Brazil: Keeping the Lights On

by Susana Moreira

In 2001, Brazil endured severe power shortages that resulted in mandatory rationing and ultimately, in a significant reduction of GDP growth.[1] Worse than the personal inconvenience and economic contraction was the embarrassment all Brazilians felt for what had happened. The "country blessed by God" had shown the world, once again, that it was unable to put its vast natural resources to good use. Brazil barely escaped forced electricity rationing; however, there is widespread belief among energy experts that rationing may yet occur within the next four years.

This paper starts with an overview of the main features of Brazil's power sector, reviewing the latest available production and consumption statistics. It continues with a discussion of the potential power generation gap in Brazil. The central section of this paper focuses on the elements of an integrated strategy for Brazil to ensure the provision of electricity for its people. The conclusion highlights the importance and urgency of this issue for Brazil and its region.

Overview

Electricity services are critical to economic development and the elimination of poverty. Like most countries, the state has played a central role in electricity development in Brazil. In March 2004, Brazil approved a new electricity sector model, in which the central government reassumed several of the coordinating responsibilities it had forsaken in the privatization efforts of the 1990s. In addition, the new model reformulated the incentive structure and the energy-planning system, in an effort to increase security of investments in energy generation and transmission. It also introduced an energy-purchasing pool and established the existence of "new" and "old" (existing) energy sources, which are to be sold under different rules.[2]

Hydropower Generation Dominance

Since 1970, hydropower has been responsible for over 80 percent of Brazil's electricity production.[3]

In the last five years, Brazil's electricity production increased 23.2 percent. Over 56 percent of this increase was produced by hydropower.[4] In 2007, hydropower represented 85.2 percent of total electricity production, including 7.9 percent

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imported from Itaipu's hydropower plant in Paraguay. At this level, hydropower's share of Brazil's electricity production is substantially higher than the world average (16 percent).

Brazil's high utilization of hydropower has resulted in the limited contributions of nuclear, natural gas, and coal to electricity production; areas in which Brazil is substantially below the world average. Hydropower, biomass, and wind power have had significant increases in production in recent years, which contributed to strengthen their relative shares. The share of renewables in Brazil's electricity supply increased 0.9 percent to 88.7 percent in 2007, despite a sharp increase in oil derivatives usage (up by 10.4 percent). In the end, Brazil's electricity production increased by 5.3 percent to 441.8 TW in 2007.[5]

Vast Interconnected System

In the mid 1960s the existing electricity systems that had been functioning independently started to work in an integrated fashion through regional coordinating groups that were able to make the most of the existing resources and improve the quality of service. These regional groups remained in operation for 30 years.[6]

In 1998, the government led by Fernando Henrique Cardoso established the National Operating System (ONS), the body responsible for the operation of the National Interconnected System (SIN) and the management of Brazil's basic national power system. Shortly before the launch of ONS, the first North-South transmission line was inaugurated, allowing for the exchange of energy between the North and Northeast and the rest of the country.

In the past 9 years, SIN expanded over 36 percent, reaching a total of 87,235 km in length in 2007, making it one of the largest interconnected electric grids in the world.[7]

Although only 3.4 percent of Brazil's electricity production capacity is outside SIN, there are substantial differences in national coverage. The transmission network is structured to carry the majority of the energy generated in the electricity system to the Southeast region, where most of the country's industrial sector and population is concentrated. The North-Northeast regions have transmission lines that carry a much lower load and a weaker grid, concentrated on the coast. The Center-West region has a better grid than the North-Northeast region, but its coverage is unbalanced, favoring the Federal District. The Amazon region has not yet been reached by the interconnected system and relies on a cluster of isolated systems.

Growing Demand

After 30 years of sustained increase in electricity consumption[8], Brazil experienced a 6.6 percent decline in 2001. Since then, electricity consumption has resumed its growth at an average rate of 4.9 percent; this rate is still lower than the average growth rate between 1970 and 2000. Since 2006, average monthly incomes increased, unemployment is at a historic low, and credit has become more accessible, contributing an increase in demand of electricity by 5.6 percent in 2007 and by 3.5

percent in the first six months of 2008.[9]

Potential Generating Gap?

As early as 1998, there were several warnings of an impending energy crisis in Brazil. Diminished investment combined with a sharp increase in demand, especially since the mid-1990s, put pressure on Brazil's existing electricity production capacity. When drought occurred in 2000, Brazil's dams had the lowest water volumes in two decades, after years of overuse. An already overstretched production system collapsed.[10]

Six years later, new signs of an overextended electricity sector started to pile up:

- Intermittent supply of electricity throughout rural Brazil, particularly in the North-Northeast regions, jeopardizing among other things the success of educational initiatives[11]
- Shut-down of natural gas supply to industries in Rio de Janeiro and Sao Paulo to ensure supply to thermoelectric plants in October 2007[12]
- The highest prices for electricity in Brazil's "spot market" since 2001, from R$58.76 in 2006 to R$569.5 in January 2008[13]
- Factory shutdowns and lay offs at Novelis and Coteminas in response to high electricity prices[14]

As before the 2001 crisis, energy experts, the business community, and even government institutions like the National Bank for Development (BNDES) responded to these warning signs and called for action by the government to prevent another debacle.[15] The general consensus is that the imminent generating gap is due to Brazil's inability to expand electricity supply as planned. At the end of 2004, the expected "firm supply"[16] of electricity for 2008 was 57,000MWmed. At the end of 2007, "firm supply" for 2008 was reduced to 51,400MWmed, which is actually lower than the existing generating capacity in 2004. This 5,600MWmed difference is explained by an absence of an integrated approach towards Brazil's natural gas sector, Argentina's decision to cut natural gas exports to Brazil and Bolivia's nationalization of its natural gas sector and subsequent decline in natural gas exports to Brazil.[17]

The structural unbalance between demand and "firm supply" made Brazil's power sector vulnerable to drought like the one in late 2007 and early 2008. In January 2008 the risk of rationing reached 22 percent, four times higher than normal. From then onwards the rationing risk has declined substantially because heavy rains have increased water volumes and because of government intervention: 6 oil-based thermoelectric plants came online and supply for 25 natural gas-based plants was ensured by Petrobras. President Lula also clearly stated that electricity production was going to be prioritized, even at the expense of transportation and industry.[18]

The Extent of New Generating Capacity Required[19]

The "10 Year Energy Expansion Plan, 2007-2016" elaborated by Brazil's Ministry of Mines and Energy (MME), expects consumption to grow between 45 and 50 percent, partly as a result of the "Light for Everyone" initiative.[20] The MME is nevertheless confident that electricity shortages will not occur, as supply within SIN will expand rapidly (49 percent). Behind this supply increase is a planned R$148.5bn investment in power generation and transmission over the 2007-2016 period. 70 percent of this investment will come from the Brazilian government, through its Program for Growth Acceleration (PAC).[21]

