Energy for Life

COUNTRY PROFILE

BRAZIL 2010

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Brazil 2010

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Figure 1 (Front cover): Map Brasil, Source: http://www.mapcruzin.com/free-maps-brazil/brazil_sm_2008.gif

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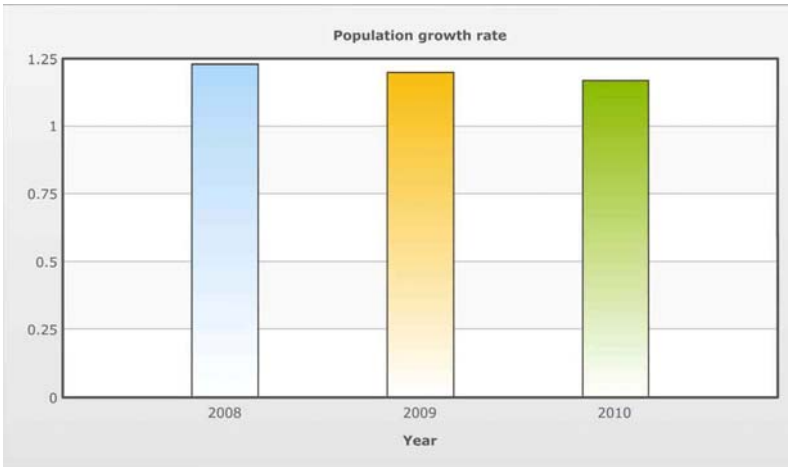
1 Background information

1.1 Country data[1]

Location of country:	Eastern South America, bordering the Atlantic Ocean
GPS:	10 00 S, 55 00 W
Total area:	8,514,877 sq km
Capital:	Brasilia
Currency:	Brazilian Real
Language:	Portuguese (official), Spanish (border areas and schools), German, Italian, Japanese, English, and a large number of minor Amerindian languages
Religion:	Roman Catholic (nominal) 73.6%, Protestant 15.4%, Spiritualist 1.3%, Bantu/voodoo 0.3%, other 1.8%, unspecified 0.2%, none 7.4%
Population:	201,103,330 (2010) urban population: 86% of total population (2008).
Population density[2]:	22 persons per sq. km
Climate:	Mostly tropical, but temperate in the south
Temperature[3]:	Average temperature 21.5°C, High 30°C and low 11°C
Precipitation[4]:	1416 mm (55.7 in) rainfall per year, or 118 mm (4.6 in) per month
Terrain:	Mostly flat to rolling lowlands in north; some plains, hills, mountains, and narrow coastal belt
Elevation:	Lowest point: Atlantic Ocean 0 m. Highest point: Pico da Neblina 2,994 m.
GDP[5]:	USD 10,000 per capita per year (2009)

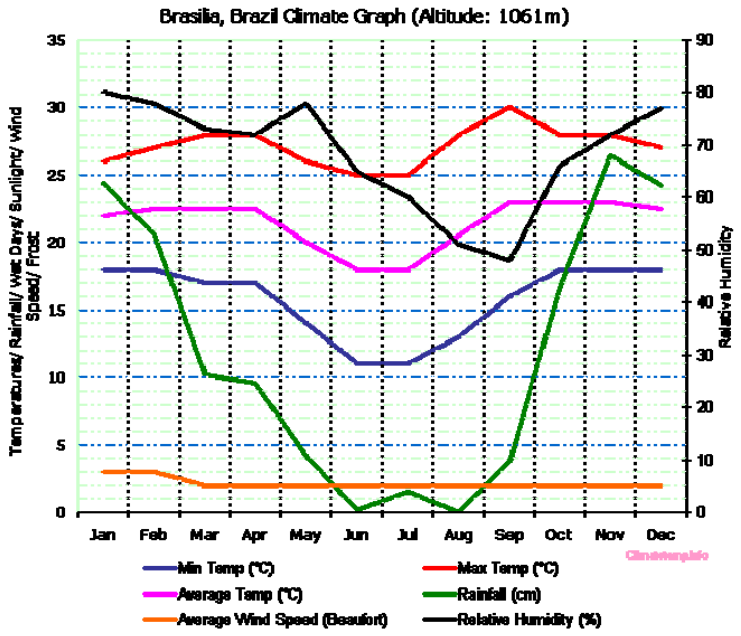
[1] The world fact book, Dec. 2010
[2] True Knowledge, Dec. 2010
[3] Climate & Temperature..., Dec. 2010
[4] Idem
[5] The world fact book, Dec. 2010

Figure 2: Population growth 2008 to 2010



Source: Index Mundi, 2010

Figure 3: Climate and weather in Brazil



Source: Climate & Temperature..., Dec. 2010

1.2 RES targets[6]

Electrification in the Amazon region of Brazil remains the ultimate challenge. Because of the small size communities (about 80% of the unattended communities have less than 30 households and less than 100 inhabitants), the grid distribution system is often viewed as unviable[7]. With the publication of the February 2009 *Manual de Projetos Especiais*[8] of the Ministério de Minas e Energia (MME) (a special projects manual that establishes technical and financial criteria to be applied for electricity services through renewable energies), the choice between which renewable energy technology to use, such as solar PV systems, wind and hybrid power plants, thermal power plants powered by natural gas or biofuels, mini and microhydro systems, and vegetable palm oil as a replacement for diesel imports, will be done according to local conditions. However, there are only 23 projects currently being considered by Electrobrás[9].

1.3 Status of the renewable energy market[10]

As a high electricity consuming country, renewable energy systems have been explored and exploited for many years already. Brazil has one of the world's most important energy markets with a long established ethanol production and large hydropower plants. As one of the world's largest sugar supplier, the country has all the elements for a variety of renewable energy sources. In fact, 46% of the country's energy and 85% of its power generation come from renewable energy sources.

The fact is that 77.3%[11] of the electricity is produced by large hydro power plants and 90% of the new cars run on a combination of ethanol and petrol (even the petrol contains 25% ethanol). By the end of the year 2008, ethanol accounted for more than 52% of the fuel consumption used by light vehicles. It is expected that the consumption of ethanol will reach 53 billion litres by the year 2017. Almost 80% of Brazil's ethanol production is consumed domestically while the rest is exported, reaching an export record of 5.1 billion litres in 2008. Ethanol is mainly exported to the United States of America and to Europe.

Notwithstanding the above mentioned large hydro power dams and sugar cane plantations as renewable energy options, the reality is that these systems often have negative ecological and social impacts; the benefits do not always justify the impacts.

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[6] GWEC, Dec. 2010
[7] Niez, Alexandra, France, 2010
[8] Programma Nacional de Universalizacao, Dec. 2010
[9] Programa Nacional de Universalização do Acesso e Uso da Energia Elétrica, 2009
[10] Arcadia Market Commentary, August 2009
[11] Ein schlafender Riese, Sept. 2011, pages 124 to 137

The impacts of Brazilian dams are described by the World Commission on Large Dams as follows:

- lack of integrated energy planning, favouring the interests of construction companies, consultants, and equipment providers, resulting in inadequate siting of dams, in overpricing and in construction cost overruns.
- social and environmental impacts handled in an inadequate way, if not totally ignored.
- social impacts treated with absolute disrespect for the rights of affected populations; today, their resistance, organization and struggle are their only hope if they are to avoid the sacrifice of their individual, community and social rights, their culture and ways of life - in the name of a kind of progress whose benefits have never, and will never be fairly shared;
- total disregard for traditional populations, indigenous people, and *Quilombos*, particularly as this involves the close ties between their cultures and their territories; these transform compulsory relocation into an irreversible death sentence for their culture, possibly leading to their physical disappearance as well;
- privileged treatment including direct subsidies, to large consumers and electro-intensive industries, many times exporters; this is the dark face of the hyper-consumerism of the developed countries, and leads to environmental destruction and the suffering of populations;
- inexistence or fragility of policies for supporting research, development, demonstration, and dissemination of alternative energy sources.[12]

Impacts of the demands for agrofuels:

- expanding the monocultures leads to loss of species diversity, water-quality problems, and habitat fragmentation in some of the world's most biologically diverse regions, the Amazon and the *Cerrado*[13]
- displacing of local population
- destroying of small and medium farmers
- loss of work places[14]
- increasing green gas emissions

[12] WCD, Dec. 2010
[13] National Geografic, Dec. 2010
[14] Stoppt den Agrarenergie-Wahn!, Dec. 2010

The success of biofuels in Brazil can be associated with the availability of large areas of arable land, abundant water resources, solid government support, expanding working age population and a cost advantage over competing fuels. In the year 2002, the government of Brazil established the PROINFA programme to encourage the use of wind, biomass and mini-hydro projects as an energy source, offering developers guaranteed power purchase agreements at favourable rates. However, wind is still a secondary source of energy in Brazil.

