on cane industry cogeneration while Brazil has 1,800 MW. The area covered by São Paulo state's largest concessionaire, CPFL (Companhia Paulista de Força e Luz) stands out as having highly productive and efficient plants equipped with the most advanced technology. Estimates of the potential for cogeneration in SP vary from 1000 to 9000 MW. The estimated potential of surplus for the São Paulo state is 700 to 2000 MW, and for the rest of country is between 1000 and 3500 MW (CENBIO).

5.2.1.2. Cellulose Pulp and Paper Industry

There are 220 pulp and paper industries in Brazil operating 255 plants in 16 states. They consume wood from 1.5 million hectares of planted forest, mainly eucalyptus and pine (BRACELPA). Based on electricity demand, low and medium steam pressure requirements and the availability of fuel residues such as black liquor and biomass waste, the pulp and paper industry offers promising cogeneration prospects. In Brazil, the Kraft Process is most prevalent.

Cellulose production plants are more homogeneous than sugar and alcohol operations. Although varying with the characteristics of raw materials and production processes, each kilogram of cellulose production yields 1.0 to 1.4 kg of concentrated liquor, with a heat capacity of 13,400 kJ/kg of liquor. The available energy is supplemented by biomass residues, mainly tree bark and wood chips, to produce steam in excess of the need for process heat. The present system consists of extraction/condensation steam turbines, with extraction at 13 and 3 bars and a specific consumption of approximately 3,300-kg of steam respectively per ton of cellulose.

On average, electricity production of 850 kWh/ton of cellulose, with steam pressure and temperature at 65 bar and 400° C, will cover the plant's needs for power and process heat. Higher levels can produce power for sale. Brazilian cellulose industries have sought self-sufficiency by installing cogeneration systems above 100 MW, in units of 15-50 MW. The typical capital cost of this capacity (0.025 to 0.045 US$/kWh) is below the current marginal expansion costs of the electrical sector. Payback occurs within 1.8 to 2 years, depending on the economic scenario. Table 5.4 lists the new investments in paper and pulp industry in five years, from 2001 to 2005, that may expand cogeneration capacity in the future.

Table 5.4 Projected New Investments in the Paper and Pulp Industry through 2005

Projects	Amount in US$ Million	Installed Capacity in 2001 (1000 t/year)	Capacity to be installed by 2005 (1000 t/year)	Total Capacity	Production increasing %
Reforestation	910				
Pulp	4088	7757	3445	11,202	44.4
Paper	1566	7802	1315	9117	16.9
TOTAL	6564				

Source: Celulose & Papel, No.69, 2000

In 1999, installed cogeneration capacity was 718 MW, mostly in cellulose plants. Cellulose plants self-production meet 80% to 85% of the need for electricity, whereas in paper operations, the figure is no higher than 10%, and in the integrated paper and pulp plants the cogeneration is 50 to 60%. A technical potential of 1,740 MW and a market potential of 1,189 MW through year 2003 is estimated by Eletrobrás-GCPS. The annual production of chemical and semi-chemical cellulose pulp reached 7.2 million tons in 1999 and the paper production reached 6.94 million tons in the same year (BRACELPA).

5.2.1.3. Other industries

Vallourec & Mannesman (V&M), a large steel manufacturer based on charcoal in Minas Gerais, and CEMIG will start a 13.5 MW thermal plant. CEMIG will build the plant in a V&M area and operate it. V&M will purchase the energy and supply ore reduction oven gas (40,000 Nm3/h) and recovered tar in carbonization ovens (4,200 t/year), the fuels to power the plant. The startup is planned to be in April 2002. The boiler will operate at 67 bar and 4800C and the turbine at 65 bar and 4750C.

The orange juice industry also burns bagasse to move back-pressure steam turbines operating mainly at 21 bar and 280° C. Generally, these plants are no further than 100 km from the sugarcane plants, so biofuel may be purchased at half the cost of fuel oil.

Cacique de Café Solúvel, a coffee processing company in Londrina, Paraná, operated a 4 MW system using a back-pressure turbine at 28 bar. This producer, as well as others, uses the grounds to produce enough steam to meet most process heat requirements. The system shut down, not due to any technical obstacle, but because contract negotiations with the utility stalled.

AGROPALMA, in Tailandia, Pará operates an innovative installation that illustrates the potential of biomass systems in isolated areas. Steam production based on the fiber of palm oil kernels moves the oil extraction machinery and meets the plant's entire need for power.

Cogeneration is unusual in the wood processing industry. However, fuel in the form of wood residues is plentiful and process heat requirements (drying) are not high temperature. Studies of medium-sized industries in Manaus, processing up to 200 m3 of wood daily, indicate technological feasibility, but uncertain economics.

5.2.2. Exclusive Electric and Thermal Generation

The use of biomass fuels exclusively for electric power or for thermal power is much less prevalent than cogeneration. Between January 2001 and August 2002, eight plants were granted authorization by ANEEL, totaling 113.8 MW (see Table 5.5). In the same period, fourteen plants were registered, totaling 43.63 MW (see Table 5.6).

Table 5.5 Authorizations for Biomass Power Plants in 2001 and 2002

Year	Enterprise	Entrepreneur	Power (MW)	Fuel	City	State
2001	2001 UTE de Uruguaiana	BK Energia Ltda.	8	Rice hulls	Uruguaiana	RS
	UTE Piratini	CGDe, Koblitz Energia S.A.	10	Wood chips	Piratini	RS
	UTE Ecoluz	Ecoluz do Paraná Ltda.	10	Wood chips	Guarapuava	PR
	UTE São José do Rio Claro	BK Energia	9	Wood residues	São José do Rio Claro	MT
	UTE Itacoatiara	BK Energia São José do Rio Claro S.A	9	Wood residues	Itacoatiara	AM
	UTE Bandeirante	Biogás Energia Ambiental S.A.	20	Biogas	São Paulo	SP
	Total 2001		**66**			
2002	2002 UTE PIE-RP	UTE PIE-RP Termoelétrica S.A	27.8	Wood chips/ Sugarcane	Ribeirão Preto SP	SP
	UTE São João Biogás	Enterpa Ambiental S.A.	20	Landfill biogas	São Paulo	SP
	Total 2002 to date		**47.8**			
	Overall Total		**113.8**			

Table 5.6 Registration of Biomass Power Plants in 2001 and 2002.

Year	Enterprise	Entrepreneur	Power (MW)	Fuel	City	State
2001	Sguário	Sguário Indústria de Madeira Ltda.	1.48	Wood Sawdust	Nova Campina	SP
	Urbano São Gabriel	Urbano Agro Industrial Ltda	2.2	Rice Hulls	São Gabriel	RS
	General Carneiro	Indústrias Pedro N. Pizzatto Ltda.	2.0	Biomass	General Carneiro	PR
	PCT Barueri Biogás	Cia de Saneamento Básico do Estado de São Paulo - SABESP	2.6	Sewage Biogas	Carapicuíba	SP
	Apiacás	Enerbrax Participações e Empreendimentos Ltda.	4.0	Wood Residues	Apiacás	MT
	Aripuanã	Enerbrax Participações e Empreendimentos Ltda.	4.0	Wood Residues	Aripuanã	MT
	Juína	Enerbrax Participações e Empreendimentos Ltda.	4.0	Wood Residues	Juína	MT
	Juara	Enerbrax Participações e Empreendimentos Ltda.	4.0	Wood Residues	Juara	MT
	Vila Rica	Enerbrax Participações e Empreendimentos Ltda.	4.0	Wood Residues	Vila Rica	MT
	UTE PAMPA	Pampa Exportações Ltda.	0.4	Wood Residues	Belém	PA
	Total 2001		**28.28**			
2002	UTE Rickli	Madeireira Rockli Ltda.	5.0	Wood Residues	Carambeí	PR
	UTE Caal	Cooperativa Agroindustrial Alegrete Ltda	3.83	Rice Hulls	Alegrete	RS
	UTE Florevale	Florestal Vale do Jequitinhonha Ltda	2.52	Wood Residues	Grão Mongol	MG
	Fazenda Santa Marta	Rio Rancho Agropecuária S.A	3.6	Wood Residues	Grão Mongol	MG
	Total 2002		**15.35**			
	Overall Total		**43.63**			

5.2.3. Ethanol

Ethanol is the main product of the sugarcane industry. Though recently the market has been shrinking, production is projected to expand due to rising domestic demand for gasohol and exports of ethanol. Brazil currently produces approximately 10.4 billion liters of ethanol annually, down from the peak of 16 billion tons in 1997. Approximately 3 million cars run on hydrated ethanol, consuming 4.9 billion liters/year. In addition, anhydrous ethanol (production of 5.5 billion liters/year) is added to gasoline in the amount of 20-24%. This share was recently increased to 20-25%, by Provisional Measure no. 24. The increase in demand for anhydrous ethanol comes at a favorable time for the sugarcane industry, as the harvest for 2002/2003 is expected to be the largest to date, totaling 300 million tons.