Nevertheless, the Institute for Applied Economic Research (IPEA), linked to the Ministry of Planning, Budgets and Management, concluded that investments foreseen by PAC will not remove the risk of a supply gap in the next five years, even if all projects are on schedule. IPEA continued, stating that if GDP grows above 5 percent over the next three years and demand elasticity doesn't decline over time, the shortages in supply could be observed as early as 2009, if there is a drought.[22]

Instituto Acende Brasil (IAC) ("Institute Light Up Brazil"), which represents investors in the power sector, accused the MME of being too optimistic, as its estimates are based on low GDP growth rates (4 percent) and do not factor in the customary long delays in increasing capacity. IAC's concerns have been validated by two factors. The first factor is PAC's poor performance in 2007. According to Brazil's Electric and Electronic Industry Association (ABINEE), the government's claim that 83 percent of PAC projects were on schedule in 2007 is inaccurate. The actual figure is somewhere around 50 percent. This is due to the government's failure to push on bidding processes and to meet the investment target for 2007 set by PAC (R$4.5bn vs.R$16.5bn). The second factor is PAC's expected disappointing performance until 2013. The Energy Research Enterprise (EPE), linked to the MME, concluded that 95 percent of projects in 2009 will be behind schedule. The situation will improve somewhat in 2010 (63 percent) and 2011 (15 percent), but greatly worsen in 2012 (99 percent) and 2013 (70 percent).[23] IAC claims that demand will outstrip "firm supply" in 2008, 2009, 2011 and 2012. There is not enough time to add generation capacity to the system and balance demand and supply in 2008 and 2009.

Filling the gap

Assuming that the actual evolution of Brazil's electricity sector will be closer to IPEA and IAC's estimates, based on the accuracy of its past predictions and the MME's systematically imprecise forecasts, Brazil will have a generating gap in three of the next four years. To fill this gap, Brazil needs to implement a comprehensive strategy that includes improvements in energy efficiency and transmission lines, expansion of hydroelectric, thermoelectric, bioelectric and aeolic production capacity, and, finally, overcoming institutional inefficiencies.

Energy Efficiency[24]

Numerous studies have shown that investments in energy efficiency are not a net cost to the economy, but rather yield positive returns. It also has a positive environmental impact, reducing carbon dioxide emissions.

For the past twenty-four years, Brazil has been developing four major power efficiency programs, for example, upgrading of consumer appliances. These projects have had some success: Electricity consumption has been more efficient than other forms of energy consumption, from 1984 to 2004, and this trend is expected to continue up to 2024. Though the performance of the electricity sector is encouraging in absolute terms, its efficiency growth rates have been significantly lower than the overall growth rates (13 percent vs. 27 percent).

In response to the slowing down of efficiency gains and estimates that there is an appreciable economy potential in the use of electricity (10-15 percent), Brazil's MME introduced a series of measures in its "10 Year Energy Expansion Plan, 2007-2016". These measures are part of the new "Strategic Plan for Energy Efficiency" (PNEf)[25] and target different consumer segments: residential, commercial and services, industrial and public services. The government is betting on both equipment replacement and project and process optimization.

Since the launch of PNEf in 2007, implementation has lagged. For example, appliances that do not meet minimum efficiency standards will be taken off the market, only in September 2008.[26] There is also proof of a disconnect between the MME plans and what is being said by the current Minister of Mines and Energy, who stated that "[t]here is no need to encourage the population to save energy."[27] This is particularly worrisome because improving efficiency requires strong political commitment.

Efficiency gains are also a function of the legal and regulatory environment, deemed in need of improvement by both government and private entities like the Association of Brazilian Energy Service Companies and the National Program for Energy Conservation (PROCEL). After reading the "10 Year Energy Expansion Plan, 2007-2016", it is clear that financial resources will continue to be scarce[28] and will come from an array of institutions and programs, which complicates matters further.

In sum, stronger political leadership is required in order to convey a higher priority to electricity efficiency. The new strategy should:

- Develop a new operational structure capable of articulating the diverse agents involved;
- Introduce a coordinated package of regulatory and fiscal policy instruments, which offers much more in the way of both carrots and sticks.
- New building regulations should introduce efficiency requirements. Estimates suggest that electricity savings could amount to as much as 50 percent.
- Launch high profile campaigns to raise awareness among the public;

Set absolute targets for reductions in demand in the South-Southeast regions as a way of revolutionizing Brazil's approach to energy saving and ensuring efficiency gains.

Transmission Grid Amplification[29]

As the MME suggests, an additional expansion of the transmission grid is warranted to ensure that market actors have easy access to the network, fostering an environment that favors competition and resource management optimization. It will also increase interconnection of sub-regions and create opportunities for gains of scale and size, increasing SIN's dependability and minimizing regional supply cost differences.[30] Energy experts add that SIN needs to be expanded to correct the persistent asymmetry in regional grid coverage.

After analyzing the Ministry's investment plan for 2007-2016, valued at approximately R$21bn, there is mixed evidence on the extent to which SIN's performance and reach will change as a result. On the one hand, the projects to integrate the presently isolated Acre-Rondonia and Manaus-Macapa sub-regional power systems into SIN will surely contribute to a reduction of regional electricity prices and create gains of scale and size to SIN. On the other hand, 8 out of the 13 projects planned for 2010-2015 are destined to connect the Southeast to newly constructed generation plants in the North and Northeast, in a self-reinforcing pattern that favors the Southeast region. None of the 13 projects is focused in expanding the existing grid inward and only two projects are set to improve transmission within the Northern states of the Amazon and Maranhao.

These unbalances exacerbate discontent among Brazilians in the North and Northeast regions. They resent SIN for taking the energy produced in their territories and using it to supply the Southeast, while the poorest states in Brazil pay the highest electricity prices due to their isolation. The Brazilian government should address these concerns and revise its current expansion plan so as to include projects that expand the grid inward, especially in the Northern states. The benefits of moving towards a more balanced transmission grid are multiple, from lower electricity prices, to reduced C02 emissions and improved educational performance.

Production Expansion

The Brazilian government anticipates a 49 percent growth in electricity supply, between 2007 and 2016. This section evaluates some of the governments' efforts to ensure this increase across Brazil's major sources of electricity: hydraulic, thermal and other renewables.

Hydropower[31]

Brazil's massive hydraulic resources amount to 266,000 MW, of which only 27 percent was being exploited by the end of 2006.[32] Even with rigorous environmental restrictions, Brazil can double its installed hydropower capacity, expanding a system that has become the essential source of supply of the entire network thanks to

insignificant marginal costs of operation.

In the MME's "10 Year Energy Expansion Plan" hydropower generation capacity is expected to grow 41 percent to 109,058MW, between 2007 and 2016. Almost all the added capacity will come from new large hydroelectric plants in the Amazon. 90 percent of new hydropower capacity auctioned in 2007 was in the Amazon and EPE expects that the Amazon will account for 87 percent of additional capacity between 2013 and 2016. Hydroelectric generation capacity in the Southeast and Itaipu will remain flat until 2016; while there will be slight capacity increases in the South and Northeast of the country, a shift from Brazil's traditional concentration of hydroelectric capacity in the Southeast.