1.4 Energy legal framework in Brazil

The **Ministry of Energy and Mines** (Ministério de Minas e Energia -MME) has the overall responsibility for policy setting in the electricity sector while the **National Agency of Electricity** (Agência Nacional de Energia Elétrica - ANEEL), which is linked to the Ministry of Mines and Energy, is the Brazilian Electricity Regulatory Agency created in 1996 under the Law 9427. The **National Council for Energy Policies** (Conselho Nacional de Política Energética - **CNPE**), is an advisory body to the MME in charge of approving supply criteria and "structural" projects while the **Electricity Industry Monitoring Committee** (Comitê de Monitoramento do Setor Elétrico **- CMSE**) monitors supply continuity and security[15]. **The Operator of the National Electricity System** (Operado Nacional do Sistema Electrica **- ONS**) is a non-profit private entity created in August 1998 that is responsible for the coordination and control of the generation and transmission installations in the National Interconnected System (SIN). The **Power Commercialization Chamber** (Câmara de Comercialização de Energia Elétrica - CCEE), successor of MAE (*Mercado Atacadista de Energia Electrica*), is the operator of the commercial market. Finally, the **Power Research Company** (Empresa de Pesquisa Energética - EPE) was created in 2004 with the specific mission of developing an integrated long-term planning for the power sector in Brazil[16].

1.5 Supporting laws and policies

In 2003 the rural electrification programme, Luz para Todos (Light for All, or LpT), was formalized and implemented aiming at giving universal access to electricity in the country's rural areas by the year 2010. The programme is based on the obligation for service providers to universalise rural electricity access (as set by the Brazilian Constitution), on substantial federal and state resources for the service providers, and on low tariffs for low-income and rural consumers[17]. The current energy policies in Brazil aim at improving energy efficiency in both residential and industrial sectors as well as increasing renewable energy source.

[15] Brazil, Country anlyse briefes, 2009
[16] Wikipédia,Empresa de Pesquisa Energética, Dec. 2010
[17] Zerriffi, H., 2007, pp. 90-117

1.6 Key supporting factors

During the year 2002, the Brazilian government established the "Programa de Incentivo às Fontes Alternativas de Energia Elétrica" (PROINFA) designed to increase the use of renewable energy sources in the production of electricity. The main objective of this PROINFA project was to increase the share of renewable energy to 10% for Brazil's electricity production by the year 2020[18].

1.7 CDM projects in Brazil

As Clean Development Mechanism (CDM) projects need to be supported by the implementing country, the following chart shows the support given by the Brazilian government on CDM projects over the years.

Table 1: CDM projects as of 10 December 2010

Status of project	Number of projects
Projects registered	180
Projects rejected	22
Projects withdrawn	8
Review requested	4
Requesting registration	4

Source: UNFCCC

[18] GWEC, Dec. 2010

2 Current status of RES

2.1 Energy related data

Electrification rate[19]	98.3% of the people have electricity (approx. 3.3 million people are living without electricity.
Electricity consumption[20]	404.3 billion kWh (2007) 96.294 MW (2006)[21]
Actual electricity consumed	~ 2,000 kWh per capita
Electricity cost[22]	USD 0.153 per kWh (2007) residential USD 0.113 per kWh industrial USD 0.142 per kWh commercial USD 0.091 per kWh rural USD 0.20 per kWh in rural remote areas[23]
Electricity generation in 2007	438.8 billion kWh
Electricity projection in 2035[24]	980 billion kWh
Main power generation sources[25]	Hydropower plants (80%), Natural gas (10%)[26]

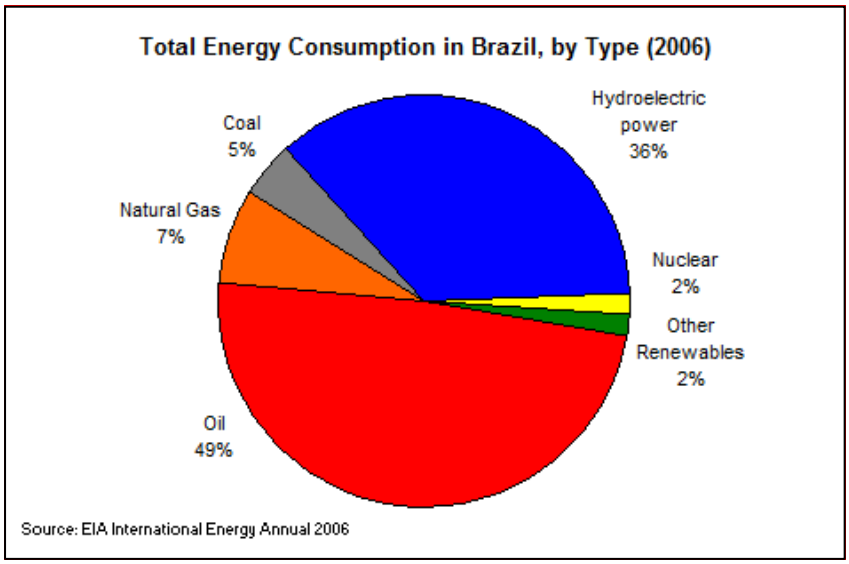
Table 2: Electricity consumption from 2003 to 2010-12-13

Year	Electricity - consumption	Rank	Percent Change	Date of Information
2003	335,900,000,000	10		2001
2004	335,900,000,000	10	0.00 %	2001
2005	351,900,000,000	9	4.76 %	2002
2006	359,600,000,000	9	2.19 %	2004
2007	415,900,000,000	9	15.66 %	2005
2008	402,200,000,000	9	-3.29 %	2007 est.
2009	402,200,000,000	9	0.00 %	2007 est.
2010	404,300,000,000	9	0.52 %	2007 est.