Bio-Diesel

An interesting option now under development is the addition of alcohol to diesel oil—"bio-diesel". Diesel oil, which is highly subsidized by the government, is consumed in extremely high quantities in Brazil due to the fact that all trucks and buses use this fuel. The use of bio-diesel is currently being tested in several cities. Experimental tests are underway in the states of São Paulo and Paraná, under the coordination of the Ministry of Science and Technology for the substitution of diesel with bio-diesel in urban buses. Preliminary results seem positive in both technical and environmental aspects. In 1999, the National Oil Agency authorized a 3% mix ethanol-diesel mix for urban buses in Curitiba, in Paraná state. In the city of Campo Grande, capital of Mato Grosso do Sul state, an 8% ethanol-diesel mix is being used in municipal buses. The adoption of bio-diesel for urban transportation can contribute positively to the reduction of pollutant emissions, according to tests carried out by the Ministry of Science and Technology.

PRO-ALCOOL

The National Alcohol Program (PRO-ALCOOL) was created in 1975 with the principal objective of increasing the production of alcohol for fuel purposes in the face of the threat from rising oil prices on the international market. The original motivation of PRO-ALCOOL is no longer of any great significance for Brazilian society. Today the questions 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 clean 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. An investment of around US$ 11.7 billion was necessary to make the production of fuel alcohol possible. 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. Subsidies for sugarcane production are being steadily phased out: São Paulo and Paraná, two of the countries strongest sugarcane producers receive no subsidies whatsoever, while the Northeast of Brazil benefits minimum intervention designed to equalize the regional cost disparities. Even these smaller subsidies are to be eliminated by 2003. The government is considering re-activating PRO-ALCOOL, however, on the condition that there be no fiscal subsidies and that the private sector guarantees the supply of fuel. Under study is the creation of a regulation mechanism between the prices of gasoline and alcohol, aiming at making the consumption of the two fuels compatible with the supply of alcohol.

5.2.4. Biomass Briquettes

In Brazil, briquetting of wood and crop residues has been done commercially since at least 1990. In the state of São Paulo alone, a 1991 evaluation identified 22 producers with 37 machines. Installed capacity at that time was 11,000 t/month (AAE, 1991). Presently, total commercialization is estimated at over 30,000 t/month of which 20,000 t is used by the commercial sector (bakeries and pizzerias) and 10,000 t by the industrial sector. Most of the briquettes are prepared from sawdust and other wood processing residues (from installations like toothpick factories, pencil factories, and sawmills). Efforts undertaken to use sugarcane bagasse have been unsuccessful due to high moisture content and production expenses.

Briquettes are an attractive feedstock (5,500 kcal/kg) as compared with firewood (3,300 kcal/kg) or even charcoal (6,900 kcal/kg), due to higher densities (0.96g/cm3) than firewood (0.39g/cm3) and charcoal (0.25 g/cm3). Product homogeneity and low-volume storage requirements make a market value of US$ 60/t quite attractive. Such a price is equivalent to fuel oil. Equipment is manufactured in Brazil by one company located in Rio Grande do Sul.

5.2.5. Use of urban waste

Due to environmental concerns and the potential of biomass power, incineration facilities are planned in some cities. São Paulo has the most advanced projects, consisting of two urban waste facilities designed to consume 2,500 tons/day. Two 40 MW steam plants will use the waste fuel fraction (48%) with a heat capacity of about 15,800 kJ/kg. The first project is about to be implemented, but requires adjustment of the emission control devices. A study showed that electricity production itself does not justify the investment. However, the environmental benefits and cost reduction from avoiding new landfills do. Private investment amounts to US$ 168 million. Yearly generation of 267 GWh will be sold to São Paulo at about US$ 0.039/kWh. Furthermore, the city will pay a tipping fee of US$ 68 per ton of garbage for five years, which will fall to US$ 19/ton after the plant has been amortized.

Eko Sane Engenharia De Proteção Ambiental S/C Ltda is a company located in Campinas-SP, which is developing a landfill project in Franca-SP to produce landfill gas and generate electricity and steam through cogeneration to local industries. The enterprise "Aterro Sanitário Energético de Resíduos Sólidos Nova Jersey" has an estimated life of 19.3 years. It can generate 1,638,155.2 MWh until 2037 (considering a capacity of 0.8 MWh/ton of residue) with an average cost of US$ 9,828,931.20 or US$ 273,026/year. The estimated revenue for the energy sales is US$ 65,526,208.00 or US$ 1,820,172.44/year with pay back in 6 to 8 years.

5.2.6. Gasification

To date there has been only limited activity involving gasification applications in Brazil. There are currently a few manufacturers of gasification units for thermal power generation in the country. In the late 1970s and early 1980s, several domestic manufacturers developed their own technology, producing small to medium capacity units for heat generation. Feedstock were firewood, wood chips and pellets, charcoal and agricultural residues. Most of these manufacturers went out of business for technical and/or commercial reasons (Bain et. al., 2000). At the same time, the electric power sector had plans to install biomass gasifier and internal combustion generator sets in the range of 48 to 240 kW in remote areas. The estimated cost of electricity was in the range of 30 to 60 US$/MWh, with a capital cost of 500 to 1400 US$/kW. However, no units were installed (Nogueira and Walter, 1997).

Two large scale experimental projects are now underway: the Wood Gasification Project in the Northeast, and the Bagasse Gasification Project, managed by Copersucar, in SP, both using atmospheric fluidized bed systems.

5.2.7. Anaerobic Digestion

As indicated in Section 5.1.4, Brazil's agroindustries practice extensive concentrated animal production. This production results in enormous quantities of waste which lead to soil and water pollution, emit greenhouse gases such as methane, and contribute to the proliferation of diseases. Optimizing the anaerobic digestion process and utilizing the biogas that it produces to generate heat or electricity on-site has been the topic of studies carried out by CENBIO, by UNESP and by the Santa Catarina state's agricultural agency EMBRAPA. Barriers to the development of this renewable energy source remain largely technical, as there is a lack of domestic know-how and equipment.

5.2.8. Small-Scale Isolated Systems for Rural Communities

The Amazon Region, covering 5,217,423 km2 and with an extremely low population density of 3,67 hab/km2 (compared to the national average of 18,38 hab/km2 –IBGE, 1996) is by far the largest region not connected to the national electric power transmission system. Within the Amazon Region, two states, Amazonas and Roraima, have the fewest number of people per area at 1,51 e 1,10 hab/km2 (1996), respectively. Electric power in these sparsely populated regions is provided by diesel generators, resulting in an enormous consumption of diesel fuel, not only for the electricity generation itself, but also for the transportation of the fuel within the region, which is almost exclusively by boat.

Currently nearly 1000 power plants, mainly using diesel oil, supply electricity to isolated cities and villages in Amazonia. More than 670 of theses are units with less than 500 kW capacity, which in general, are old and inefficient, emitting high levels of pollutants (Goldemberg, 2000). The cost of the electricity produced by such 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. Until recently the subsidy was provided essentially for power plants burning diesel and oil; in August 1999 however, Resolution 245 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 (dendê – elaeis guinneensis), macauba (acronomia aculeata) and 'buriti' (mauntia flexuosa), with corresponding annual productions of 71 thousand tons, 25 thousand tons and 35 million tons. Two main projects have been developed in Brazil, both generating electricity for small communities, which produce the oil. One is a palm oil-fuelled engine in Vila Boa Esperança, in the state of Pará, and the other, an andiroba oil-fired unit in an Indian Village in the state of Amazonas. In both cases a multi-fuel diesel engine (Elsbett) of German origin are used, burning the oils 'in natura'. Funds for the oil extraction plant of Vila Boa Esperança came from the federal Ministry of Science and Technology, while the project in the Indian Village was funded by ANEEL and is managed by the University of Amazonas.

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. The 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 on these plantations are approximately 5 tons of oil/hectare; when burned in a multi-fuel diesel engine, electricity can be produced at the ratio of 0.235 kg/kWh generated (Kalter, 1999). Other end 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. In isolated communities, however, where the sale of the oil is not an option, its use for generating electricity may be feasible.

5.3. Barriers

The most significant barriers against the implementation of a large program on bioenergy in Brazil are political and economic. In the electric sector, despite the official policy to strength the independent power producers (IPP), there exists conservative behavior within the utilities, as many still consider mainly the hydroelectric option for the sector's expansion.

The official planning did not take into account other mechanisms like an integrated resource planning that includes cogeneration or self-generation processes, as well as renewable sources, like the sugarcane–based cogeneration or the diesel motors fueled with vegetable oils in Amazon and Northeast, as an important option for isolated communities. Presently, with the privatization of Brazilian electric sector, there are no prices officially imposed for the electricity sales for the utilities. The IPP can sell electricity to other consumers but the tariffs defined for wheeling are still quite high and do not encourage such a process.