The Madeira hydroelectric project, part of PAC, is critical to the growth of Brazil's installed capacity to meet growth in medium-term energy demand. It will have a generating capacity of 6,450MW and supply electricity to 22 million homes. The 3,150MW Santo Antonio hydropower plant is the first of two that will be built in the Madeira basin, following a competitive auction held by Agencia Nacional de Energia Eletrica (ANEEL), the Brazilian electricity regulatory authority, in December 2007. The required construction license was issued by the Brazilian Environment and Renewable Resources Institute (IBAMA) in August 2008. The dam will cost US$5.94bn and should be finished by 2012.[33] The other dam, Jirau, was auctioned in May 2008 and should be completed by 2013.[34]

Brazil is also studying the construction of six bilateral hydroelectric stations with Argentina, Bolivia, and Peru. It's believed that once constructed, the six stations would provide electricity of a total of 10,000MW to 12,000MW. Depending on its neighbors may be risky, as the imbroglio with Bolivia attests. Moreover, Fernando Lugo -Paraguay's recently elected President- has called for a renegotiation of the Itaipu agreement, under which each country is granted 50 percent of the energy produced but is required to sell surplus energy to the other party at cost. The Brazilian government has declared that it will not renegotiate, but has already offered funds for Paraguayan development, including a beefed up transmission line to electricity-starved Asuncion, in an effort to secure access to its share of the power generated in Itaipu.[35]

Despite the government's commitment to the expansion of hydropower capacity, the share of thermoelectricity in ANEEL's energy auctions has been growing, while hydropower's participation has declined. Ideally, hydropower's share should be about double its current average of 35 percent.[36] The disappointing performance of hydropower can be explained by a combination of different factors:

Large dams are expensive and time-consuming to build (up to 10 years) and new projects have met delays and difficulties, especially in obtaining environmental licenses.[37]

Hydropower may be much cheaper than thermoelectric generation, but its unitary costs, i.e. the sum of operational and fixed costs, increase dramatically as generation levels are reduced, because of the huge and long-

term fixed costs.

Generation is subject to uncertain rainfall, necessitating both long-term planning to coordinate investments to expand capacity and coordination of transmissions throughout the system.

Big dams are likely to be located far from centers of demand, requiring large investments in transmission lines to connect them to the national grid.

The negative environmental impact of dams has generated growing opposition by non-governmental organizations and indigenous groups.[38]

Damming often requires the loss of land and property. As a result there has been an increase in organized opposition.[39]

Despite these shortcomings, hydropower still offers very significant advantages: it is clean, renewable, produced domestically (in most instances), and generally available when needed. An alternative that capitalizes on hydropower's advantages, while avoiding most of its shortcomings, are small hydroelectric plants (PCH). PCHs have a smaller environmental impact, require lower investment volumes, mature earlier, and are a way of supplying isolated areas with cleaner and less expensive electricity. Besides, PCHs are considered an alternative energy source and using them gives credits under the Kyoto Protocol that can be traded in proper markets. The value of these credits will certainly not pay for the whole investment, but will bring some return and, these days, give its producers and users an environment friendly image.

Estimates suggest that Brazil has the potential to build over 1,600 PCHs, which should add around 15,000MW of generating capacity to the system. there were only 253 PCHs operating in Brazil in 2007, of which nearly 50 percent were integrated in SIN. There have been some recent efforts to accelerate the growth of PCHs, including Petrobras' 2008 opening of 13 PCHs across the country, which will produce 300MW.[40] Though laudable, Petrobras' investments are not enough. To explore the existing potential to its fullest, Brazil needs political will capable of leading the system away from overdependence on large dams. Expansion of PCH use also requires stronger fiscal incentives, improved technical support and high profile campaigns, targeting both consumers and industry specialists.

Another way of mitigating some of the downsides of large hydropower plants is to capture and burn methane at existing dams to produce electricity. Methane builds up when trees and other plants that were flooded decompose without oxygen. Burning methane can result in a 30 percent increase in power generation, according to Brazil's National Space Research Institute (Inpe). In fact, some believe that it would be better to burn the methane produced by hydroelectric plants already in place in the Amazon than to build a new plant in the region.[41] Industry representatives have shown interest in this new option, but investment in its development is lacking. The Brazilian government should actively support this initiative because it is an opportunity to develop valuable technological expertise. Much like with ethanol, Brazil has a strong motivation (growing risk of a mismatch

between demand and supply of electricity), large quantities of a cheap resource (water already sitting in dams), and developed research institutes (like Inpa and Inpe). Furthermore, the distribution problem that plagued ethanol development has already been solved by the fact that almost all dams are a part of SIN. The government's support should come in the form of dedicated funding and the design of a regulatory and administrative framework that ensures intellectual property protection and promotes collaboration between government institutions (both federal and regional) and between them and private companies.

Hydropower is thus one of Brasilia's best alternatives to secure increased generation capacity, due to vast hydraulic resources yet to be brought online and an existing regulatory and industrial framework to explore them. The government, however, needs to move away from set practices, like investing almost exclusively on large dams. This conservative approach prevents Brazil from taking advantage of alternative approaches and technologies that would help establish a more sustainable hydropower generation model.

Thermoelectric Generation

Hydropower is the backbone of Brazil's electricity generation system, but it is also climate sensitive. The realization of overdependence on this resource after Brazil's energy crisis in 2001, combined with the belief that climate change may further reduce the dependability of this power source[42] resulted in new investments in thermoelectric generation to diversify the electrical supply system.

Thermoelectric generation is not vulnerable to changing weather and helps stabilize supply levels,[43] though the cost is much higher than hydroelectric energy from amortized plants. This cost difference, estimated at around 65 percent is one of the main reasons for thermoelectricity's small share in Brazil's electricity generation matrix (14.7 percent in 2007). In December 2006 there were a total of 75 thermoelectric plants, 32 of which were powered by natural gas. The other sources of thermoelectricity are biomass, nuclear power, oil derivatives, coal and industrial gas.[44]

Natural Gas

In 2000, the government launched a program to make viable the use of gas as an alternative and complementary energy source for generating electricity. This followed an increase in the supply of natural gas, both from within Brazil and imported from Bolivia, through Gasbol.[45] At first 49 plants were selected, spread throughout Brazil, 73 percent of which were completed by 2006. Excluding biomass and industrial gas, natural gas represented 59.3 percent of total thermoelectric installed capacity in December 2006, but only 24.6 percent of thermoelectric generation in 2007, due to natural gas shortages.[46]