Source: Index Mundi, 2007

[19] http://www.iea.org/weo/database_electricty10/electricity_database_web_2010.htm
[20] The world fact book, Redirects, Dec. 2010
[21] Wikipedia, Electricity sector in Brazil, Dec. 2010
[22] Idem
[23] OECD/IEA 2010, Dec. 2010
[24] eia, Dec. 2010
[25] Arcadia Market Commentary, August 2009
[26] Wikipedia, Electricity sector in Brazil, Dec. 2010

Figure 4: Total energy consumption in Brazil by type 2006



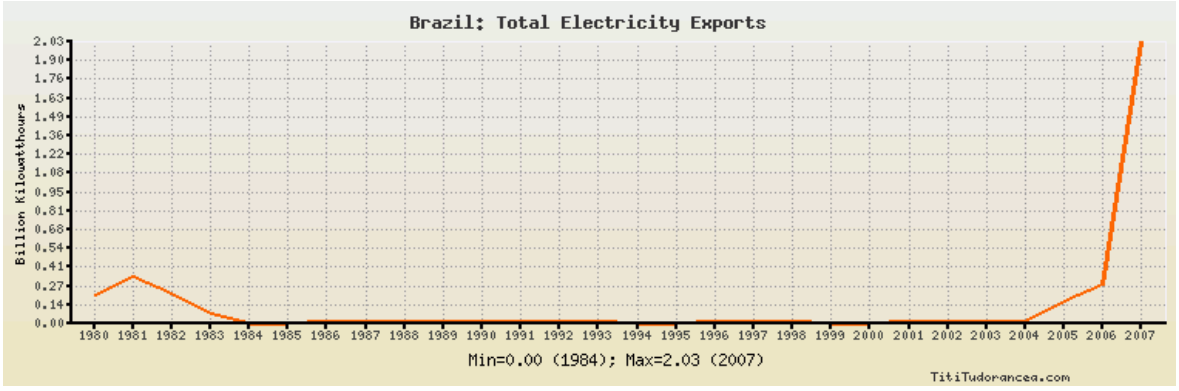
Source: Brazil, Country anlyse briefes, Dec. 2010

Table 3: Net electricity generation in Brazil by fuel, 2007-2035 (trillion kilowatthours)

Year	Liquids	Coal	Nuclear	Other renewables	Natural gas	Hydropower
2007	0.01	0.01	0.01	0.02	0.03	0.37
2015	0.01	0.01	0.02	0.02	0.06	0.45
2020	0.01	0.01	0.02	0.02	0.09	0.51
2025	0.01	0.01	0.03	0.02	0.12	0.59
2030	0.01	0.01	0.03	0.03	0.16	0.67
2035	0.00	0.01	0.04	0.03	0.18	0.72

Source: eia, Dec. 2010

Figure 5: Total energy export 1980 to 2007



Source: The Titi Tudorancea Bulletin, 2010

2.2 Current situation

Electricity

Brazil has a very high rate of electrification, accounting for 97.8% of all Brazilians with access to electricity, of which 99.5% of the people in urban areas have electricity and 88% in rural areas. The government aims at 100% by the end of year 2010. During the year 2007, 55.35 million out of a total 56.34 million permanent residences were connected to electric energy[27].

In 2010, the total electricity generation capacity in Brazil stood at 107.5 GW[28]. Brazil produced 438.8 billion kWh of electricity in 2007, making it the 11th electricity producer in the world, the 10th largest energy consumer in the world and the largest in South America with an annual consumption of an estimated 404.3 billion kWh. Brazil exported 2.034 billion kWh of electricity in 2007 while it imported from Paraguay some 42.06 billion kWh in 2008. Electricity is also used for transport. Of Brazil's total 28,857 km of railway, some 459 km of the 5,709 km 1.600m broad gauge are electrified[29]. Brazil is also an important oil and gas producer and the second largest ethanol fuel producer in the world.

Table 4: Electricity generation plants by source as of 2007

Source	Number of plants	Installed capacity (MW)	Total
Hydroelectricity	633	73,678	72.1%
Gas	101	10,798	10.6%
Oil	568	4,446	4.4%
Biomass	269	3,693	3.6%
Nuclear	2	2,007	2%
Coal	7	1,415	1.4%
Wind	15	237	0.2%
Total installed capacity	**1,595**	**96,294**	**94.3%**
Contracted imports		5,850	5.7%
Available power		102,144	100%

Source: Ministry of Energy and Mines, 2007

[27] OECD/IEA 2010, Dec. 2010
[28] GWEC, Dec. 2010
[29] The world fact book, Dec. 2010

Large government-controlled companies control the electricity sector: Electrobrás, a government owned company, holds about 40% of capacity (including 50% of the Itaipu dam), with state-companies CESP, Cemig and Copel controlling 8%, 7% and 5% of generation capacity respectively[30].

Table 5: Generation capacity is shared among the different companies

Company	Controlling shareholder	Installed capacity (MW)	Total
Electrobrás (1)	Federal Gvt.	38,111	40%
CESP	SP State Gvt.	7,451	8%
Cemig	MG State Gvt.	6,692	7%
Copel	PR State Gvt.	4,550	5%
Tractebel Energia	GDF Suez	6,870	7%
AES Tiete	AES Corp.	2,651	3%
Others	Mostly private	29,969	31%
Brazil Total		**96,294**	**100%**

Source: Eletrobrás, CESP, Cemig, Copel, Tractebel Energia, AES Tiete, Ministry of Energy and Mines31
Considering 6,300MW of Iguaçú

It is estimated that approximately 27 percent of the generation assets are managed by private investors. Taking into consideration the plants under construction, and also the concessions and licenses already granted by ANEEL, this figure will increase to 31 percent in the medium term and should reach almost 44 percent over next five to six years. It is safe to assume that private capital in the generation of electricity will shortly reach 50%.

[30] Wikipedia, Electricity sector in Brazil, Dec. 2010
[31] OECD, Dec. 2010

Table 6: Electricity production from 2003 to 2007

Year	Electricity - production	Rank	Percent Change	Date of Information
2003	321,200,000,000	10		2001
2004	321,200,000,000	10	0.00 %	2001
2005	339,000,000,000	10	5.54 %	2002
2006	387,500,000,000	9	14.31 %	2004
2007	546,000,000,000	9	40.90 %	2005
2008	437,300,000,000	9	-19.91 %	2007 est.
2009	437,300,000,000	10	0.00 %	2007 est.
2010	438,800,000,000	10	0.34 %	2007 est.

Source: Index Mundi, 2007

Transmission[32]

Transmission of electricity in Brazil has remained, until now, almost exclusively under government control, being companies such as the government owned Electrobrás, and other state companies such as Sao-Paulo-CTEEP, Minas Gerais-Cemig, and Parana-Copel. This is slowly changing under the new regulatory model, where some 40 transmission concessions were issued. Most of these concessions are still somewhat controlled by the government of Brazil while subsidiaries under Electrobrás are holding some 69% of the total transmission lines.

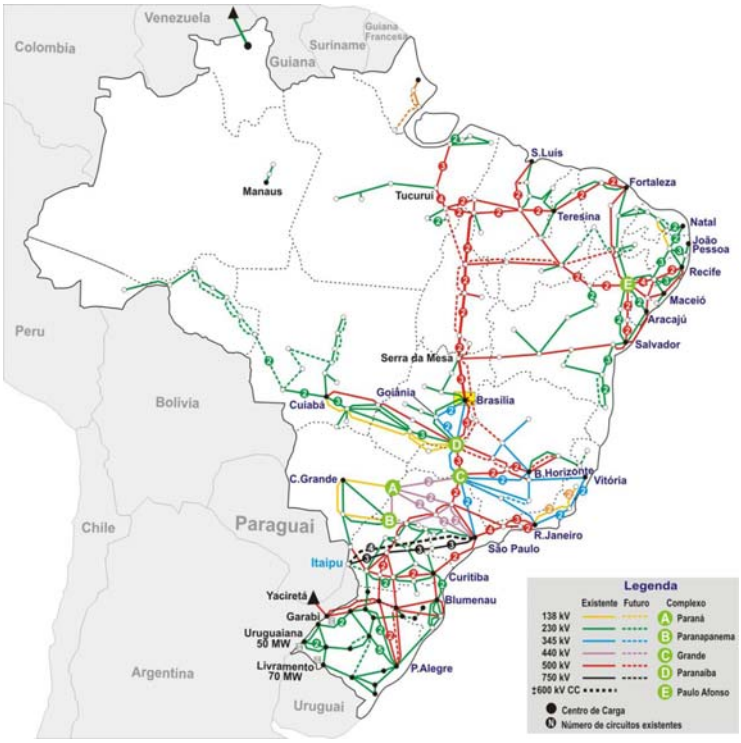
[32] Wikipedia, Electricity sector in Brazil, Dec. 2010