Regarding vegetable oils, the greatest difficulty in Brazil (and in other countries) is the high price of the vegetable oils: around US$ 400-500 per ton for soybean oil or palm oil when compared to fuel oil. Nevertheless, the production cost identified in one of the commercial plants in Brazil is US$ 250/ton (Silva, 1997).

5.4. Financing and Assistance

BNDES launched the program "Operação Programa para Empreendimentos à Cogeração de Energia Elétrica a partir de Resíduos de Cana-de-Açúcar" on May 25, 2001. The program has made financing available for biomass plants that will generate electricity and sell the excess power to concessionaries or engage in its direct commercialization. Table 5.6 outlines the terms and conditions of this financing which are the same for the two lines of credit available, the first for sugarcane residues and the second for other biomass residues. In August 2001, four projects were approved, totaling147.3 MW with 105.3 MW surplus. There are seven more projects in analysis by the BNDES to produce 203 MW, with a surplus of 161 MW.

Table 5.6 BNDES financing for biomass cogeneration plants

Focus	Limit	Term	Grace Period	Interest Rates
Co-generation plants using sugarcane and other biomass residues	80% of investment	Up to 12 years	Up to 6 months	TJLP + Basic Spread (1%) + Risk Spread (0.5-2.5%) or Agent Spread (variable)

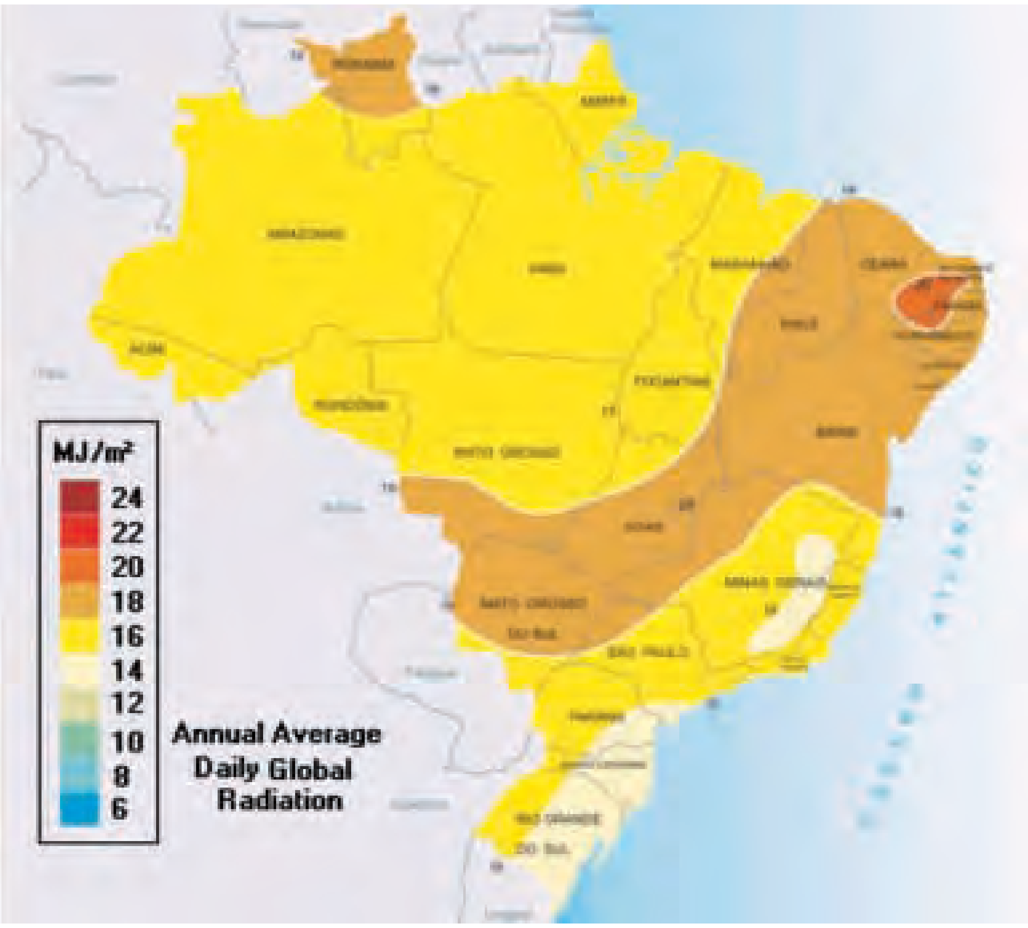
The World Bank has recently launched the Prototype Carbon Fund, which aims to foster the mitigation of climate change through the replacement of fossil fuels by renewable energy, and specifically biomass. Plantar S/A, a steel company in Minas Gerais state, is one of five projects in the world selected to receive investment—in this case US$13,648,033, from the World Bank Prototype Carbon Fund. The goal of the Plantar project, which is in its second year of operation, is to completely replace the coal/coke fuel used in the iron mill with charcoal, produced sustainably from eucalyptus plantations in accordance with the Forest Stewardship Council (FSC) procedures. Between 2001 and 2008, the project will have achieved 806,021 ton of carbon emission reductions and 953,102 tons of carbon sequestration. For more information, visit www.prototypecarbonfund.org.

6. SOLAR ENERGY

6.1. Brazil's Solar Resource

Data originating from measurements and mathematical models that use satellite imagery to estimate radiation in any point of the country are available in Brazil. CRESESB[20], GTES[21], UFPE[22] and UFSC[23] all have developed instruments to help estimate the solar resource of a given locality. In 2001, the UFPE published an updated version of the 1997 Solar Atlas of Brazil, which is based on compiled ground insolation data for nearly 350 points in Brazil and bordering countries. These information sources present average daily global radiation and other relevant information for a solar energy project design. Figures 6.1 and 6.2 show daily global radiation across the country.

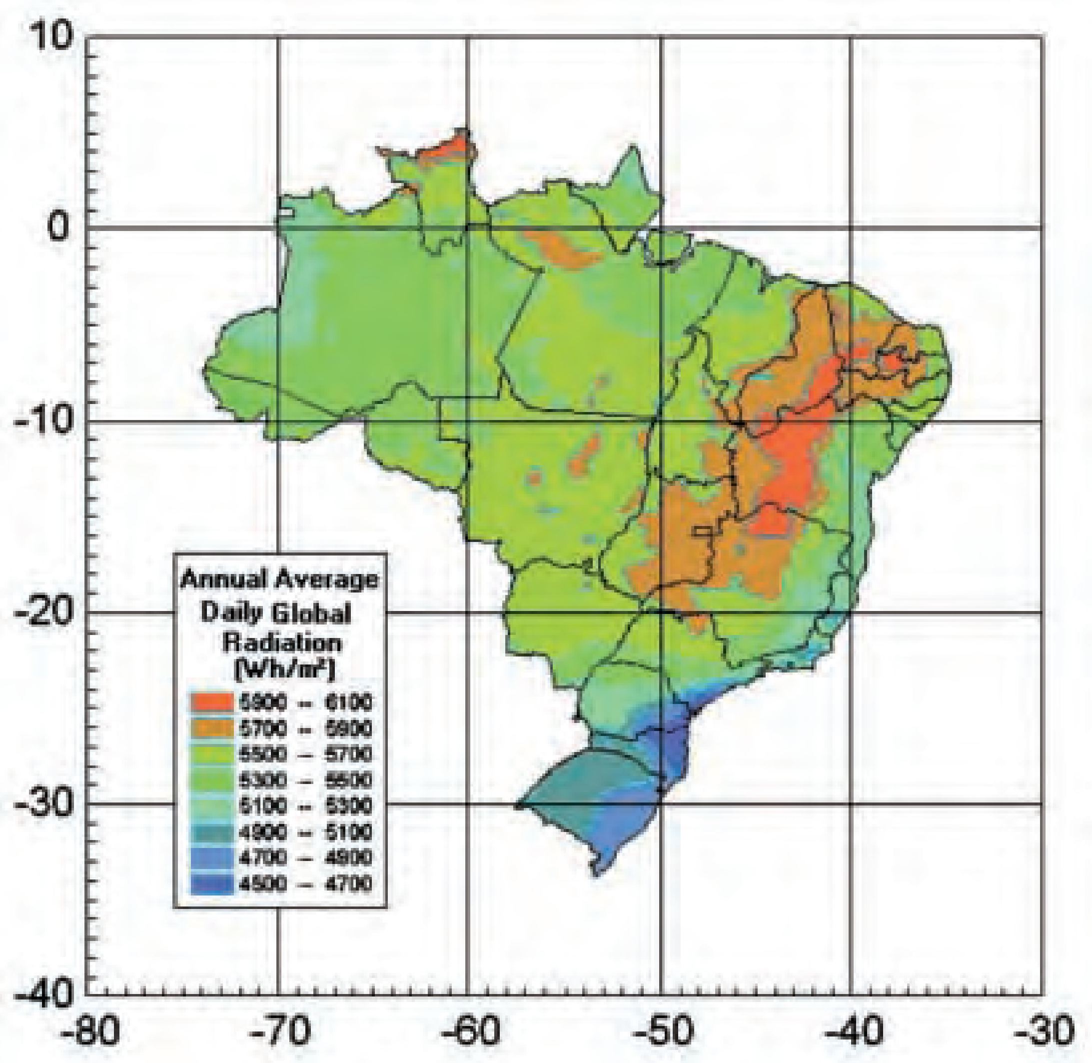
Figure 6.1 Solar Radiation Map Based on Data from Ground Stations



