New electricity sales arrangements and the expansion of the natural gas distribution network provide opportunities for on-site generation in Brazil, while a favourable environment also exists for biomass-fuelled schemes. However, these types of projects still face questions of competitiveness, reports Antonio Carlos Pereira Maia.

Brazil weighs up new potential

the outlook for CHP and DG

In 2004, Brazil's installed electricity generation capacity reached 83 GW. Some 97.5% of this is distributed through the National Interlinked System, and hydro electric plants generated 83% of it. Most of 2004 saw heavy rainfall raise reservoir levels so that the majority of regions have recorded their highest volumes in five years. This excess of hydro energy and the residual decline in demand – a legacy of the energy rationing of 2001 – have meant that thermoelectric plants have had to provide only small amounts of power in Brazil. This situation has also discouraged investment in new cogeneration and distributed generation (DG) projects.

The new electricity sector model aims to guarantee supply and keep tariff charges to a minimum

Oversupply of electricity and deflated electricity prices on the wholesale market meant that the country saw practically no growth in cogeneration and DG in 2004. Despite the modest performance of DG in Brazil during that year, 2004 may end up becoming a turning point for the industry.

The main reason for optimism lies in the potential for creating a market niche for DG when the regulatory framework to the new electricity sector model is implemented, particularly Law 10,848/04 and its accompanying executive decree 5163/04. The new framework introduces the possibility of selling surplus energy to the electricity distribution concessionaires, or utility companies that have the right and obligation to provide service within an exclusive area and that are regulated by a state agency. Here, surplus energy is sold according to a formula in which the tariff to the end consumer includes the costs of acquiring surplus energy from DG projects.

A NEW MODEL FOR THE ELECTRICITY SECTOR

In the first half of 2004, the legal provisions for the basis of the new Brazilian electricity sector model came into force. While the previous model focused on a global and competitive market solution, its replacement includes mechanisms for using central planning to expand the system. This new model aims to guarantee supply and keep tariff charges to a minimum by requiring distributors to guarantee energy to all of their markets through regulated contracting. Also, generators have to provide evidence of underlying energy sources, either their own or based on third-party contracts. The sale of electricity will occur in two so-called environments.

The Regulated Contracting Environment will employ auctions, whereas the Free Contracting Environment will see sale prices among market agents freely negotiated and governed by bilateral purchase and sale contracts. Electricity distributors will only contract in the regulated environment. In the free environment, market players who are not distributors will freely negotiate contracts.

Two electricity energy auctions occurred in the transition to the new model, one in December 2004, the other in April 2005, both for power from existing power plants. Both occurred in the

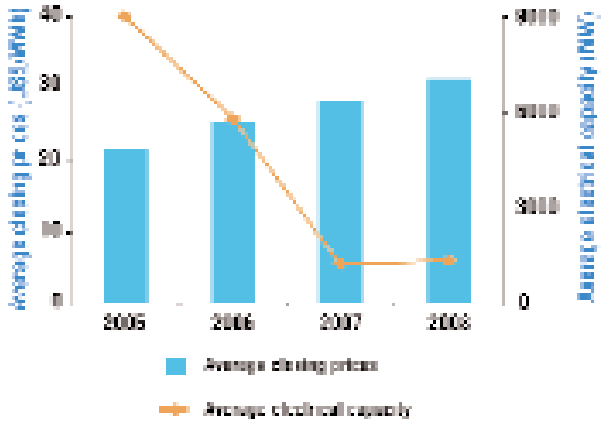


Figure 1. Closing prices and quantities of the auctions for eight-year contracts of energy from existing plants

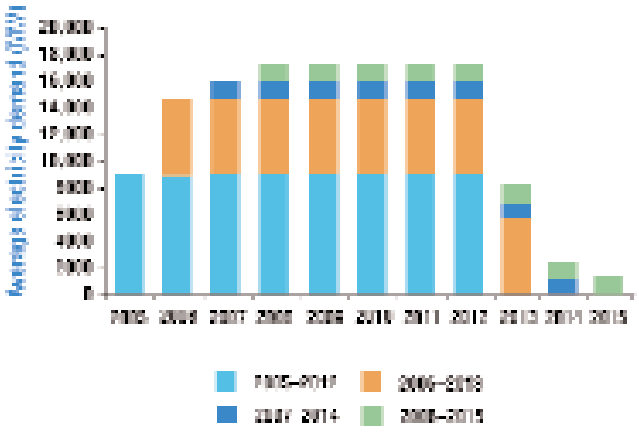


Figure 2. Demand taken by successfully tendered contracts at auctions of electricity generated by existing operations

environment of oversupply created by the recovery in reservoir levels and by the residual impact of the sharp decline in demand following the rationing introduced after the 2001 Brazilian electric power crisis. In this buyer's market, the auctions were characterized by low prices, as Figure 1 shows.