Table 7: Electricity transmission companies in Brazil

Company	Controlling shareholder	Concession area	Transmission lines (km)
Pure transmission companies			
CTEEP	ISA (Colombia)	São Paulo State	11,837
Terna Participacoes	Terna (Italy)	Goias, Bahia, Brazilian, Maranhao	2,447
Companies with significant transmission operations			
Cemig	State of MG	Minas Gerais	21,184
Copel	State of Parana	Parana	7,045
Electrosul, Furans, Electronorte, Chesf	Electrobrás	Throughout Brazil	56,384

Source: Bear Stearns 2007

Figure 6: Sistema Interligado Nacional (SIN, or National Interconnected System)



Source: OECD/IEA 2010, Dec. 2010

Distribution

The distribution of electricity in Brazil is ensured by the 49 utilities with distribution concessions[33] while approximately 64% of Brazilian distribution assets are controlled by private sector companies[34].

The following table gives a list of the most important distribution companies in Brazil

Table 8: Electricity distribution companies in Brazil

Company	Controlling shareholder	Concession area	Sales (GWh)	Sales
Cemig	MG State Govt	Minas Gerais	20,221	8.0%
Eletropaulo	AES Corp.	São Paulo city	31,642	12.5%
CPFL	VBC Group	São Paulo State outside São Paulo city	36,135	14.3%
Copel	PR State Govt.	Parana	17,524	6.9%
Energias do Brasil	EDP	São Paulo, Rio Grande do Sul	15,863	6.3%
Celesc	SC State Gvt	Santa Catarina	15,157	6.0%
Light	EDF	Río de Janeiro City	19,139	7.6%
Equatorial (Cemar)	GP Investimentos/Pactual	Maranhao	2,793	1.1%
Ampla (Cerj)	Enersis	Rio de Janeiro	6,832	2.7%
Others	Mostly private sector		87,594	34.6%
Brazil Total			**252,900**	**100.0%**

Source: Bear Stearns, 2007

[33] Abradee, Dec. 2010
[34] Bear Stearns, 2007

Nuclear energy[35]

Approximately 4% of the electricity in Brazil is produced from nuclear energy that is about 13 billion kWh per year. The nuclear power generation monopoly is owned by Eletronuclear (Eletrobrás Termonuclear S/A), a wholly owned subsidiary of Eletrobrás.

Table 9: Nuclear power plants in Brazil

Location	Capacity	Year of installation
Angra I	657 MW	1982
Angra II	1,350 MW	2000.
Angra III	projected output of 1,350 MW	Expected 2014
Others[36]	1,000 MW each	Expected 2030

Source: Nuclear Power in Brazil, Dec. 2010

Oil

Brazil is the 15th largest oil producer in the world. Although Petróleo Brasileiro S.A. (Petrobras) used to have total monopoly on oil, today more than 50 oil companies are involved in oil exploration. Nevertheless, the only oil producer today is Petrobras accounting for an output of more than 2 million barrels (320,000 m^3) of oil equivalent per day, acting not only as a producer but also a distributor and refiner[37].

Natural gas

In 2005, Brazil's natural gas reserves were estimated at 306 x 10^9 m^3, with possible reserves expected to be 15 times higher. The gas production was 18.7 x 10^9 m^3, which is less than the natural gas consumption of Brazil[38].

[35] Nuclear Power in Brazil, Dec. 2010
[36] Nonproliferation for Global Security Foundation, Dec. 2010
[37] Wikipedia, Electricity sector in Brazil, Dec. 2010
[38] Wikipedia, Organisation for Economic Co-operation and Development, Dec. 2010

Coal

Brazil has total coal reserves of approximately 30 billion tonnes, with varying deposit quality and quantities. Proven recoverable reserves are estimated at 10 billion tonnes[39]. Almost all coal output in Brazil is steam coal, of which about 85% is fired in coal power stations.

Oil shale

Brazil holds the second largest oil shale resources in the world (Irati shale and lacustrine deposits) and also the second largest shale oil production after Estonia. According to the reports of the Brazilian Ministry of Mines and Energy in 1999, the amount of proven oil shale resources was 445.1 million m^3 whereas the probable reserve potential of the country is estimated at around 9,402 million m^3 Operated by Petrobás; production in 1999 was about 200,000 tonnes[40].

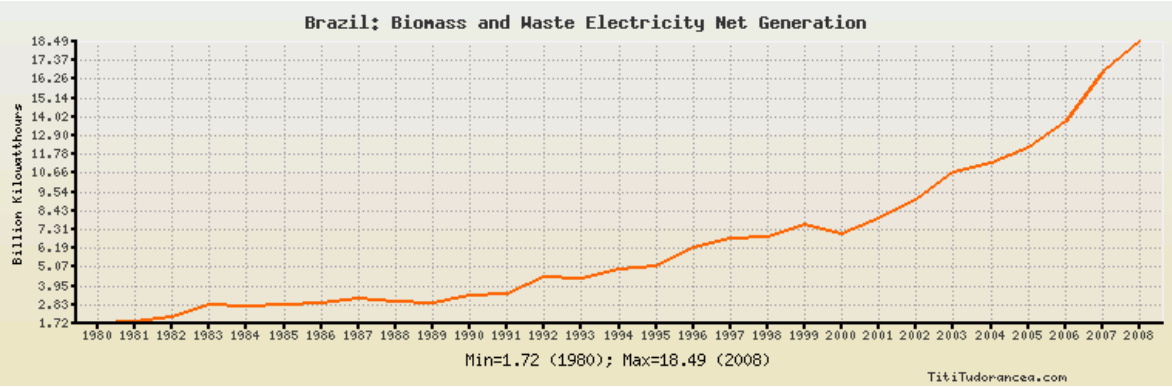
Uranium

Brazil has the 6th largest uranium reserves in the world with proven reserves of 162,000. Cumulative production at the end of 2002 was less than 1,400 tonnes[41].

2.3 Biomass energy installed and identified systems

As a world leader sugar producer, Brazil is using sugarcane related products for biomass energy production. In Avaré (State of São Paulo), cane is used for biomass energy.

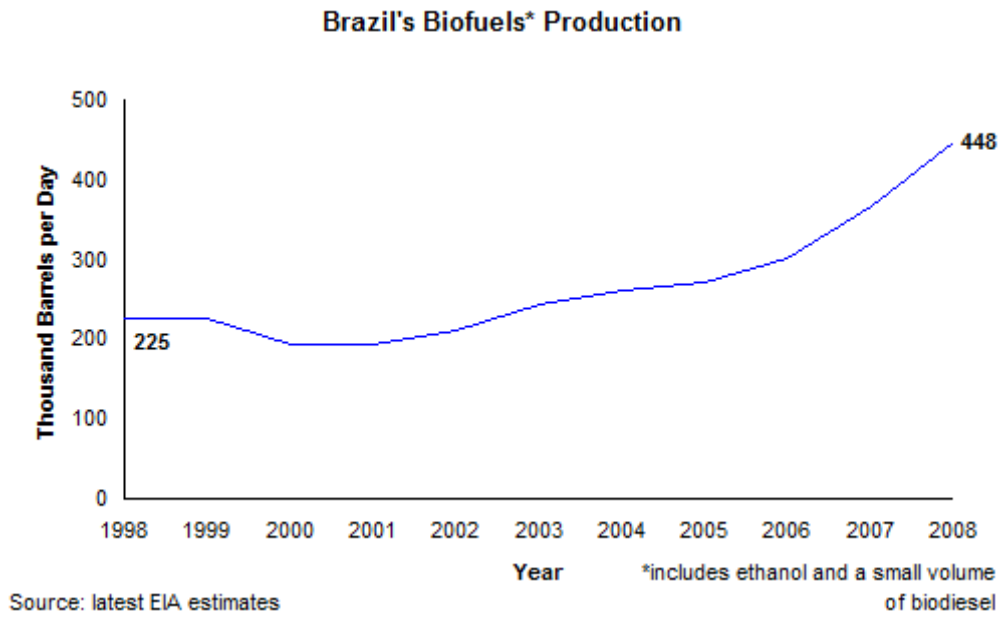
Figure 7: Biomass and waste electricity net generation from 1980 to 2008