Source: UFPE

[20] SUNDATA – Search software for a database of solar radiation based on geographic coordinates. SUNDATA shows the average monthly values of solar radiation at the stations closest to the point of interest and calculates the radiation for three inclinations (angle equal to latitude, angle that provides the best annual average, and angle that results in the highest minimum). This data base is available at the site http://www.cresesb.cepel.br/sundatn.htm .
[21] Solar maps published in 1979 by G.S.S.Nunes, R.G.B.André, R.L.Vianello and V.S.Marques (GTES, 1999).
[22] Research Group on Alternative Energy Sources, Federal University of Pernambuco (FAE/UFPE).
[23] Solar Irradiation Atlas of Brazil published in 1998 by the Solar Energy Laboratory of the Federal University of Santa Catarina (LAB SOLAR/UFSC) and by the Institute of Space Research (INPE), based on computer models to determine solar radiation on a surface from satellite imagery. The atlas is available on the website www.labsolar.ufsc.br.

Figure 6.2 Solar Radiation Map Based on Satellite Imagery



Source: UFSC/INPE

Brazil is one of the 13 countries benefiting from the Solar and Wind Energy Resource Assessment (SWERA) project to be carried out with a US$5.7 million investment from the Global Environment Facility (GEF). The aim of SWERA is to make a database and analytical tools available to key stakeholders and decision makers, providing the resource information needed to accelerate the development and deployment of solar and wind energy projects. Solar information will include NASA's global horizontal solar radiation information and other higher resolution solar maps available from previous studies at the targeted regions. The information will be incorporated into a user-friendly Geographical Information System (GIS) tool.

6.2 Solar Thermal Applications

6.2.1 Solar Thermal Power Generation

Solar energy in quantities suitable for large-scale commercial use is found predominantly in the semi-arid area, located in the Northeast. It offers the best climate conditions for solar thermal plants: low precipitation and humidity, high average daily insolation, and the highest level of direct solar radiation.

The Northeast also offers a potential market, mainly in the São Francisco river basin, as roughly 30.8 million hectares of land need irrigation. In practical terms, factors such as distance to water source, high pump head, limited availability of water and competing uses restrict the area that could be irrigated to 1.5 million hectares. The corresponding potential demand for electricity for this application is estimated at 4,500 to 7,500 MW (Moszkowicz, 1996).

In 1997, Brazil applied through the United Nations Development Program (UNDP) for a Project Development Fund (PDF) at GEF for conducting a study on Reducing the Long-term Cost of Solar Thermal Power Generation (the document can be viewed at www.solarpaces.org/Brazil62ExCo2002-04-24.pdf). The application was approved by GEF in early 1998 and an implementation agreement was signed with UNDP. After a period of project reorganization, work was started by CEPEL in December 2001. The study is to be published in spring 2003.

6.2.2 Water Heating

Brazil's abundant solar resource and significant demand for hot water have created a favorable environment for the development of the solar water heating industry. On-demand, electric water heaters currently predominate, being found in 67% of residences, as well as in many hotels, employee dressing rooms, public restrooms, hospitals etc. Within the residential sector, which is responsible for 24% of the nation's electricity consumption, 26% are used to heat water. It is exceeded only by air conditioning, and accounts for 6% of total power used by all sectors. Today there are over 25 million electric shower-heaters in use across the country. The conversion to heat in these appliances is extremely efficient and only the immediately consumed water is heated. Prices and power ranges of models run from US$ 15 and 4,400 W, to over US$ 350 and 9000 W. For utilities, however, they can be problematic. Research done by Eletricidade de São Paulo utility company and the University of São Paulo found that electric showers cause installed capacity to be 121% higher than it would otherwise be. Peak demand is 365% above baseline. This results in low load factors, and only minor contributions to gross revenue. While the equipment cost is low to the end user, the upstream investment is high for the utilities, reaching US$ 900.

Solar water heaters, therefore, have a positive contribution to make, not only in using a clean, inexhaustible resource, but also as a way of alleviating the peak demand on the national power grids. According to the Brazilian Association of Refrigeration, Air-Conditioning Heating and Ventilation (ABRAVA), approximately 150 million liters of water per day are heated by solar thermal systems in Brazil. The electric power saved by heating this volume of water is 128,000

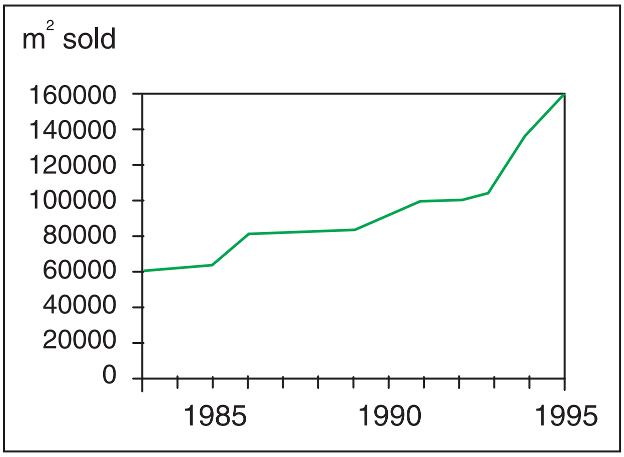
MWh annually, equivalent to the consumption of 600,000 middle-class families (using an average of 200 kWh/month). The reduction in demand from the electric power system is of approximately 440 MW.

The benefits of solar water heating in a country of such abundant solar resource are becoming better acknowledged with time. The major barrier in expanding sales remains price: consumers are reluctant to make an investment that can be ten times that of the conventional electric alternative, and that has a 2-4 year payback. However, increasing electricity tariff and credit lines that have recently become available for purchase of solar water heaters are beginning to improve the cost/benefit situation for the consumer.

6.2.2.1 Market Development

Solar heating technology has been applied in Brazil since the 1960s, when research in the area commenced. The first companies to explore this technology commercially date back to 1973, the time of the international oil crisis. The majority of these companies were technically and commercially unable to succeed. This situation changed at the end of the 1980s, when environmental concern and higher electricity tariffs fuelled the development of the sector. Since then, sales have shown a steady increase, more than doubling between 1980 and 1995, as shown in Figure 6.3.

Figure 6.3 Yearly Solar Water Heater Sales 1980-1995



Source: ABRAVA

Growth in recent years has accelerated. Between 1999 and 2000, sales increased by 30% and in the following year by more than 50%. Table 6.1 shows the production status of the sector.

Table 6.1 Solar Water Heating Industry Figures

Annual Production (2000):	260.000 m^2
Estimate for 2001:	600.000 m^2
Installed Production Capacity of the Industry:	approx. 1.000.000 m^2/year
Sales in 2000:	approx. R$30 million
Number of manufacturers:	approx. 100

Source: ABRAVA, 2002

The principal applications of solar water heating in Brazil are residences, hotels, motels, hospitals, dressing rooms and industrial restaurants. Water heating for swimming pools is an application that has been growing rapidly in recent years.

The most recent and significant impetus for the development of the solar water heating market has been the electric power crisis and the subsequent rationing of electricity (see Section 2.3). During the period of June 2001 through February 2002 residential consumers in most areas were required to reduce their monthly electricity use by 20% and utilities applied higher rates for consumption over 200 kWh/month. As water heating accounts for nearly one fourth of residential consumption, many consumers decided to replace their electric heaters with gas-fuelled or solar heaters. The result was an explosive increase in demand for solar heaters for which manufacturers were not prepared, leading to a short-term increase in delivery time-from 10-20 days to 60-70 days. Manufacturers already in operation were led to expand production capacity at the same time that several new companies sprung up, attracted by the overnight boom. With the end of the rationing program, inquiries and sales have slowed slightly but continue to increase.

There are approximately 100 manufacturers of solar water heating equipment in Brazil. These are generally small companies, with yearly revenues under US$400,000, located primarily in the Southeast and operating regionally. The states of São Paulo and Minas Gerais, specifically, because of their more temperate climate and relatively high per capita income, have the largest share of the market. Belo Horizonte, the capital of Minas Gerais, leads the nation with large-scale solar water heating systems installed in over 830 establishments, including apartment buildings, hospitals, hotels and motels.