As the MME anticipated in its "10 year Energy Expansion Plan, 2007-2016", natural gas demand for industrial and thermoelectric purposes outstripped supply in 2007.[47] If all existing natural gas fired thermoelectric plants had been brought online,

there would have been a 16 million m3/day deficit in supply. The situation in early 2008 only worsened with the deficit ballooning to 25 million m3/day. Petrobras, the largest thermoelectric producer in the country was supplying the market with only 2,700MW in January 2008, despite having an installed capacity of 6,000MW.[48] The situation is expected to improve by the end of the year, as a result of rising imports; the inauguration of gas pipelines that connect Rio de Janeiro and Manaus to the natural gas producing fields in Espirito Santo and Urucu, respectively; and, finally, the launch of a floating regasification and storage unit (FRSU) in Rio de Janeiro.[49]

The MME estimates that national supply of natural gas will match demand between 2009 and 2011. This positive development is product of a combination of logistics improvements and new added production capacity, both within Brazil and imports (LNG), including:

- Several new natural gas fields in the Espirito Santo, Campos and Santos basins will come online in 2008-2011. The Santos basin is expected to expand its production to 25 million m3/day by 2010.[50]
- The Nordestao 2 and Urucu-Porto Velho gas pipelines are scheduled to become operational in 2009-2010. Nordestao 2 will take natural gas to the interior of the country, while the Urucu-Porto Velho projects will take Amazon produced gas to Rondonia.
- By 2009-2010, the Gasene gas pipeline system will connect existing southeastern gas system to the Northeastern gas system.
- By 2009-2010, the new FRSU unit in the northeast (Ceara state) will provide 220 million m3/day, for a combined 670 MMcf/d of gas sendout capacity from both FRSU units.

As ICA and EPE point out, many of the above mentioned projects are currently behind schedule, mostly due to licensing delays. Even if they do fail to become operational in time, the demand for natural gas will be higher than the supply.

The MME predicts that in 2012 there will be a supply deficit that will continue through 2016 but it may be avoided, thanks to:

- The Jupiter and Tupi finds. Although exploration may be difficult and costly, these two fields have dramatically increased Brazil's natural gas reserves. They are expected to be fully operational by 2013.
- LNG imports from various sources, including Algeria, Nigeria and the Middle East.[51]
- Establishment of a new FRSU unit, which will add flexibility to natural gas supply and secure supply to areas not covered by the existing gas pipeline network.[52]

The Brazilian government should also introduce a new regulatory framework for the natural gas sector, creating incentives for private investment; establish minimum

production quotas for electricity generation; and reduce the system's overdependence on Petrobras. In addition, dependence on Bolivia's natural gas should decrease, since it is apparent that supplies will remain unstable.[53]

Biomass

Biomass[54] is one of the most sustainable inputs in the short term. It can be used to produce fuel and/or generate electricity and benefits at many levels: environmental (greenhouse gases emissions reductions, local pollution reduction), social (job generation and income distribution), economic (reducing fuel imports), technological (paying royalties) and operational ones (capacity to install, operate and reproduce in the various regions).[55]

In 2002, the Brazilian government introduced the Program to Promote Alternative Sources of Electricity (Proinfa). The main goal was to increase electricity supply, reducing greenhouse gas emissions and promoting sustainable development. To achieve this objective, the Brazilian government gave R$11bn to Proinfa and introduced a series of fiscal incentives. It also financed a variety of R&D projects in biomass energy technologies.

In the five years that followed Proinfa's launch, Brazil rapidly increased its bioelectric capacity, particularly in the South-Center-West region (80 percent) and in the North-Northeast region (20 percent). In 2007, biomass generated 3.5 percent of Brazil's total electricity, which makes it the second largest source of thermo-electricity. A large part of the 16,235MW produced in 2007, trace back to the country's booming sugar and alcohol sector.

The burning of bagasse, the leftover from crushed sugar-cane stalks, provides a cheap source of thermoelectricity that is located in close proximity to the country's major consumption centers (reducing transmission and distribution costs). Despite being seasonal, sugar cane's harvest season coincides with the dry season in the Southeast/Center-West, which allows it to complement hydroelectric generation. The thermoelectric generating potential of bagasse is expected to continue to grow at a strong rate, following the likely expansion of sugar cane production (1bn tons by 2020) and the diffusion of a new co-generation technology, thrice more efficient than the existing technology.[56]

As part of the government's strategy to promote biomass and other alternatives, ANEEL organized the "First Auction of Energy produced by Alternative Sources", in June 2007. The auction ended up adding 638.64MW of generating capacity, 85 percent of which was ensured by bioelectric plants. In August 2008 the first auction to contract reserve energy, generated by biomass was held. 2,300MW were contracted out, twice the capacity needed to power San Francisco. The bioelectricity producers signed mid-term supply contracts, which provide them with a stable source of income.

It is thus apparent that the Brazilian government is doing a good job of promoting biomass as an alternative generation source. However, the various new institutes and research centers doing R&D on biomass still lack coordination.[57]

Furthermore SIN is often inaccessible to bioelectricity producers, which prevents them from selling their excess electricity. The government needs to advance technology and make the most of Brazil's potential. Finally, biomass is no "silver bullet". It has some important disadvantages, such as a relative higher cost than hydroelectric generation, geographical concentration, and moderate C02 emissions.

Other Renewables & Distributed Generation

Brazil has a very significant aeolic and solar power potential, which has remained mostly unexplored. Both wind and sunshine are free if available. Generation and maintenance costs of these energy sources have decreased, making them reasonable-cost renewable sources. Both are well suited to rural areas, as current technology requires large amounts of land to ensure low to moderate amounts of energy generation.

Brazil's aeolic production has been expanding rapidly, following the launch of Proinfa in 2002. In a single year, 2007, Brazil was able to expand its aeolic generation by 137 percent to 559MW, despite some significant delays in construction. In early 2008, 23 farms were operating in Brazil's main producing areas, Minas Gerais and the Northeast of Brazil, particularly Ceara.[58] The continued financial and regulatory support of the state through Proinfa, combined with growing international interest and expertise in wind power, is expected to result in 1,100MW of added generation capacity to the system by the end of 2008.[59]

One of the sunniest countries in the world, Brazil has been experimenting with solar-powered electricity generation for the past two decades. There are currently several pilot projects being implemented across Brazil, but solar power is still a minimal source of electricity. There is little chance that things will change, since the government has discarded solar power as a viable way of adding generating capacity, by excluding it from the projected 2016 electricity mix.[60] The response of private investors has also been slow but there is some indication that things may be about to change. In March 2008, Brazilian power company MPX signed an accord with Yingli Solar—a Chinese company that is one of the world's largest producers of solar panels —to open a solar plant in mid-2009 with installed capacity of 50MW in the north of Rio Janeiro state. Although private investment can be a major force behind energy development, it works best when operating within a framework drawn up to coordinate efforts and promote technological exchange. Brazil's government should step up and develop such a framework, possibly integrating solar power into Proinfa.