Source: The Titi Tudorancea Bulletin, Brazil: Biomass and Waste Electricity Net Generation, 2010

[39] Survey of Energy Resources, 2004
[40] Irati shale and lacustrine deposits
[41] Outlook of Nuclear Power in Brazil, Dec. 2010

Figure 8: Production of biofuels in Brazil



Source: Brazil, Country anlyse briefes, Dec. 2010

2.4 Hydroelectric installed and identified systems

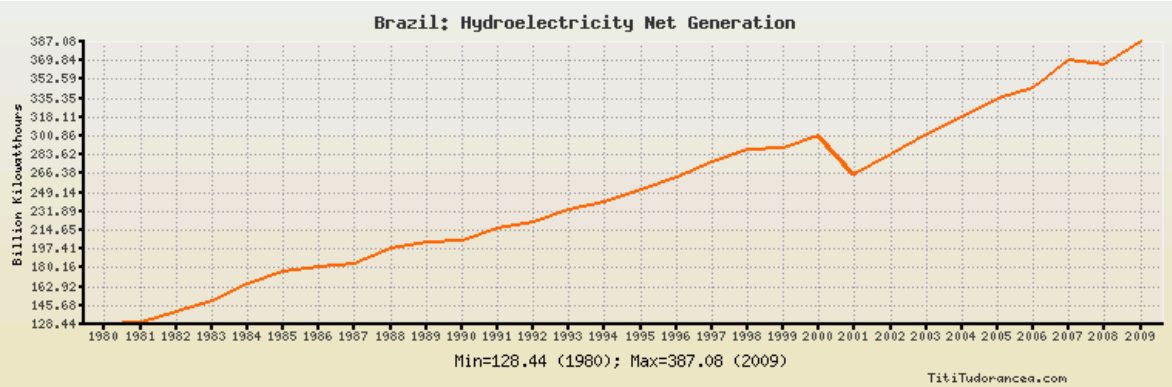
Hydroelectric power plants are an important source of energy in Brazil. In fact, Brazil is the third largest hydroelectricity producer in the world after China and Canada. During the year 2007, hydropower accounted for 83% of the total electricity production in Brazil[42]. During the year 2004, Brazil produced 321 TWh of hydropower[43]. The installed capacity is 59 GW[44]. About 2,235 MW small hydro capacity have been installed in Brazil as of 2007[45]

Brazil co-owns the Itaipu hydroelectric power plant on the Paraná River located on the border between Brazil and Paraguay, which is the world's second largest operational hydroelectric power plant with installed generation capacity of 14 GW by 20 generating units of 700 MW each[46]. Nevertheless, for its construction, 40,000 people, mainly indigenous, had to be resettled. The lake has an extension from 1.305 km² to 1.460 km². Large areas of tropical forest were destroyed and the environment was irreversibly damaged.[47] Other examples of the difficulties

[42] Wikipedia, Energy policy of Brazil, Dec. 2010
[43] Key World Energy Statistics , Dec. 2010
[44] Idem
[45] Brazil: Latin America's Beacon, Dec. 2010
[46] USGS, Dec. 2010
[47] Wikipedia, Itaipú, Dec. 2010

encountered with large dams in Brazil are the Tucuri dam[48] and the Belo Monte[49]. Both are well known for their high social and environmental impacts.

Figure 9: Hydroelectricity net generation from 1980 to 2009



Source: The Titi Tudorancea Bulletin, Brazil: Hydroelectricity Net Generation, 2010

2.5 Solar installed and identified systems

Because of the large water potential in the country, the Brazilian government has less interest in developing the solar sector. The main difficulty is the high price for a solar plant: plants connected to grid cost more than 6,000 Euros per Kilowatt. While the cost for conventional energy use are very high (more than 0,22 Euro per kwh), one solar plant needs 30 years for its amortization. This year 235 Kilowatts were directly connected with the public energy grid[50].

Total installed photovoltaic power capacity: 20 MWp[51]:

~50% is used for telecommunications systems

~50% of the solar energy is used for rural energy systems[52]

Between 2007 to 2008, and with the support of Gesellschaft für Technische Zusammenarbeit GmbH (GTZ), the concessionaire Electroacre installed 103 Solar-Home-Systems Type SIGFI13 in the community of Xapuri in Acre. Currently GTZ plans, together with Eletrobras Amazonas, to install 12 mini photovoltaic grids in 12 communities to supply 222 households in the Amazonian state. Furthermore GTZ works together with the concessionaire CELPA in Para on the installation of 4 hybrid systems (PV, wind energy and diesel backup) in 4 communities to ensure the

[48] Tucuruí Hydropower Complex Brazil, 2000
[49] Defending the Amazon, Dec. 2010
[50] Ein schlafender Riese, Sept. 2011, pages 124 to 141
[51] Idem
[52] Survey of Energy Resources, 2004

electricity supply of 75 households in remote areas. There is also a plan to equip two stadiums for the World Cup of 2014 with solar energy. [53].

2.6 Wind energy installed and identified systems

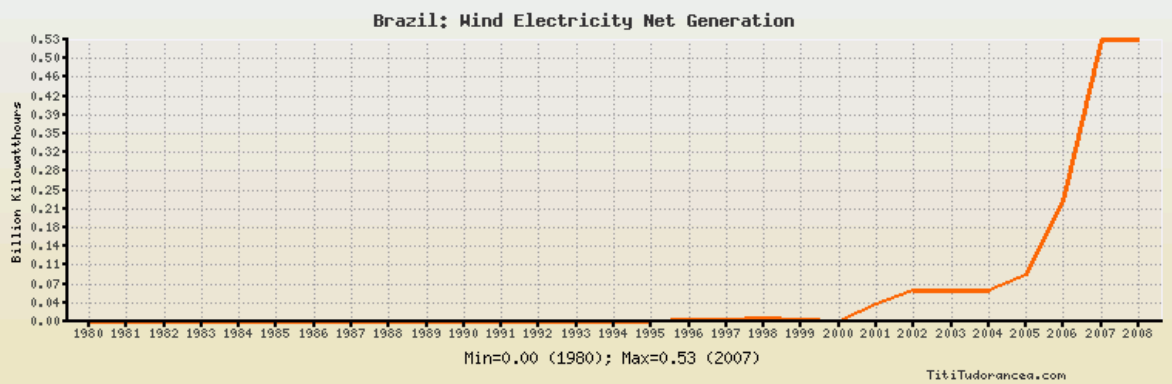
By the end of 2009, 36 systems were installed generating 602 MW installed capacity[54] and located in the north-eastern part of Brazil (5 states), in Southern Brazil (3 states) and in south-eastern Brazil (1 state). In 2010 the total installed capacity amounted at 800 MW[55].