In 1992, a solar heating department, DaSol, was created within the Brazilian Association for Heating, Ventilation, and Refrigeration (ABRAVA), a trade association that has existed for more than 34 years. The department compiles and publishes information on production, sales and technological advances in the area, as well as promoting the use of solar heating in Brazil through events and in the media. DaSol's website is accessible through www.abrava.com.br.

Testing and Certification

The solar water heating industry took an important step in increasing its credibility and professionalism with the inclusion of solar heating reservoirs and panels in the certification program by INMETRO. Of the more than 100 manufacturers currently in business, eleven have had their equipment tested and approved by INMETRO. Panels and reservoirs are submitted to durability tests and are rated for efficiency. The INMETRO seal is widely respected, and in fact, financing for the purchase of solar water heaters is only available for certified products. Information about testing procedures and a current list of certified products is available at www.eletrobras.gov.br/procel/mainframe_10_1_4_b_2.htm.

6.2.2.2 Market Opportunities

Although the solar water heating industry has been active in Brazil for 20 years, its share of the market is still extremely limited—in 2000, solar thermal energy accounted for only 0.5% of the country's energy matrix. Despite having one of the world's most abundant solar energy resources, when compared to other countries it is clear that Brazil has only just begun to explore its potential (see Table 6.2).

Table 6.2 - Solar Collector Installations across the World

Country	Collector surface area installed per 1000 inhabitants (m^2)
Israel	67.1
Austria	17.5
Japan	7.9
Germany	5.1
China	3.2
Brazil	**1.15**
USA	0.1

Source: ABRAVA, 2001

The challenge of the solar water heating industry is to take over a portion of the market dominated by electrical heaters and gas-fueled heaters. Increasing electric power rates and the increase in cost of GLP have made the solar alternative more attractive. Furthermore, the lines of credit recently made available are making these systems, which have a relatively high up-front investment, more accessible to consumers.

6.2.2.3 State of the Industry

The solar water heating business is an active and competitive one, in which technological improvements and adaptations are continuously being developed and commercialized. The characteristics of Brazil's consumer market, climate, and architecture have greatly influenced the development of domestic solar water heating technology. A MERCOSUR survey found that Brazilian consumers are highly price-sensitive. The preference for low prices, despite sacrifices in quality, makes it difficult for more sophisticated products to enter the market. In reality, however, there is little need for highly efficient equipment because of Brazil's abundant sunshine, and the increase in cost due to such technologies as vacuum-tube collectors or even selective paint make the equipment prohibitively expensive when compared with electric and gas heating alternatives.

As such, collectors are predominantly made of copper or aluminum, encased in aluminum housings and covered with a single sheet of conventional glass. The absorption plate is painted with flat black commercial paint. Reservoirs are generally made with stainless steel and/or copper inner tanks, surrounded by polyurethane insulation and encased in aluminum. Most reservoirs are equipped with a back-up electrical heating element. Most residential systems function in the thermo-siphon configuration, in which the water circulates due to the difference in density of the hot and cold water, with no need for pumps. In industrial, commercial and large residential applications such as apartment buildings, systems are more complex, involving forced circulation and central devices.

Brazilian residences haves several characteristics which have required adaptations of solar water heating equipment. The first is the existence of elevated cold-water storage tanks, fed by the public supply network, which deliver the water to the house by gravity. The slope on most Brazilian roofs is between 17 and 20 degrees, which generally is not enough height to install the hot water reservoir and collectors below the cold-water tank in a thermo-siphon concept. Several manufacturers have succeeded in overcoming this difficulty however, and reservoirs are now available that can be installed at the same level as the cold water storage tank. Another particular feature of Brazilian homes is that because the majority use on demand electric heaters located at the point of use, the houses are not equipped with a hot water distribution system. Until recently this meant that to install any central water heating system in an already constructed house, appropriate piping had to be installed, involving significant cost and inconvenience. In order to facilitate installation in existing houses, the market now offers an adaptor installed at the showerhead, which dispenses the need for internal hot water piping. In addition, many manufacturers offer temperature and timing command panels to control back-up heating function.

The market price of domestic flat-plate solar collectors has decreased over the years as production scale increases (Figure 6.4). Table 6.3 below shows approximate prices for residential system equipment currently available on the market.

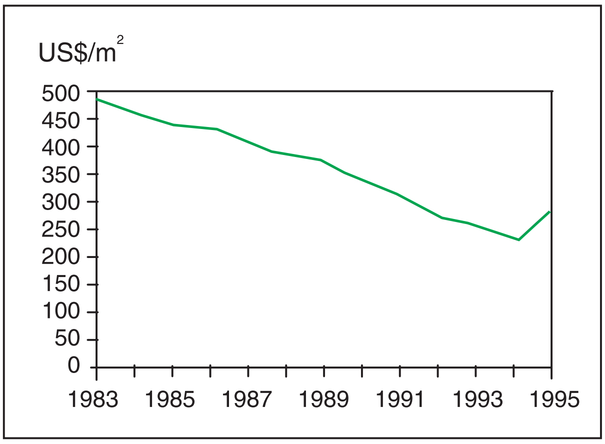
Table 6.3 Approximate Prices for Residential Water Heating Equipment[24]

Public housing residences	R$ 550.00
Middle-class residences	R$ 1500.00
Upper-class residences	R$ 2000.00
Note: Add 20-30% for installation labor and hardware.	

Source: ABRAVA, 2001

[24] At publication US$1 = R$2,4

Figure 6.4 Evolution of Market Price of Solar Flat-Plate Collectors



Source: ABRAVA, 2001

The Research Support Foundation of São Paulo state (FAPESP) and the National Council on Scientific and Technological Development (CNPq) are sponsoring a project to develop low-temperature water heaters (up to 50°C) that could be made with PVC instead of the more expensive copper and aluminum materials generally used. The intention is that this model be sold as a do-it-yourself kit for under R$100, and would make solar water heating technology accessible to low-income consumers. For more information, visit www.sunpower.com.br.

6.2.2.4 Incentives and Financing

Hot water reservoirs and solar collectors are exempt from the state IPI tax and the federal ICMS (defined in Section 1.3.4).

Three Brazilian financial institutions offer financing for the purchase of solar water heating systems: Caixa Econômica Federal, Banco Real and Banco do Brasil. Table 6.4 below outlines the terms and conditions for the lines of credit available.

Table 6.4 - Financing for Purchase of Solar Water Heating Systems

Institution/ Program	Eligibility	Limit	Term	Interest Rate[25]
Caixa Econômica / FGTS	Clients with monthly family income up to R$2160	--	60 months	8% + TR
Caixa Econômica / Construcard	Clients building or renovating a house	--	24 months	1.9% monthly
Caixa Econômica / Condomínio	Apartment buildings	--	36 months	12% annual
Banco Real	Clients of Banco Real	Equal to customer's CDC limit	24 months	2.9% monthly
Banco do Brasil / BRB Pró-Energia	Companies of the Federal District that have accounts with Banco do Brasil	Up to 80% of system cost	36 months / 6 months grace period	For micro and small companies, 5% + TJLP; all other 7.5% + TJLP

[25] TJLP: Long-Term Interest Rate is fixed for each quarter by the Central Bank, according to the norms of the National Monetary Council. See Table 1.1, Section 1.1 for values. TR: Reference Rate is disclosed daily by the Central Bank. Over the year 2001, the TR varied from a low of 0,03 to a high of 0,39% monthly. For a record of TR values, visit www.estadao.com.br/ext/economia/financas/cotacoes/descritivo/historico.htm .

6.3 Photovoltaics

6.3.1 State of the Industry

The Brazilian market of photovoltaic modules is supplied by one domestic manufacturer and by the major foreign large-scale manufacturers, all of which have established commercial representation in the country. Estimated total installed capacity is beyond 12 MWp, of which about 2 MWp were produced by the Brazilian company Heliodinamica since it was established in São Paulo state, 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 to which modules were subject 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 taxes exemption (see Table 6.9). At this writing, 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. There is not yet a well-developed market of equipment specifically designed for renewable energy applications, and more often components are adapted from other uses. For example, only recently have a few of the more than 100 manufacturers of vehicular batteries 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 both from 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.

ABEER

The Brazilian Association of Renewable Energy Companies (www.abeer.org.br), created in 1995, has not historically played a prominent role in the sector. This organization is being reactivated, however, under the leadership of a new board of directors. Its members include the major photovoltaic companies doing business in Brazil, and it is expected that ABEER will become a significant source of information on the progress of the solar-electric market in Brazil.

6.3.2 Applications and Market Development

Photovoltaic systems are currently used for a wide variety of purposes across the world, with a strong emphasis on residential purposes such as illumination, TV and radio, as shown in Table 6.5.