At the first and second auctions, the average power sold was 16 GW and 1.3 GW respectively.[1] Figure 2 shows the distributors' demand taken up by the contracts successfully tendered – below their market requirements, from customer's demand or distributor's load. As a result, distributors will have to award contracts through energy auctions or via public invitation directly from the DG projects. The latest amounts are limited to 10% of the distributor's load requirements.

IMPLICATIONS OF DG REGULATION

The cost of expanding the electricity system, based on new medium to large hydro units, is expected to rise because of the need to install more complex systems. This will add greater complexity to an already highly complex, integrated and interlinked national network and will expand the transmission infrastructure, which will be needed to harness hydro resources that are more and more distant from main centres of demand.

Before the end of 2005, a further auction is expected for energy from new plants. Deliveries are slated to begin in 2008, giving a three-year lead time, or a five-year lead time in 2010. The minimum and maximum supply periods are 15 and 35 years. Today's low-price environment, caused by the auctions of energy from existing projects, is at odds with the need to expand the system, which will incur higher costs, and with the need to adequately remunerate the capital invested in the new projects.

In this transitional and uncertain scenario, DG projects become a strategic alternative for consumers, mainly for those who are most energy-dependent.

THE NATURAL GAS MARKET MATURES

Natural gas's share of the Brazilian energy matrix has become increasingly important. It accounted for 7.7% of energy in 2003 compared with 2.7% in 1987, according to the National Energy Balance 2004, published by the Ministry of Mines and Energy. In 2004 sales of domestic and imported gas increased by 23% to 37.7 Mm^3/day, a figure which includes the consumption of 7.2 Mm^3/day by thermal power plants, according to Petrobras.[2] To meet growing demand, Brazil imported 19.5 Mm^3/day of natural gas in 2004. From 2002 to 2004 alone, natural gas sales rose by 32%. Increasing natural gas reserves, expansion in the gas distribution infrastructure and the growing pressure to use fuels which have a smaller impact on the environment all contributed to this trend.

Figure 3. Brazil's natural gas transportation infrastructure

The outlook for the next few years is for Brazil's natural gas market to continue to expand. The main projects in natural gas transportation, which will be part of this growth, are Malhas, the Southeast–Northeast pipeline (Gasene) and the Urucu-Porto Velho and Coari-Manaus pipelines in Amazonia.

Today's low-price environment is at odds with the need to expand the system

Signed in 2004, Malhas should increase the supply of gas by 9 Mm^3/day in the north-east of the country (14 Mm^3/day by 2012) and by 13 Mm^3/day in the south-east.

In 2004, construction work began on the 453 km Campinas–Rio gas pipeline at an investment of about US$339 million, slated for conclusion in late 2005. This project will be an integral part of the south-east network and will be in addition to Gasene and existing lines (Figure 3). It will expand the current 8860 km network by 4200 km. Gasene comprises the Cacimbas (ES)–Vitória (ES) gas pipeline and two other major pipelines: Cabiúnas (RJ)–Vitória (ES) and Cacimbas (ES)–Catu (BA) [*ES* = State of Espírito Santos; *RJ* = State of Rio de Janeiro; *BA* = State of Bahia]. Both are in the early stages of obtaining environmental licences, negotiating a package of engineering, procurement and construction, and the legal and financial structuring. Gasene's total capital expenditure is estimated to be $1.1 billion.

In the state of Amazonas, the pipeline that will carry natural gas over 516 km from Urucu Province to Porto Velho in the state of Rondônia will have a capacity of 2.2 million m^3/day. The pipeline to link the state of Amazonas municipal regions of Coari and Manaus will stretch 397 km and will have a capacity of 7.5 million m^3/day. Investment in it is estimated to be $407 million. This pipeline aims to meet demand from Manaus and neighbouring markets, which will allow natural gas-fired cogeneration and DG projects to be constructed, thus reducing the Amazon Basin's dependence on diesel-fired generation.