Table 10: Installed capacity per year of installation

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010*
MW	22	29	29	29	237	247	341	606	800

*Source: Global Wind Energy Council, * Photon, Sept. 2011*

Figure 10: Wind electricity net generation from 1980 to 2008



Source: The Titi Tudorancea Bulletin, Brazil: Wind Electricity Net Generation, 2010

2.7 Other renewable energy installed and identified systems

Geothermal[56]

[53] Ein schlafender Riese, Sept. 2011, pages 124 to 141
[54] Clobo.com, Dec. 2010
[55] Ein schlafender Riese, Sept. 2011, pages 124 to 141
[56] Hamza, V. M., 2003

The lower temperature thermal systems under economic exploitation are estimated at 362 MWt, which represent about a dozen systems. Most of these geothermal systems are located in the central part of Brazil, in the states of Goiis and Tocantins, and in the southern part of the country in the state of Santa Catarina. Currently, the geothermal resources are being used mainly for bathing, recreation and tourism.

Wave or Tidal

There are currently to wave or tidal systems identified in Brazil.

3 Potentials of RES in Brazil

3.1 Biomass Energy Resource potential

The cogeneration potential of agricultural and livestock residues in Brazil is estimated at 4 GW and can reach 47 GW by 2025[57]. It is estimated that the energy potential from sugarcane bagasse ranges from 1,000 to 9,000 MW, depending on the technology that is to be utilized. According to an analysis from Frost & Sullivan, Brazil's sugarcane bagasse used for power generation has reached 3.0 GW in 2007, and it is expected to reach 12.2 GW in 2014. In fact, the sugarcane bagasse cogeneration accounts for 3% of the total Brazilian energy production[58]. This energy source is especially valuable during the dry season when the water levels in the dams are running low.

Brazil is also well recognized for its ethanol fuel production. Ethanol fuel is produced from sugar cane, Brazil having the largest sugar cane production in the world and as such, is also the largest exporter of ethanol. During the year 1975, the Brazilian government initiated the Pró-Álcool program or *Programa Nacional do Álcool* (National Alcohol Program), a nation-wide programme financed by the government with the aim to phase out all automobile fuel derived from fossil fuels as to replace it with ethanol. To date, the programme successfully reduced by 10 million the number of cars running on gasoline in Brazil, thus reducing the country's need to import oil[59].

3.2 Hydro Energy Resource potential

It is estimated that Brazil has a hydropower potential of 190,000 MW[60]. The gross theoretical capability or potential exceeds the 3,000 TWh per year, of which 800 TEh per year is exploitable economically[61].

[57] Survey of Energy Resources, 2004
[58] IHS, Dec. 2010
[59] Wikipedia, Ethanol fuel in Brazil, Dec. 2010
[60] New Hydroelectric project in Brazil, Dec. 2010
[61] Survey of Energy Resources, 2004

Table 11: Three largest projects currently planned in Brazil

Name	Location	Power	Cost	Expected completion date
Jirau	Madeira River in the Amazonian state of Rondônia	3,300-MW	US$3.9 billion	2013
Santo Antônio	Madeira River in the Amazonian state of Rondônia	3,150-MW	US$5.94 billion	2012
Belo Monte	on the Xingu River in the state of Pará	11,000-MW	n/a	In pipeline

Source: Latin America's Beacon, Power magazine, Dec. 2010

Brazil has the potential to build some 1,600 additional small hydroelectric plants, adding almost 15,000 MW of generating capacity to the grid (2010)[62].

3.3 Solar Energy Resource potential[63]

Sunlight hours[64]: Average 7 hours per day, depending on the location and the time of year.

Radiation intensity: 6 kWh/m^2/day

Greatest radiation potential: São Francisco River Basin and Sobradinho area in the Northeast.

Advantages of these sites: Excellent topographic conditions, grid access, cooling water, road access, low wind speeds, and moderate ambient temperatures with little daily variation, can easily accommodate large-scale solar power plants.

Direct radiation per year: 1800 and 2300 kWh/m² per year

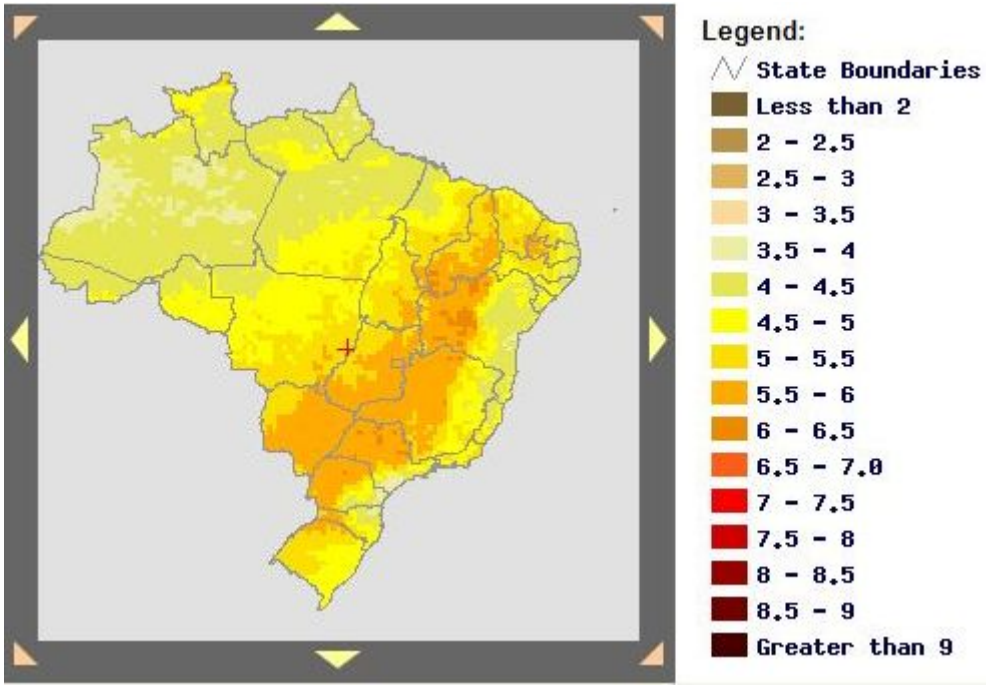
Note: Potential sites in Brazil are close to the equator and this has an optical advantage. Other sites with potential interest include Januária and Itacarambi.

[62] Brazil: Latin America's Beacon, Dec. 2010

[63] CSP Project Developments in Brazil, Dec. 2010

[64] IEA, Dec. 2010

Figure 11: Solar radiation map



Source: Maps of Solar Power Potential in LAC, Brazil, Dec. 2010

3.4 Wind Energy Resource potential

June to December offer the best potential for wind energy, which is during the lower rainfall season[65]. Brazil's wind potential is estimated to be 143GW[66]. In 2008 and 2009, new measurements carried out in several states based on measurements at 80-100 meters indicate that the real potential is considerably higher, probably more than 350 GW[67].