Another area that has been neglected by the Brazilian government is distributed generation, i.e. the provision of small-scale generation on a local basis at the point of demand. Distributed generation offers access to electricity to previously isolated communities and potentially huge improvements in energy efficiency particularly in the case of combined heat and power (upwards of 90 percent).[61] Several organizations point out that a 'small is beautiful' approach produces additional benefits as it brings home to consumers the costs associated with energy consumption and the need to manage and reduce it. Distributed generation can

counterbalance the existing centralized power generation system. It is a viable, relatively inexpensive and environmental-friendly way of expanding access to electricity, while creating jobs in often impoverished communities. In sum, the ultimate objective of increasing aeolic and solar power generation is to augment the production of alternative energy to help guarantee reliability to the whole electric system. At the end of the day, alternative sources are renewable and reduce dependency on foreign sources of energy. The Brazilian government is on the right path, by supporting aeolic generation. The next step should be to adopt a similar approach toward solar power, especially since the regions that have the highest solar exposure are also the poorest. Distributed generation can and should be an integral part of Brazil's efforts to ensure access to electricity.

Overcoming existing institutional inefficiencies

Experts suggest that the private sector should assume 60 percent of investments made in the power sector, to guarantee the needed expansion in electricity supply. At present, the level of private investments is much lower than advisable, due to a set of different factors.[62]

Auctions for power generation have unclear and inefficient rules;

Excessive taxation and deficient collection design negatively impact consumption (prices are artificially low), investments and competition;

Regulation does not reward efficiency;

Regulatory agencies lack independence;

Confusing and contradictory planning within the government. These conflicting efforts include opposition between the MME and the Ministry of Environment and within MME, and disagreement between areas that want to direct existing natural gas resources to industry and transportation and areas that want to use it to generate electricity;[63]

The actions taken by the Power Sector's Monitoring Committee (CMSE) lack transparency;

Delay-riddled and complex environmental licensing processes hamper development, compounded by a difficulty in determining the roles and jurisdiction of all actors involved, including courts, regional, and federal institutions.[64]

The latest victim of this unfavorable environment was CESP; Sao Paulo's state government had to cancel its privatization, because of a lack of interest from potential bidders. As the Financial Times states, "the deal would have raised a minimum of $R6.6bn for a company which is Brazil's third-largest power generator and accounts for about 10 percent of the nation's electricity."[65]

There are some signs of improvement, namely the 14 percent increase in the number of environmental licenses granted by IBAMA in 2007. Several of these licenses were given to important projects like the Santo Antonio hydroplant. IBAMA

is said to have received a "special directive" to move along the major works that are part of PAC.[66] Notwithstanding, projects like Estreito's hydroplant continue to be stopped by a court order, despite having obtained the required licensing.[67]

By failing to adequately address institutional weaknesses, the Brazilian government is constraining the power sector's ability to expand electricity generation and avoid shortages. Planning to increase generation is important, but making it happen is what really makes a difference. Implementation requires coordination, transparency, an improved investment climate, and respect for contracts and licensing deadlines.

Conclusion

The risk of Brazil experiencing yet another highly damaging electricity crisis is manifest. The country escaped electricity rationing in early 2008, thanks to diluvian rains. The supply system is highly vulnerable to electricity shortages and requires a significant overhaul.

The Brazilian government has taken the lead in attempting to access the potential generating gap—largely by a new extensive program of new hydro and gas-fired power plants and an enlarged transmission grid, supplemented by a significant growth in biomass and wind power. The adopted model is rather unbalanced, favoring hydropower projects, particularly large dams, and electricity consumption in the Southeast and Center in detriment of other regions.

The real issue which the government is failing to address is whether the current policies are sufficient to stimulate the growth of generation on the scale required. Based on the observed delays in PAC projects, postponed energy auctions and cancelled privatization efforts in recent months, it is obvious that Brasilia needs to review its regulatory framework and include some of the measures mentioned in earlier sections. Without it, there is little hope that Brazil will be able to implement all the necessary investments and expand electricity generation capacity at a rate necessary to keep up with demand.

Notwithstanding, there is no indication that the Brazilian government is considering regulatory reform, which greatly increases the risk of a future crisis. In the off-chance that things change, Brazil may be able to use its plentiful resources to its fullest and become an energy powerhouse in the region, benefiting not only Brazilians but maybe even its neighbors.

ANNEX
OLD X New Sector Power Model

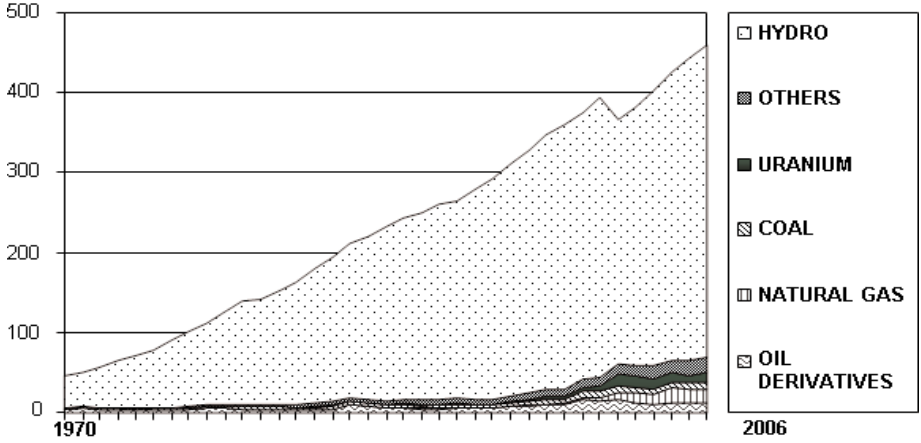
Source: E. Fernandes, et al, op. cit.

Old Model	New Model	Observation
Market competition (tender for public assets and gradual freeign of the market)	Competition for the market (competition for generation by tender for enw enterprises ad consupmtion blocks)	-Genereation competition does not unlink the business from the public service concept -Generation investor risk is assumed by the integrated system
Tender by highest return for use of a public asset	Teder by the lowest price for the energy offered	-Each enterprise receives a permitted income based on the price of the tender -Under these conditions the generation are will become a type of joint owership, similiar to that of transmission
Indicative planning	Strctured determinative plannig and with indication of priorities for the tenders	-Activity under the responsibility of the Energy Planning Company EPE (Empresa de Planejamento Energetico)
System operated by ONS (National System Operator) a private limited company	System operated by ONS at first, preserving its current legal structure	-Changes may occur in its governing structure
MAE (Wholesales Electricity Market) Accountng and settling contract deviations and short term transactios	The institution of a body to administer energy (electricity supplied by the generators with various prices adn compostion of a supply tariff to the distributors)	-Responsible body: CCEE-Electricity Tradig Chamber -MAE extinct, its remaininng functions incorporated in the CCEE
Consumers freely served by distributors/ generators/independent producers (PIE)/traders	Consumers freely served by independent producers/traders	-The free market tends to be lower than the regulated market