OPPORTUNITIES FOR NATURAL GAS-FIRED DG

A recent survey by Petrobras on corporate scenarios for Brazil and its natural gas industry focused on six economic segments which have good prospects for cogeneration.[3] Three are in the industrial sector (chemicals, pulp and paper, and beverages), and the other three in the service sector (hospitals, hotels and shopping centres). These segments will promise a good future for the natural gas-fired cogeneration market, as Table 1 shows.

This evaluation focuses only on six segments of the economy. While these are representative, they do not reflect the country as a whole. But if we regard the evaluation as a close approximation and ignore the economic and institutional factors (economic feasibility and legal/regulation constraints that could inhibit projects from being implemented), then the numbers could be considered to reflect the country's potential. They could also let us predict that natural gas consumption would reach 17–21 Mm^3/day from cogeneration projects alone. This potential for the Brazilian market mirrors a world trend towards natural gas as a fuel and reflects the search for clean energy sources.

OPPORTUNITIES BASED ON ALTERNATIVE SOURCES

A biomass cogeneration and DG market is already in place in Brazil, thanks largely to the sugar and alcohol sector. It generates

Table 1. The technical and economic potential of industrial and commercial sectors for gas consumption in Brazil in Mm³/day for the year 2015

Industrial sector		Consumption			
Technical potential	Scenario	I	II	III	IV
	Chemical industry	15.4	14.0	13.0	11.7
	Pulp and paper	3.2	2.7	2.3	2.1
	Beverage industry	0.2	0.2	0.1	0.1
	Total	18.8	16.9	15.4	13.9
Economic potential	Scenario	I	II	III	IV
	Chemical industry	4.1	6.9	3.2	3.0
	Pulp and paper	0	0	0	0
	Beverage industry	0.07	0.07	0	0
	Total	4.2	7.0	3.2	3.0
Commercial sector		**Consumption**			
Technical potential	Scenario	I	II	III	IV
	Shopping centres	1.5	1.5	1.5	1.5
	Hospitals (average)	1.1	1.2	1.2	1.2
	Hotels (average)	0.1	0.1	0.1	0.1
	Total	2.6	2.7	2.7	2.7
Economic potential	Scenario	I	II	III	IV
	Shopping centres	1.5	1.5	1.5	1.5
	Hospitals (average)	0.6	0.6	0.12	0.12
	Hotels (average)	0.1	0.1	0.04	0.04
	Total	2.1	2.1	0.2	0.2
Total	Technical	21.4	19.6	18.2	16.7
	Economic	6.3	9.1	3.4	3.2

Scenario I: high economic development with integrated planning orientation (successful structural reforms)
Scenario II: low economic development with market orientation
Scenario III: high economic development with market orientation
Scenario IV: unsustainable economic development with integrated planning orientation (unsuccessful structural reforms)

about 4000 GWh/year and has a commercial potential estimated at 4000 MWe in new installations. The logging and forestry sector also has major potential for this market, based on silvicultural practices but excluding the cutting-down of native forests.

Brazil has pursued various initiatives for supporting the development of alternative sources of electricity generation in recent years. However, on 26 April, the government unveiled an innovative structured programme for diversifying the national energy matrix: the Alternative Electric Energy Sources Incentive Program (PROINFA). The programme sought to promote the installation of 3300 MW of capacity produced from wind, biomass and small hydro units – 1100 MW from each source. Energy produced over a 20-year period from generation plants that are built under the scheme and that begin operations on or before 30 December 2006, would have their respective purchase contracts guaranteed by Centrais Elétricas Brasileiras SA (Electrobrás). The projects qualifying under PROINFA would also be eligible for financing from the National Economic and Social Development Bank (BNDES).

The initial expectation of contracting equal amounts of energy from the different sources – 1100 MW per source – did not occur. Successful bids for wind energy dominated at 1370 MW, or 41% of the capacity successfully bid. Tariffs for wind energy are greater than for biomass-based sources, which with only 655 MW, comprised 19.9% of the capacity bid. Small hydro units contracted 1265 MW. Figure 4 shows Eletrobrás' estimated tariffs per primary source.

The use of incentives to guarantee the purchase of electricity from these generation schemes has proved necessary to get the projects off the ground, although these measures by themselves have been insufficient. Entrepreneurs allege that the prices set for biomass-generated energy are unattractive or insufficient to make the projects economically viable considering the financial conditions on offer. The agro-industrial sector has been less than enthusiastic about the schemes because of the 20-year contracting period, in which prices are fixed but linked to an inflation index. In other words, the price system fails to account for the market expectations for the rise and fall of energy prices. Today's excess in supply, for example, has led to depressed prices, but also signals the possibility of future recovery.