During 2009[68], 10 projects were under construction with a capacity of 256 MW. In 2010, 45 new projects in various states were initiated with the objective to generate 2,139 MW. During the 2009 United Nations Climate Change Conference, (COP15) in Copehagen, the National Electric Energy Agency of Brazil (ANEEL) held the country's first energy auction. In all, about 1,800 MW were contracted with energy from 71 wind power plants scheduled for delivery early July 2012 as follows:

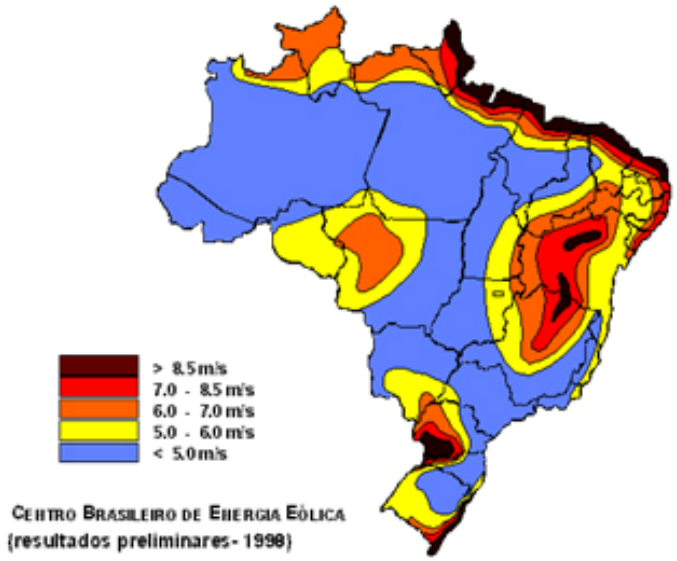
[65] Clobo.com, Dec. 2010
[66] MME, Dec. 2010
[67] GWEC, Dec. 2010
[68] Idem

Table 12: Wind power plants scheduled for delivery early July 2012

Location	Installed power	Number of wind farms
Rio Grande do Norte	657 MW	23 wind farms
Ceará	542 MW	21 wind farms
Bahia	390 MW	18 wind farms
Rio Grande do Sul	189 MW	8 wind farms
Sergipe	30 MW	1 wind farms

Source: GWEC, Dec. 2010

Figure 12: Wind energy resource map



Source: Centro Brasileiro de Energía Eólica

3.5 Other renewable energy sources potentials

Geothermal[69]

The total resources in geothermal is estimated at 1022 joules, of which only a fraction is being exploited. There is considerable potential for low temperature geothermal water use for industries and space heating in the southern and southeaster parts of Brazil where there is a cold season.

Wave or Tidal[70]

Tides in the North Region: 5 to 11 m

Waves: Hs= 1.2 to 3m T = 5 to 12s

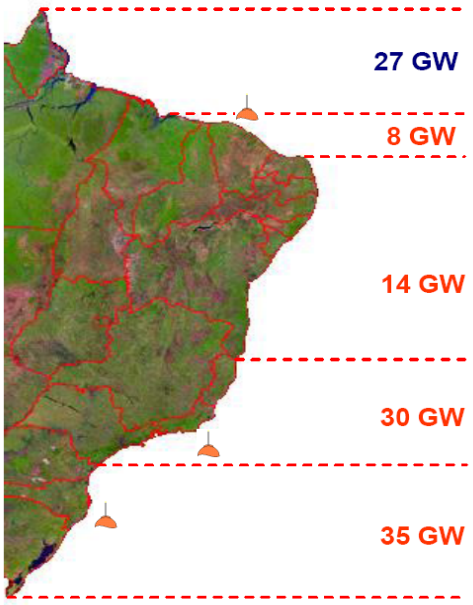
Table 13: Tidal energy potential by region

Region	Energy Potential (GW)
North (Tides)	27
Northest	22
Southest	30
South	35
Brazilian Potential	**114**

Source: Ocean Renewable Energystatus & Perspectives in Brazil, Dec. 2010

[69] Hamza, V. M., 2003
[70] Ocean Renewable Energystatus & Perspectives in Brazil, Dec. 2010

Figure 13: Tidal energy potential according to location



Source: Ocean Renewable Energystatus & Perspectives in Brazil, Dec. 2010

4 References

Books

Hamza, V. M. An Appraisal of Geothermal Energy Use in Brazil, Obeservatório Nacional, de Janeiro, Brazil, Geothermal Resources Council Transactions, Vol. 27, October 12-1 5, 2003

Ministerio de Minas y Energia, Programa Nacional de Universalização do Acesso e Uso da Energia Elétrica – Manual de Projetos Especiais. Anexo à Portaria Nº 60, de 12 de fevereiro de 2009. Eletrobrás/Ministry of Mines and Energy, Brasília

Niez, Alexandra, International Energy Agency,Comparative Study on Rural Electrification Policies in Emerging Economies, Keys to successful policies, France, 2010

Zerriffi, H., From çaí to access: distributed electrification in rural Brazil. International Journal of Energy Sector Management 2, 2007

Articles

Ein schlafender Riese, Viel Samba und viel Sonne, aber die Photovoltaik steckt in Brasilien noch in den Kinderschuhen, Articel in Photon, Sept. 2011

Internet sources

Arcadia Market Commentary, Renewable Energy, Development in Emerging Markets, http://www.arcadia4u.com/commentaries/200908-Arcadia%20Market%20Commentary.pdf, August 2009

Associação Brasileira de Distribuidores de Energia Elétrica (Abradee), http://www.abradee.org.br/, Dec. 2010

Biodiesel, Ministério de Minas e Energia (MME) http://www.mme.gov.br/mme/perguntas_frequentes/faq.html, Dec. 2010

Brazil, Country anlyse briefes, Brazil Energy Data, Statistics and Analysis - Oil, Gas, Electricity, Coal, September 2009, http://www.eia.doe.gov/emeu/cabs/Brazil/pdf.pdf, Dec. 2010

Brazil, Globla Wind Energy Council (GWEC), http://www.gwec.net/index.php?id=118, Dec. 2010

Brazil, The world fact book, Central Intellegence Agency (CIA), https://www.cia.gov/library/publications/the-world-factbook/geos/br.html, Dec. 2010

Brazil: Latin America's Beacon, Power magazine, January 1, 2010, http://www.powermag.com/distributed_generation/Brazil-Latin-Americas-Beacon_2363_p3.html, Dec. 2010

Climate & Temperature, What is the Climate, Average Temperature/ Weather in Brazil?, http://www.climatetemp.info/brazil/, Dec. 2010

Clobo.com, Brasil conclui primeiro leilão de energia eólica, a gerada pelos ventos, 14/12/09, http://g1.globo.com/Noticias/Ciencia/0,,MUL1415078-5603,00-BRASIL+CONCLUI+PRIMEIRO+LEILAO+DE+ENERGIA+EOLICA.html, Dec. 2010

Comparative Study on Rural Electrification Policies in Emerging Economies, OECD/IEA 2010, http://195.200.115.136/papers/2010/rural_elect.pdf, Dec. 2010

CSP Project Developments in Brazil, Solar Power And Chemical Energy Systems, http://www.solarpaces.org/News/Projects/Brazil.htm, Dec. 2010

Defending the Amazon, Belo Monte Dam, http://www.amazonwatch.org/amazon/BR/bmd/index.php?page_number=2 , Dec. 2010

http://www.iea.org/weo/database_electricty10/electricity_database_web_2010.htm

IHS, The source for critical information and insight, Frost: Brazil Turns to Sugarcane Bagasse Power Generation to Reduce Hydropower Dependence, September 30, 2008 // *Published as a news service by* HIS, http://energy.ihs.com/News/biofuels/2008/frost-brazil-bagasse-093008.htm, Dec. 2010

Index Mundi, Brazil Electricity – consumption, http://www.indexmundi.com/brazil/electricity_consumption.html, 2007 est.

Index Mundi, Brazil Population growth rate, http://www.indexmundi.com/brazil/population_growth_rate.html, 2010 est.