Hydropower Dominance

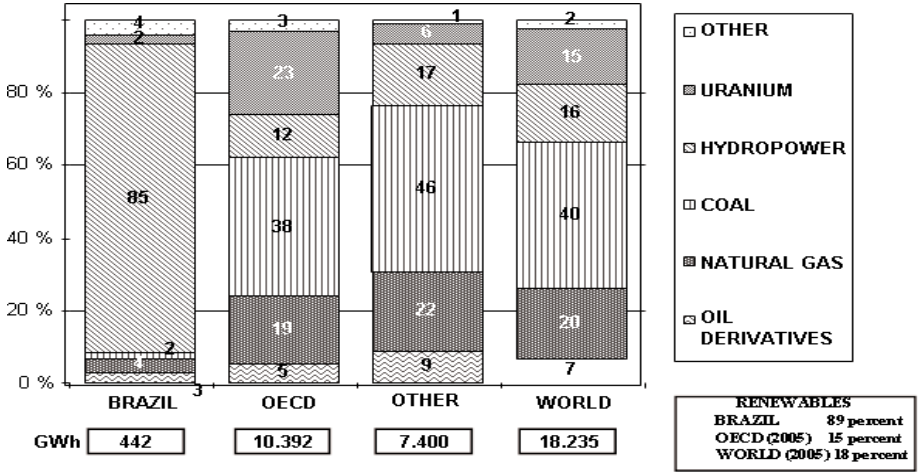
Domestic production of electricity, by source (GWh)

Source: Ministry of Mines and Energy, Brazil, 2008.

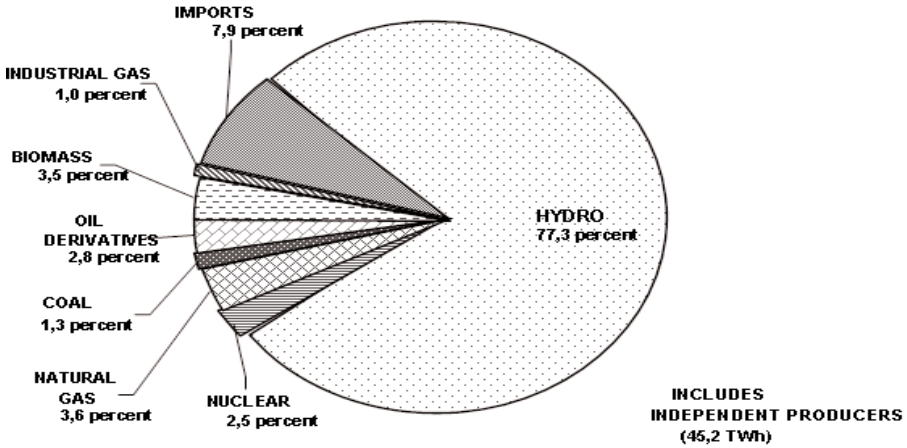


Electricity Production Matrix in Brazil and in the World (2005)

Source: Ministry of Mines and Energy, Brazil, 2008.



Brazil's Electricity Generation Matrix (2007)



Source: Ministry of Mines and Energy, Brazil, 2008.

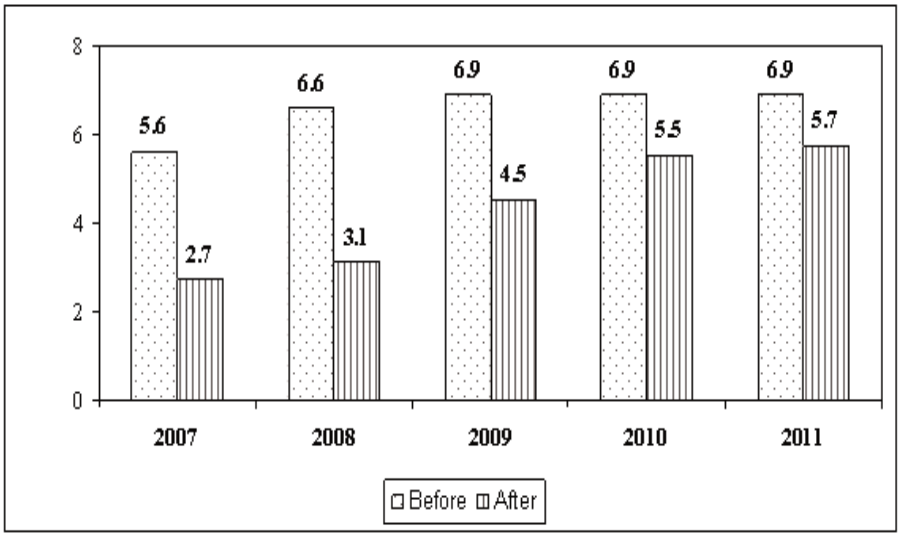
Source	GWh		06/07 percent	Structure (percent)	
	2006	2007		2006	2007
Hydro	348,805	374,378	7,3	75,7	77,3
Nuclear	13,754	12,307	-10,5	3,0	2,5
Natural gas	18,258	17,608	-3,6	4,0	3,6
Coal	7,222	6,454	-10,6	1,6	1,3
Oil derivatives	12,374	13,663	10,4	2,7	2,8
Biomass	14,959	16,794	12,3	3,2	3,5
Industria gas	3,964	4,838	22,0	0,9	1,0
Imports	41,164	38,480	-6,5	8,9	7,9
Total	460,500	484,520	5,2	100,0	100,0
Notes: (a) include independent producers - 45,2 GWh; (b) biomass includes 559 GWh of wind power in 2007					

Source: Ministry of Mines and Energy, Brazil, 2008.

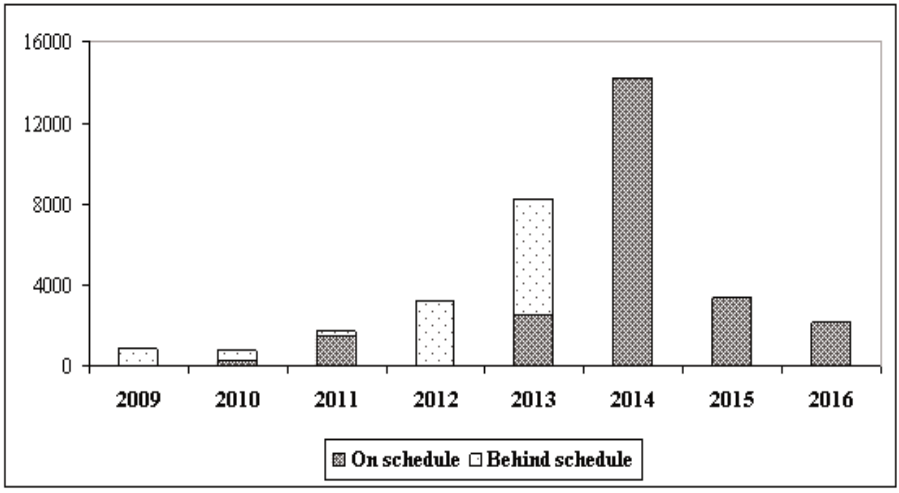
Potential Generation Gap

Firm supply of electricity (GWmed) before and after the Agreement between ANEEL and Petrobras

Source: Instituto Acende Brasil, 2008.