In Brazil, all the applications listed in Table 6.5 can be found but in different proportion. The main applications are off-grid residential systems, public services, water pumping and telecommunications.

Table 6.5 - Photovoltaic System Applications Worldwide

Application	Participation (%)
Illumination, TV, radio, etc. for residential use	81
Illumination, TV, radio, small appliances in commercial establishments (bars, restaurants, stores)	47
Medical centers (refrigeration, illumination etc.)	44
Telephone via radio or satellite	42
Illumination and audiovisual equipment for schools and other community buildings	37
Water pumping for drinking	35
Water pumping for irrigation	30
Public lighting	28
Tourism (illumination, TV, refrigeration)	21
Illumination, power tools for small businesses (machine and craft shops)	19
Refrigeration (residences, bars, agricultural products, meat, fish and dairy products)	16
Fence electrification	16
Office equipment (computers etc.)	16
Illumination for farms and raising livestock	14
Water purification	12
Water pumping for animal consumption	9
Veterinary purposes (refrigeration, illumination etc.)	9

Source: CAMPEN et al. (2000)

6.3.2.1 Rural Electrification

As highlighted in Section 2.6, over 2.5 million domiciles in rural areas do not have access to the electric power grid. With the objective of alleviating this problem, a wide range of initiatives is underway utilizing stand-alone PV systems and more than 40,000 PV systems were purchased in Brazil for Rural electrification. Table 6.6 outlines some of the most significant projects in Brazil in this area and their status.

Table 6.6 Initiatives Involving Stand-Alone Photovoltaic Systems for Rural Electrification

Program	No. Of systems	Average power output (Wp)	Application	Observations/status
PRODEEM (Phases I to IV)	5742	535	Schools, medical centers, churches, community centers, water pumping, etc.	Only 50% of the systems have been installed as of yet. High rate of failure due to lack of adherence of some regional agents.
PRODEEM Phase V	3000	724	Rural schools	About 65% turn key. To be installed.
PRODUZIR[26]	11000	50 (estimated)	Residential electrification: illumination, TV, radio, water pumping etc.	Funded by World Bank through the Rural Poverty Alleviation Program. All systems installed. Difficulties in implementing management strategy.
APAEB	427	60 (estimated)	Electric fences and residential electrification	216 systems through rotating fund; 184 sold directly and 27 in stock (July 2000). All systems in operation. Low failure rate.
SOLAR BRASIL	5000	N/A	Various	Direct Sales, mainly in the state of SP. Call center concept with local distributors trained by Solar Brasil.
CEMIG	750	75[27]	Schools, residences, water pumping, community centers, churches, public phones	Initially with the support of the USDOE[28] and GTZ. 5000 pre-electrification systems foreseen under the Luz Solar program, and 800 community systems.
CESP/ECOWATT	120	140	Residences, schools and churches	Installed in Vale do Ribeira (SP). Tariff charged for total recovery of system costs (R$13.50/month). High rate of default. Operational problems already detected in 2000. Diagnosis carried out by IEE/USP.
IEE/USP	15	N/A	Residences and schools	Installed in Vale do Ribeira (SP). Maintenance fund created (R$90 for installation + R$56/month). Systems operational and with community involvement.
IDER	500	50 (estimated)	Residences	Rotating fund plan. Systems are operational.
FTV/Luz do Sol	2520	50	Residences	84 micro-entrepreneurs, each responsible for 30 systems. Financed by BNB.
APAEB/BN/FTV	500	60 (estimated)	Residences	Line of credit under negotiation with BN, R$1,479.00 per system. Systems obtained from previous FTV initiative (for battery charging) that failed due to user default on payments.
CELPE	749	106	Residences and schools	Financed by USDOE and Eldorado program. High level of un-operational and poorly functioning systems. Many systems deactivated with the arrival of grid electrification.
CELPE	15	1100	Water pumping	Financed by Eldorado program.

[26] The PRODUZIR program has reached 75 municipalities of Bahia, through 202 projects, benefiting more than 9000 families. Similar initiatives are underway in other states receiving funding from the Rural Poverty Alleviation Program and are not included in this table.

[27] Average power of the residential systems.

[28] In 1993 CEPEL established an agreement with NREL through which PV equipment was donated by USDOE. This project was carried out in partnership with several utilities (COELBA, CEMIG, CELPA, CEAM, COELCE, CELPE, CEB and CEAL).

cont. Table 6.6

Program	No. Of systems	Average power output (Wp)	Application	Observations/status
COELCE	563			Financed by USDOE. Recent reports indicate that the systems were abandoned by COELCE. Many systems deactivated with the arrival of grid electrification.
CERB/BA	164	55	Water pumping	Attending 79 municipalities and benefiting approx. 21,000 people.
COPASA/MG	174	N/A	Water pumping	Systems in operation. COPASA will also be responsible for the pumping systems now operated and maintained by CEMIG (through COPASA/CEMIG accord)
GTZ	15	N/A	Water pumping	Installed in Ceará, in partnership with COELCE
COELBA	156	963	Residences, water pumping for human consumption and irrigation, schools, electric fences, other	USDOE resources. Status unknown.
CESP/GTZ and CESP/State Health and Environmental Departments	65	N/A	Medical centers, coastal state parks	Partnership between CESP and governmental institutions to supply Vale do Ribeira with electric power.
NAPER	126	384	Residences	Funded by the "Programa de Combate à Pobreza do Estado de Pernambuco-Prorural"
USTDA/CERB	20	N/A	Water Pumping	Technical support of NMSU/SWTDI and Winrock Brazil
IDS Mamirauá	5	150	Water Pumping and Purification	Partnership between Winrock Brazil and IDSM, sponsored by PTU/MCT.
COELBA	9000	75	Residences	Bidding process complete, turnkey.
UNIFACS/BP Solar	64	55	Residences	Installed in Bahia. Revolving fund being implemented.
IDEAAS	2,200	45	Rural Residences	Rio Grande do Sul (50%), other States (50%).
TOTAL	**42,890**			

Source: Update of the original (Ribeiro, 2002)

Despite the privatization process that the electric power sector is undergoing, the government retains the task of stimulating or providing electricity to remote regions that are not considered attractive business opportunities by the utilities. In the 1990s, awareness of the potential of PV to reduce the cost of this type of rural electrification grew within the sector. Although ample room exists for decreasing the cost and increasing the efficiency of generation and storage components, the use of photovoltaic technology is a competitive alternative to grid extension, particularly for applications of social interest. Power needs of rural, off-grid communities in Brazil are relatively modest and therefore compatible with stand-alone PV systems. In rural areas of the northeastern and northern regions, the domiciles are normally dispersed, making them very adequate for the use of distributed solar home systems. Estimates indicate that between 5 and 10% of the non-electrified domiciles (aproximatelly 250,000) could be supplied with PV systems. A recent and conservative study (Ribeiro, 2002) has shown that under the current financing framework of the Luz no Campo Program, present tariffs and costs, localities 5 km from the distribution grid, with less than 30 consumers and up to 20 consumers/km^2 would require less investment if supplied with PV systems. PV also resulted as the best choice for localities with up to 100 consumers provided the density is below 10 consumers/km^2.

6.3.2.2 Programs

PRODEEM

Among the various initiatives being carried out in Brazil to install photovoltaic systems for rural electrification, PRODEEM, (Program for the Energetic Development of States and Municipalities), directed by the Ministry of Mines and Energy, is the largest program in terms of total installed capacity and projected new acquisitions. Over US$30 million have been invested in the purchase of nearly 9,000 systems, and estimated investment of US$150 million is foreseen between 2001 and 2003.

PRODEEM's principal objective is to make electricity available to the rural population in order to foster the social and economic development of these isolated communities. The most prominent needs met within this program are the electrification of schools (Brazil has around 50,000 un-electrified schools) 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.

Table 6.7 presents the number and peak capacity of the PV systems purchased during the phases carried out within the Social Development Subprogram. Phase V of PRODEEM has already resulted in the purchase of 3000 additional systems to be installed in rural schools located within municipalities with low HDI[29], according to the program's new directives.