International Energy Agency, EIA, Statistics, Electricity, Electricity/Heat Data for Brazil, http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=BR, Dec. 2010

International Energy Outlook 2010, eia, http://www.eia.doe.gov/oiaf/ieo/electricity.html, Dec. 2010

Key World Energy Statistics Key World Energy Statistics, International Energy Agency, IEA, 2006, http://web.archive.org/web/20070709212140/http://www.iea.org/dbtw-wpd/Textbase/nppdf/free/2006/key2006.pdf, Dec. 2010

Maps of Solar Power Potential in LAC, Brazil, http://www.temasactuales.com/temasblog/wp-content/Images/BZsolarMap.jpg, Dec. 2010

National Geografic, Ethanol Production Could Be Eco-Disaster, Brazil's Critics Say, Kelly Hearn, for National Geographic News, February 8, 2007, http://news.nationalgeographic.com/news/2007/02/070208-ethanol.html, Dec. 2010

New Hydroelectric project in Brazil (16 MW), Velcan Energy, Press Release

SÃO PAULO, 14th March 2008, http://www.velcan.fr/docs/VEPressRelease14032008.pdf, Dec. 2010

Nonproliferation for Global Security Foundation – NPSGlobal, Brazil and Argentina's Nuclear Cooperation, Carnegie Endowment for International Peace - Proliferation Analysis, Irma Arguello, 9 January 2009, http://npsglobal.org/eng/component/content/article/106-latin-america-and-caribbean/374-brazil-and-argentinas-nuclear-cooperation.html, Dec. 2010

Nuclear Power in Brazil, Briefing Paper # 95, June 2006, http://web.archive.org/web/20070208105204/http://www.uic.com.au/nip95.htm, Dec. 2010

Ocean Renewable Energystatus & Perspectives in Brazil, Segen Estefen, COPPE/UFRJ –Ocean Engineering Department, Brazil NEET Workshop –Brasília, 19-20 November 2007, http://www.iea.org/work/2007/neet_brasilia/Estefen.pdf, Dec. 2010

OECD Economic Survey of Brazil 2005: Regulation of the Electricity Sector, Excerpt from Chapter 3 of the OECD Economic Survey of Brazil, 2005, OECD, http://www.oecd.org/dataoecd/12/11/34427493.pdf, Dec. 2010

Outlook of Nuclear Power in Brazil, Ronaldo C. Fabrício, Meeting of the Americas, Wahington D.C., 17 November 1998, http://www.eletronuclear.gov.br/downloads/41/49.pdf , Dec. 2010

Programma Nacional de Universalizacao, do Acesso e Uso da Energia Elétrica, Manual de Projetos Especiais, Ministério de Minas e Energia, Eletrobrás, de 12 de Fevereiro de 2009, http://luzparatodos.mme.gov.br/luzparatodos/downloads/Manual%20de%20Projetos%20Especiais.pdf, Dec. 2010

Solar Power and Chemical Energy Systems, START Report 2/98, International Energy Agency (IEA), http://www.solarpaces.org/_Libary/START_Brazil%20Start%20Mission%20Rept.pdf, Dec. 2010

Stoppt den Agrarenergie-Wahn!, Published by GRAIN | seedling@grain.org | www.grain.org, Rettet den Regenwald e. V. | info@regenwald.org | www.regenwald.org

Übersetzung: Norbert Suchanek, http://www.swissaid.ch/global/PDF/entwicklungspolitik/agrotreibstoffe/agrarenergie_grain_sonderheft_de.pdf, Dec. 2010

Survey of Energy Resources, 2004, World Energy Counsil, http://www.worldenergy.org/documents/ser2004.pdf, Dec. 2010

The Titi Tudorancea Bulletin, Brazil: Biomass and Waste Electricity Net Generation, http://www.tititudorancea.com/z/ies_brazil_biomass_waste_electricity_generation.htm, October 21, 2010

The Titi Tudorancea Bulletin, Brazil: Hydroelectricity Net Generation, http://www.tititudorancea.com/z/ies_brazil_hydroelectricity_generation.htm, October 21, 2010

The Titi Tudorancea Bulletin, Brazil: Total Electricity Exports, http://www.tititudorancea.com/z/ies_brazil_electricity_exports.htm, October 21, 2010

The Titi Tudorancea Bulletin, Brazil: Wind Electricity Net Generation, http://www.tititudorancea.com/z/ies_brazil_wind_electricity_generation.htm, October 21, 2010

The world fact book, Central Intellegence Agency (CIA), Redirects, CIA Site Redirect http://www.cia.gov/library/publications/the-world-factbook/geos/br.html, Dec. 2010

True Knowledge, http://www.trueknowledge.com/q/population_density_of_brazil_2010, Dec. 2010

Tucuruí Hydropower Complex Brazil, Final Report: November 2000, La Rovere, E.L., Mendes, F.E., World Commission on Dams (WCD) Case Study, http://www.dams.org/docs/kbase/studies/csbrmain.pdf, Dec. 2010

U.S. Geological Survey's (USGS) Water Science for Schools, Itaipú Dam: The world's largest hydroelectric plant, 14-Dec-2010, http://ga.water.usgs.gov/edu/hybiggest.html, Dec. 2010

Wikipédia, a enciclopédia livre, Empresa de Pesquisa Energética, http://pt.wikipedia.org/wiki/Empresa_de_Pesquisa_Energ%C3%A9tica, Dec. 2010

Wikipedia, die freie Enzyklopädie, Electricity sector in Brazil, http://en.wikipedia.org/wiki/Electricity_sector_in_Brazil, Dec. 2010

Wikipedia, die freie Enzyklopädie, Energy policy of Brazil, http://en.wikipedia.org/wiki/Energy_policy_of_Brazil, Dec. 2010

Wikipedia, die freie Enzyklopädie, Ethanol fuel in Brazil, http://en.wikipedia.org/wiki/Ethanol_fuel_in_Brazil, Dec. 2010

Wikipedia, die freie Enzyklopädie, Itaipú, http://de.wikipedia.org/wiki/Itaip%C3%BA, Dec. 2010

Wikipedia, die freie Enzyklopädie, Organisation for Economic Co-operation and Development, http://en.wikipedia.org/wiki/OECD, Dec. 2010

World Commission on Dams (WCD), A review on regional dams and reservoirs in Brasil, Aziz Nacib Ab'Saber, Department of Geography University of São Paulo, http://www.dams.org/kbase/consultations/latin/abs_p1_en.htm#saber, Dec. 2010

5 Related links

Brazil Government organizations

Organization	Web site
Brazilian Institute for the Environment and Renewable Natural Resources (Ibama)	http://www.ibama.gov.br/
Electrobras	http://www.eletrobras.gov.br/
Ministério do Meio Ambiente	http://www.mma.gov.br/sitio/
National Agency of Electricity (Agência Nacional de Energia Elétrica - ANEEL)	www.aneel.gov.br/
Operator of the National Electricity System (**Operado** Nacional do Sistema Electrica - ONS)	http://www.ons.org.br/home/
Power Commercialization Chamber (Câmara de Comercialização de Energia Elétrica - CCEE),	www.ccee.org.br/
Presidency of Brazil	http://www.presidencia.gov.br/
The Ministry of Energy and Mines (Ministério de Minas e Energia -MME)	http://www.mme.gov.br/mme

International organizations

Organization	Web site
Banco Interamericano de desarrollo	http://www.iadb.org/
Food and Agriculture Organization of the United Nations	www.fao.org
International Energy Agency	www.iea.org
International Monetary Fund	www.imf.org
JICA - Japan International Cooperation Agency	www.jica.org.kh
United Nations Development Programme	www.undp.org
World Bank	www.worldbank.org

Other information sites

Organization	**Web site**
Central Intelligence Agency, USA	www.cia.gov/library/publications/the-world-factbook
Climate & temperature	www.climatetemp.info
Index Mundi	www.indexmundi.com
Internet World Stats	www.internetworldstats.com
NASA Atmospheric Science Data Center	http://eosweb.larc.nasa.gov
Probe International	www.probeinternational.org

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