PAC: Status of electricity supply expansion projects (MW)



PAC: Status of electricity supply expansion projects (MW)

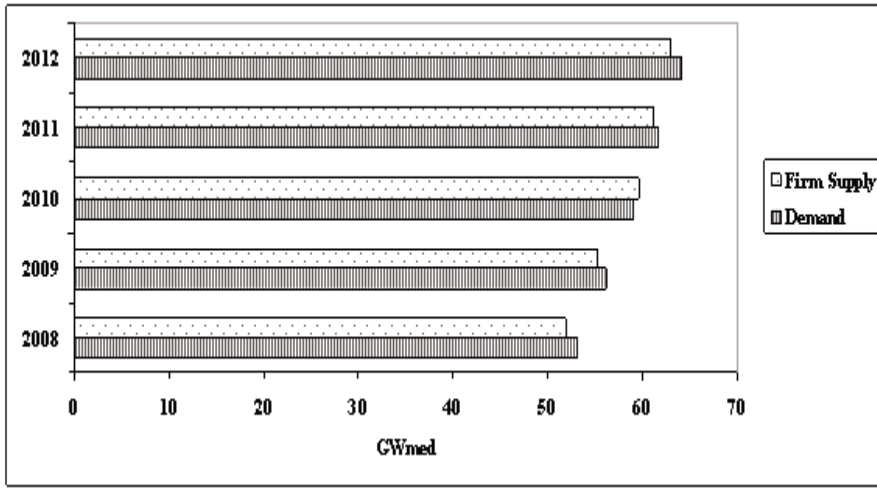
(continued)

	2009	2010	2011	2012	2013	2014
On schedule	42	282	1453	32	2478	14218
Behind schedule	790	480	256	3166	5783	
Percent of delays	**95 percent**	**63 percent**	**15 percent**	**99 percent**	**70 percent**	**0 percent**

The extent of new generating capacity required

Demand vs. Supply, 2008-2012

Source: Instituto Acende Brasil, 2008



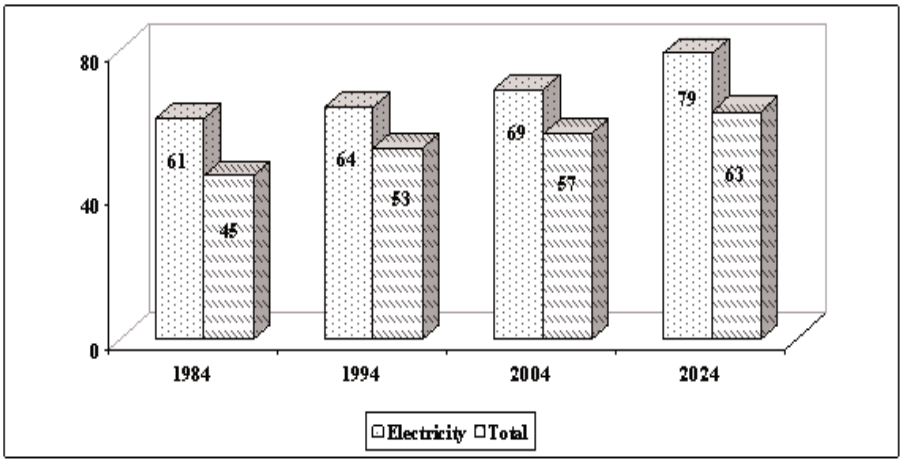
	2008	2009	2010	2011	2012
Demand	53.2	56.2	59	61.6	64.2
Firm Supply	51.9	55.3	59.5	61.2	63
Demand – Supply	-1.3	-0.9	0.5	-0.4	-1.1
Percent Demand	-2.50 percent	-1.60 percent	0.90 percent	-0.60 percent	-1.80 percent

Based on the demand and supply information of the Monthly Operation Plan of February 2008; growth of demand was 4.7 percent y/y.

Energy Efficiency

Average Efficiency (percent)

Source: Ministry of Mines and Energy, Brazil, 2005.

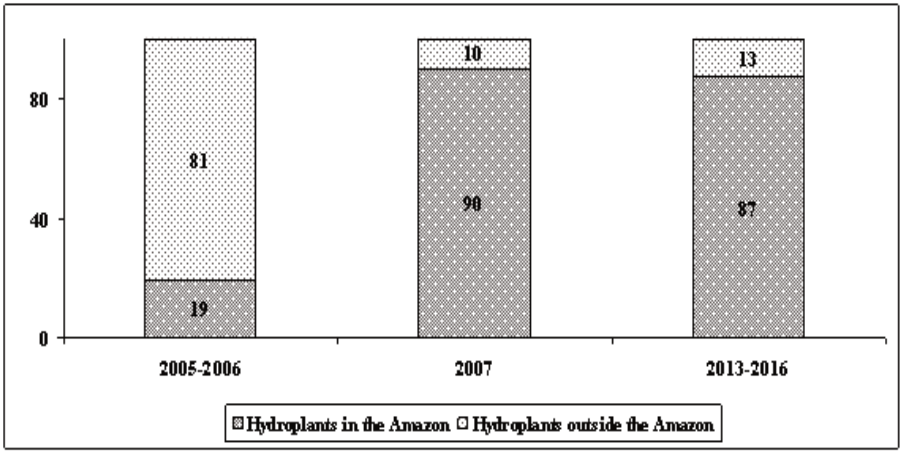


Note: The 2024 data are estimates.