In addition, some structural conditions also contributed to the results of the programme, notably in the case of sugar cane bagasse. These conditions include the chronic instability of the oil market, implementation of agriculture-based renewable energy policies in many countries, as well as historic and new usage (for example, as an automotive fuel) of ethanol in different industries. Environmental initiatives have also played a role in the programme's results: these include the Kyoto Protocol, the need of energy diversification and security worldwide, the increasing use of renewable energy feedstocks which has fostered the international trade of ethanol, and the increased domestic consumption in ethanol which has raised the need for energy crops.

Many Brazilian sugar mills date from the 1970s, when Brazil was using incentives to promote the use of ethanol as a vehicle fuel. These plants tend to employ low boiler pressure and to use energy generation equipment that is nearing the end of life. Today, demand in the international commodities market has led to favourable prices for sugar and alcohol. Projects in the core business are economically and strategically attractive. Mill throughput has been rising and industrial installations have expanded. Therefore, smaller mills (which have smaller financial

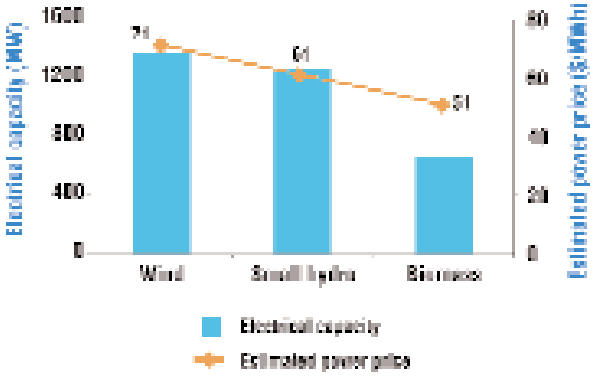


Figure 4. Tariffs (estimated) and capacity for primary energy sources for PROINFA projects

capability) have enthusiastically adopted PROINFA for their integrated operations. This would mean modernizing their equipment, substituting old boilers and increasing operating pressures, leading to an increase in cogeneration capacity.

Brazil's biomass cogeneration and DG market has a commercial potential of about 4000 MWe in new installations

In the recent government initiatives to foster alternative energy sources, a new dynamic is apparent in the development of the domestic energy sector. On the one hand, the government is promoting an integrated energy policy in which it bases strategic investment decisions on a policy of incentives and on the significant participation of state-owned companies in the sector's industrial organization. These state-owned companies – in this case Eletrobrás and the Brazilian Development Bank (BNDES) – play a major role in stimulating the development of the country's production structure and, in particular, the energy sector. On the other hand, market investors are making investment decisions by judging how attractive the investment project is and what returns it will give. The market also is most likely to aim to take advantage of the new approach to energy policy as a means of mitigating risk.

A MOSTLY POSITIVE OUTLOOK?