Table 6.7: Photovoltaic Systems Purchased by PRODEEM

SYSTEMS	Phase 1		Phase 2		Phase 3		Phase 4		Emergency		Phase 5		Total	
	Nº	kWp	Nº	kWp	Nº	kWp	Nº	kWp	Nº	kWp	Nº	kWp	Nº	kWp
Water Pumping	54	78	179	211	176	135	1240	696	800	235			2449	1355
Public Lighting	137	7,5	242	17	-	-	-	-	-	-			379	24.5
Power Systems	190	87	387	200	677	419	1660	972	-	-	3000	2172	5914	3850
TOTAL	383	187	808	428	853	554	2900	1668	800	235			8742	5229

Source: Update of the original (Ribeiro, 2002)

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 completely ineffective in maintaining the systems operational, and in 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 IDB and the National Department of Energy Development (DNDE) prepared

[29] Human Development Index is an indicator used by the United Nations to rate the living conditions of different populations. The HDI varies from 0 to 1, and takes into account level of education, life expectancy, and per capita GDP.

an Action Plan, making a grant of up to US$ 9 million available to restructure the program. The goal of the Plan, that also had 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. Changes in the coordinating team of PRODEEM and in the electric power sector regulations, specifically in regards to Universal Electrification (see Section 3.2), will most likely require a re-evaluation of the current version of the Action Plan before it is to be implemented.[30]

Luz Solar Program (Minas Gerais)

An interesting application of photovoltaic systems is being carried out with state funding by CEMIG, Minas Gerais' principal electric utility. Through the Luz Solar Program, listed in Table 6.6, stand-alone PV systems are installed in off-grid communities with the purpose of "pre-electrification". CEMIG intends to eventually extend the conventional power grid to all those within its concession area, and PV systems are being used in the interim to partially satisfy the electric power needs of those communities on the wait-list. When the grid arrives to replace the PV systems in a particular community, these are removed and installed in other residences, continuing to carry out the role of "pre-electrification". In general, residential PV systems are designed to supply enough energy for lighting and a black and white TV or radio for four hours a day; school PV systems allow for lighting, color TV, video cassette recorder and satellite also up to four hours a day; water pumping systems vary depending on the situation. The PV system remains the property of CEMIG, for which users pay a monthly fee. CEMIG's goal is to have installed around 6,000 systems in cities in the northern and eastern parts of Minas Gerais by 2003. In order to assure the satisfactory performance of these systems, CEMIG has developed training programs to prepare electricians to install, monitor and maintain the PV systems located throughout the state. In addition, the utility offers educational seminars to help users understand the benefits and limitations of the photovoltaic equipment.

Luz do Sol Program (Northeast)

As outlined in Table 6.6, the Luz do Sol program, formerly directed by the Teotonio Vilela Foundation (FTV) and now under the auspices of the Eco-Engenho Institute, installed 2520 systems in 84 communities in Brazil's Northeast. A financing mechanism was set up by the Bank of the Northeast of Brazil (BNB) to provide a credit line to local small entrepreneurs to finance the PV systems. Eco-Engenho is re-evaluating the program in partnership with Winrock International. Expansion of a modified Luz do Sol program is being considered.

[30] Funds from the FUMIN and JSF are already available for the MME and will be used in the implementation and/or adaptation/updating of the Action Plan.

Law 10.438

Eletrobrás is to institute a program to foment the use of solar electric equipment, through contracts with utilities and permissionaires, for individual and collective use, according to article 4 of law 10.438, enacted in April 2002. Resources from the Global Reversion Reserve (RGR) are to be made available for this purpose. As the law was just recently enacted, no official action has yet taken place towards its implementation.

Light in the Countryside (Luz no Campo) Program

The opportunity exists of using photovoltaic technology to reach a share of the one million homes targeted for electrification by the federal Light in the Countryside program (described in Section 3.3.1). Although the program has focused on grid-extension, advocates of renewable energy are working to include participation of alternative sources, with an emphasis on solar-electric energy where this technology drives to lower investment needs. In the state of Bahia, 9,000 solar home systems were included in the local utilities´ plan under the Program.

6.3.2.3 Grid-Intertied Systems

The first and largest Brazilian grid-connected photovoltaic system was installed by a utility company (CHESF) in parallel with its electric power grid, in Recife, state capital of Pernambuco, in the Brazilian Northeast. Three other systems were installed by university research groups – UFSC – Federal University of Santa Catarina, USP – University of São Paulo, and UFRJ – Federal University of Rio de Janeiro (see Table 6.8). The research groups responsible for each of the installations regularly follow up on the performance of these systems.

Table 6.8 Grid-intertied Photovoltaic Systems Installed in Brazil

System	Location (city)	Installation (yr)	PV Power
CHESF	Recife	1995	11 kWp Polycrystalline
LABSOLAR	Florianópolis	1997	2 kWp Amorphous
LSF/IEE/USP	São Paulo	1998	750 Wp Monocrystalline
COPPE	Rio de Janeiro	1999	848 Wp Monocrystalline

Source: OLIVEIRA & ZILLES (2001)

To date applications of this type have been primarily for demonstration and research purposes. The reason remains that for those who have access to the conventional power grid, the price of PV-generated power is considered exorbitant. There is currently no legislation targeting small-scale, grid-intertied renewable power production. If in the future the issue gains exposure, it is possible that financial incentives will increase the feasibility of grid-intertied photovoltaic applications.

6.3.3 Fiscal Incentives

Fiscal incentives exist in Brazil for selected photovoltaic equipment. The three most significant taxes to which products are subject are: the federal IPI, the state ICMS, and the importation tax. These taxes are defined in Section 1.3.4. By ICMS Accord 101/97, photovoltaic generators of less than 750 W capacity, unassembled solar cells and DC water pumps under 2 HP are exempt from the ICMS tax until December 31, 2002. By Decree 3827 of May 31, 2001 the IPI was reduced from 2% to 0% on solar cells, and from 5% to 0% on photovoltaic modules. The taxes on these and other equipment that integrate solar-electric systems are shown in Table 6.9 below. Exemptions were extended to April 2004.

Table 6.9 Taxes on Photovoltaic System Components

Product	Import Tax (%)	IPI Tax (%)	ICMS Tax (%)
Solar Module	21	0	0
Solar Cell	17	0	0
Water Pump (under 2 HP)	21	0	0
Charge Controller	21	2	7
Inverter	20	5	7
Battery	21	15	18

6.3.4 Barriers

The main barriers in Brazil to significant market development of solar-electric energy are similar to those faced in other countries: high investment cost, system failure due to poor maintenance and poor tracking of subsidized rural electrification initiatives leading to over- sized distribution grid extension where stand-alone PV systems could supply very low consumption levels.

The high price of photovoltaic systems relative to electric utility rates and the fact that most of the electricity generated in the country comes from renewable sources (predominantly hydro) continue to limit applications in Brazil to those in which grid access is not available or practical. Meanwhile, the same circumstances—isolated, sparsely populated sites with difficult access—that make photovoltaic technology competitive in certain areas, can become obstacles to the smooth performance of the systems. Preparing and carrying out operation and maintenance plans is crucial to ensuring that the systems continue to function as designed. The majority of the 40,000 systems installed in Brazil do not rely on a reasonable maintenance structure, and in consequence, many have not operated to satisfaction.

On a broader level, there is a lack of initiative on the part of electric utilities and Eletrobrás to incorporate solar-electric technology in their electrification efforts, even where it proves to be the lowest cost option. In spite of the various institutional frameworks tried in Brazil, current rural electrification policy and available financing makes the involvement of the utilities almost inevitable, either installing and operating or partnering with local players. As the issue of Universal Electrification (see Section 3.2) progresses, however, it is expected that utilities will recognize the important role that PV systems can have in meeting the targets to be set by ANEEL.

7. WIND

Similarly to other renewable energy sources, the use of wind power in Brazil offers the following possibilities: diversification of the energy matrix, production of power near consumer centers, and displacement of fossil fuels. In addition, wind power offers two benefits: the wind cycle is complementary to the hydrological cycles upon which the country is dependent, and large-scale wind power parks can be erected within a relatively short period. In view of these advantages and the favorable policies recently adopted toward renewable energy, the situation is favorable for wind energy to gain a strong foothold in Brazil, as it has in many other nations.

7.1. Brazil's Wind Resource

In Brazil, there are regions with good wind power potential, usually located in areas for which the supply of electric power is limited. Atlases of the wind resource in Brazil are available to estimate the wind power potential for any region in the country and can be obtained in printed or electronic form. Figure 7.1 shows the map published by Eletrobrás in 1988, while Figure 7.2 shows the 2001 atlas published by CEPEL and Eletrobrás in 2001. The studies carried out by these two entities have led to the identification of specific areas of the country where the available wind power potential is the most promising. These are: the coastline and center of the North and Northeast, the north of the state of Roraima, and the South, with a highlight on the coastal region of the Rio Grande do Sul state.