Hydropower

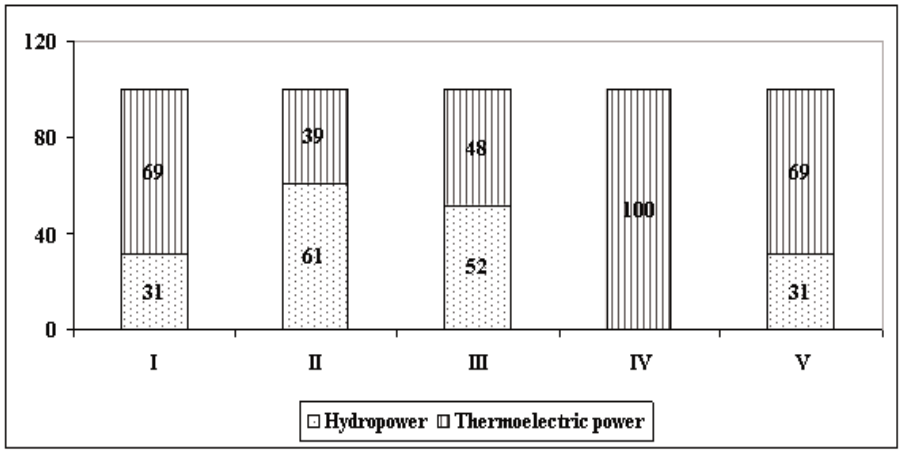
Hydroelectric plants auction

Source: EPE, Plano Decenal de Energia 2007-2016, 2007



Energy sold in recent auctions, by type

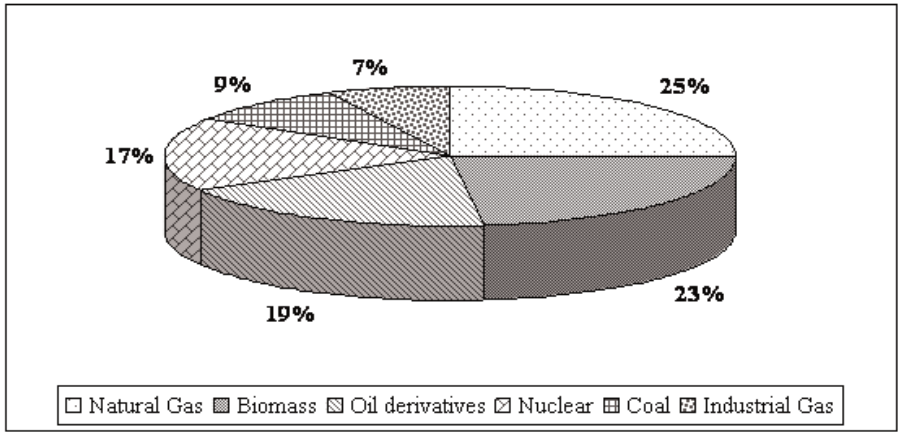
Source: Ministry of Mines and Energy, 2007



Thermoelectric power

Thermoelectric generation, by source (percent), 2007

Source: Own development based on data provided by the Ministry of Mines and Energy, Brazil, 2008.



Thermoelectric plants by fuel source (12/2006)

Source: Own development based on data collected in the Plano Decenal de Expansão de Energia, 2007-2016, MME, 2007.

Fuel Source	*Quantity*	*Total capacity (MW)*	*Share of installed capacity (percent)**	*Share of thermoelectric supply in 2007 (percent)**
Natural Gas	32	8,941	59.31	24.60
Nuclear	2	2,007	13.31	35.19
Coal	9	1,415	9.39	12.90
Diesel	23	1,400	9.29	
Oil	9	1,311	8.70	27.31
Total	75	1,5074	100	100

Excluding biomass and industrial gas.

Overcoming institutional inefficiencies

Analysis of projects licensed by IBAMA (1997-2006)

Source: World Bank data of 63 projects licensed by IBAMA.

Stages	Official deadlines	Observed average
Approval of reference term	30 days	**13 months**
Approval of Environmental Impact Study (EIS)	180 days	**19 months**
Public Discussion	45 days after (EIS)	**8 months**
Emission of a Preliminary License	1 year (1997-2005) 270 days (since 2005)	**39 months**

Notes

1A 10-month electricity rationing program was instituted from June 2001 to March 2002. As a result industrial output declined and GDP growth was 1.5 percent i2001, 2.9 percent lower than in 2000.
2 Fernandes, E., et al, "Natural-gas-powered thermoelectricity as a reliability factor in the Brazilian electric sector," Energy Policy 36, no.3 (March 2008): 999-1018. For a summary of the main changes introduced to the electricity sector, please refer to the table in the annex.
3 For more information, please refer to the graphs and table in the annex.
4 Presidência da República do Brasil, Secretaria-Geral da Presidência da República, "Mensagem ao Congresso Nacional: 2ª Sessão Legislativa Ordinária da 53ª legislatura,"2008.
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6 For more information, please refer to the graph in the annex.
7 Presidência da República do Brasil, Secretaria-Geral da Presidência da República, "Mensagem ao Congresso Nacional."
8 For more information, please refer to the graphs in the annex.
9 Empresa de Pesquisa Energética, "Consumo nacional de energia elétrica cresce 3.5% no semestre","Resenha mensal do mercado de energia elétrica, No. 10, (July, 2008). Available at: http://www.epe.gov.br/ResenhaMensal/20080729_1.pdf (accessed August 6, 2008).

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14 Jonathan Wheatley, "Brazil would like nothing better than to be singing in the rain," Financial Times, February 29, 2008.
15 Kelly Oliveira,"Além de construir usinas é preciso administrar crescimento do consumo de energia, diz especialista,"Agência Brasil, August 20, 2007. Available at: http://www.agenciabrasil.gov.br/noticias/2007/08/20/materia.2007-08-20.3433422330/view (accessed July 30, 2008); Alana Gandra, "Coutinho ressalta que crescimento maior depende de oferta de energia," Agência Brasil, September 13, 2007. Available at: http://www.agenciabrasil.gov.br/noticias/2007/09/13/materia.2007-09-13.0731943958/view (accessed July 30, 2008); Alana Gandra, "Associação pede medidas rápidas para evitar racionamento de energia," Agência Brasil, January 9, 2008. Available at: http://www.agenciabrasil.gov.br/noticias/2008/01/09/materia.2008-01-09.4816364159/view (accessed August 25, 2008); Alandra Gandra, "Estudo aponta descompasso entre demanda e oferta de energia", Agência Brasil, January 18, 2008. Available at: http://www.agenciabrasil.gov.br/noticias/2008/01/17/materia.2008-01-17.1620510235/view (accessed July 30, 2008).
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19 For more information, please refer to the graphs in the annex.
20 The program 'Light for Everyone' was established by the Lula government and it intends to accomplish universal access to electricity supply. Although the program is behind schedule, it has already brought electricity to 9.5 million and is expected to provide electric power to another 2.9 million people. Sources: "Mensagem ao Congresso Nacional",op. cit; Carolina Pimentel, "Luz para Todos vai universalizar acesso à energia em 12 estados este ano, afirma Dilma,"Agência Brasil, January 22, 2008. Available at: http://www.agenciabrasil.gov.br/noticias/2008/01/22/materia.2008-01-22.4290612572/view (accessed August 1, 2008).
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26According to the Ministry of Mines and Energy, the PNEf specifies goals, costs, deadlines and new business models to be established. It also determines the responsibilities of the agents involved as well as the resources required for the plan's implementation. "Plano decenal de expansão de energia: 2007/2016", op. cit., p. 748.
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30 "Mensagem ao Congresso", op. cit. "Plano decenal de expansão de energia: 2007/2016", op. cit.
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45 For further information, please refer to graph and table in the annex.
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48 For further information, please refer to graph in the annex.
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