Figure 7.1 –National Windpower Potential Atlas – developed by Eletrobrás in 1988

Figure 7.2 – Windpower Atlas of Brazil – developed by CEPEL and Eletrobrás in 2001

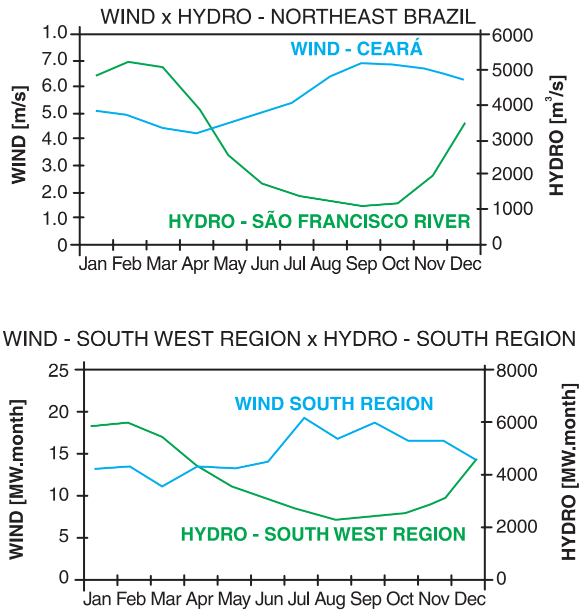
Based on the National Windpower Potential Atlas of 2002 (CEPEL/Eletrobrás), which takes into account annual average wind speeds above 7 m/s at a height of 50m, the gross potential of wind power in Brazil is estimated to be approximately 143,000 MW. It is important to consider the area that is unoccupied and actually available for installation of wind power parks; in this case, the potential is estimated between 60,000 and 70,000 MW. When considering annual average wind speeds above 6 m/s, measured at 50 m, the estimate increases to over 500,000 MW[31]. Even at the most conservative estimate, the potential for power production from the wind is almost equal to Brazil's entire generating capacity (72,810 MW in 2001).

In addition to being abundant in selected areas, the wind resource in Brazil offers a significant advantage in its seasonality. Studies developed by the Companhia Hidroelétrica do São Francisco – CHESF, in the Northeast, and by the Companhia Paranaense de Energia – COPEL, in the

[31] The following assumptions were made for this calculation: winds follow Rayleigh's statistical distribution, utilization of 20% of the areas with winds above 6 m/s at 50 m and an average capacity factor of 0,30.

South, show that for a national interconnected electric system, the hydrological system, which constitutes the basis of Brazil's energy matrix, may be complemented by the wind patterns throughout the year (Rocha, 1999). See Figure 7.3 below for a comparison of the availability of the wind and hydrological resources.

Figure 7.3 – Complementary Wind and Hydrological Patterns throughout the Year



Complementing the available wind resource information on a national level, regional data may be found, such as the Windpower Potential Atlas of the states of Ceará, Paraná, Ceará and Bahia, already developed, and of Rio Grande do Norte and Rio Grande do Sul, under development. Both the type and presentation of the information contained in these atlases are similar to those found in the atlas of national range.

The installation of windpower parks – enterprises involving considerable investments – require, however, a much more detailed and current knowledge of the wind resource of the targeted area, as well as of other variables such as: market demand, local energy supply, the possibility of generation with other energy sources, etc. In general, detailed information on the wind resource is obtained by local measurement campaigns, which generally take from 6 to 12 months. In some cases, it is possible to use data which has already been measured and catalogued in wind databases. Several official organisms and companies collect wind data in Brazil (see Table 7.1). Since the wind data are measured for different objectives, however, the sensors and procedures utilized (frequency and sampling time, positioning of the sensors, type of treatment of the data, etc) vary greatly, and many may be inadequate for prospecting wind power.

Table 7.1 Sources of Raw Wind Data

Institution	Number of Stations
INMET – Ministry of Agriculture	464
DEPV - Ministry of the Air Force	51
DHN – Ministry of the Navy	43
ANEEL/INPE	26
CEMIG	60
CEPEL	47
COPEL/SIMEPAR	65
COELCE	14
Energy Secretariat of the state of Rio Grande do Sul	18
CELESC/UFSC/Wobben	27
Total	788

7.2. State of the Industry

Despite the significant potential for harnessing wind power in the country, and the existence of a solid industry capable of producing components and systems, Brazil's industrial park is limited. What exists is an incipient industry focused on the production of small capacity windpower systems generally used to supply small, isolated communities. Wobben Windpower Indústria e Comércio Ltda (www.wobben.com.br) is currently the only company focused on large-scale windpower systems in Brazil. This company manufactures components, in part for exportation. Wobben is a subsidiary of Enercon GmbH, and also works as an independent energy producer on the main wind energy powerplants in operation in Brazil (see Table 7.2). Wobben is headquartered in Sorocaba (SP) and has recently opened a manufacturing unit in Ceará (in the industrial district of Pecém). Production in Brazil is still focused on machines of 600kW, even though the present world tendency is for larger machines, with capacities above 1 MW.

Table 7.2 lists the windpower stations in operation in Brazil, while Table 7.3. presents a list of windpower parks authorized by ANEEL[32]. Analyis of these two tables shows the strong interest which has been raised regarding wind energy use in the country since the second half of the 1990s.

[32] Though the large numbers of authorizations sought out and granted is an important indicator of the intentions of the private sector in the area of wind power, authorization is only the first of many steps toward implementation.

Table 7.2 – Windpower projects implemented in Brazil

Windpower Parks	Implementation	Year	Capacity
F. de Noronha	CELPE/UFPE	1992	75kW-275kW[33]
Morro do Camelinho	CEMIG/Eldorado Project	1994	1MW
Porto de Mucuripe	COELCE/CHESF/Eldorado Project- Wobben	1996	1.2MW-2.4MW[34]
Sistema Híbrido Joanes	CEPEL/CELPA/NREL	1997	40kW
Prainha	Wobben /COELCE	1999	10MW
Taíba	Wobben/ COELCE	1999	5MW
Palmas	Wobben/ COPEL	1999	2.5MW

Table 7.3 – Windpower Parks Authorized by ANEEL

State	Windpower Parks Authorized by ANEEL as of June 2002	
	Number of Parks	Capacity (MW)
Ceará	21	1718.60
Rio Grande do Norte	19	1695.75
Pernambuco	7	366.90
Bahia	3	218.44
Rio de Janeiro	2	174.60
Total	**52**	**4174.29**

Source: ANEEL

7.3. Opportunities and Barriers

Law number 10438 of April 26, 2002, described in detail in Section 2.5, institutes the Incentive Program for Alternative Energy Sources – PROINFA, with the objective of raising the participation of autonomous independent producers (PIAs[35]) in the generation of grid-intertied electricity from wind, biomass and small hydropower. According to this law, in the first phase of the program Eletrobrás will sign contracts ensuring the purchase of the electricity, for fifteen years, up to the capacity of 3300 MW. The contracts are to be equally distributed, in terms of installed capacity, among the three generation sources targeted. In other words, up to 1100 MW of the wind enterprises authorized by ANEEL are to have the purchase of their electricity by Eletrobrás guaranteed.

In the case of wind energy, the Executive Branch may authorize Eletrobrás to sign contracts with Independent Producers which are not autonomous, as long as the total contracted power does not exceed 50% of the annual programming for acquisition of wind energy by a given distributor, and that such contracts do not displace the supply of an Autonomous Independent Producer. An

[33] Capacity raised in 2000. CBEE operates a wind power plant as an independent energy producer.
[33] The original 300kW turbines were replaced in 2000 for 600kW units, duplicating the installed capacity.
[35] Autonomous Independent Producer is defined in Law 10.438 as a power producer whose partnership is not controlled by or linked to an electric energy generation, transmission, or distribution consortium. For further detail, see chapter 2.

important observation, however, which could be an obstacle for the development of wind energy in the short term, is that two companies, SIIF and ENERBRASIL, non-autonomous independent producers, own more than 80% of the windpower projects authorized by ANEEL.

7.4. Reference Centers

The main reference centers on wind energy in Brazil are listed below:

CRESESB – Reference Center for Solar and Wind Energy Sérgio de Sálvio Brito. CRESESB's homepage lists seminars, workshops, national equipment producers, service companies, and offers access to publications, including the 2001 wind atlas. (www.cresesb.cepel.br).

UFPE/CBEE – Federal University of Pernambuco / Brazilian Wind Energy Center. CBEE carries out activities focused on the use of wind energy including research of windpower potential, activities of implementation of windpower systems, and research and tests with small capacity turbines. (www.eolica.com.br).

LAFAE – Alternative Energy Sources Lab, COPPE/UFRJ - LAFAE is dedicated to the study and research issues related to the use of alternative energy sources, including wind energy.

The Wind Atlas of the state of Bahia is available at
www.coelba.com.br/setor_eletrico/documentos/atlasba_rev_1.pdf

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National Economic and Social Development Bank www.bndes.gov.br
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World Bank www.worldbank.org

2. Electric Power Sector

Brazil's National Energy Balance www.mme.gov.br/sen/ben/ben.html
Energia Brasil www.energiabrasil.gov.br
Eletrobrás www.eletrobras.gov.br
Ministry of Mines and Energy www.mme.gov.br
National Electric Energy Agency-ANEEL www.ANEEL.gov.br
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