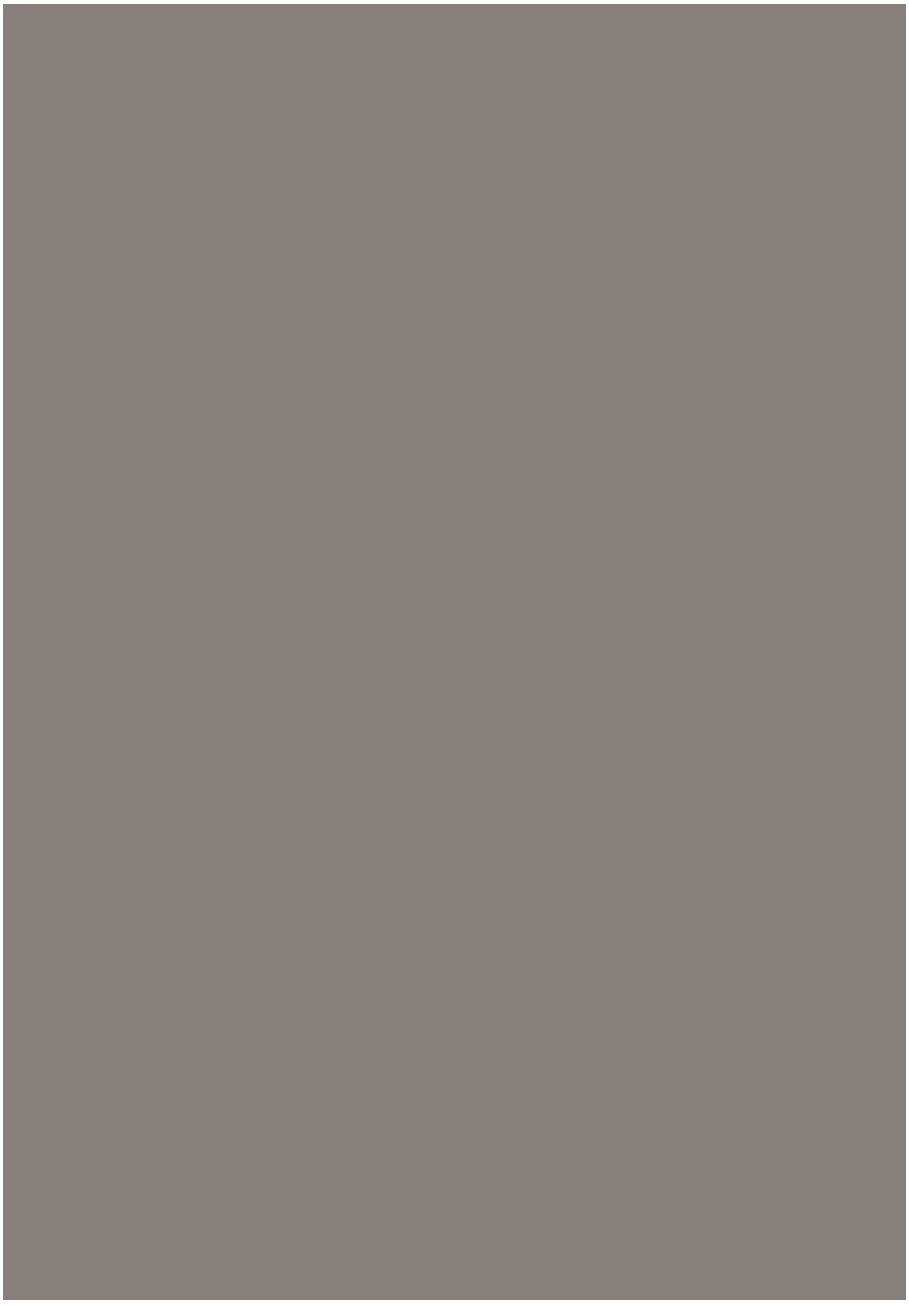
There seem to be good reasons to expect that there will be no shortages in energy supply over the next three to four years. Prospects are that electricity consumption will increase, but the Brazilian economy will continue to grow and generation capacity to expand. However, some events could reverse this situation and create the need to anticipate additional requirements for energy. Among these events are:

- environmental restrictions on the installation of new hydroelectric plants
- greater electricity consumption following a greater rate of economic growth
- reduction of guaranteed energy from generating operations and from imports.

Based on a combination of these factors and the new electricity sector regulatory framework – notably the greater flexibility for purchasing electricity from DG projects – we can conclude that the outlook is positive for alternative sources of generation to enter the market, particularly those beginning operation in the medium term. Cogeneration from natural gas and biomass is becoming a natural alternative to expanding capacity. However, this more favourable outlook may not be enough.

Some of the details in the regulatory framework deserve a closer look. A fair incentive for DG projects would be to recognize how they help reduce investments in the transmission and distribution systems and help cut their losses. This recognition could be in the form of a reduction or elimination of charges built into tariffs for the use of these systems relative to the amount of additional energy to be sold. When it comes to acquiring reserve energy, electricity sector regulation might be reviewed in light of the penalty system that exists for exceeding the '12 times per month' limit for accessing the distribution network, irrespective of the power load required.

Yet another market-related factor for the successful development of cogeneration is the entrepreneurial posture of the



Sugar cane being harvested. Steam and heat are important in the process of obtaining sugar and alcohol for cogeneration. Steam, obtained from burning sugar cane bagasse, drives the turbines that generate the electrical power (Petrobras)

A wind turbine tower is being installed in Macau in the State of Rio Grande do Norte. Petrobras recently inaugurated its first pilot wind project with an installed capacity of 1.8 MW (Petrobras)

electricity distributors. The new electricity-sector regulation, which requires all distributor demand to be contracted and the purchasing of up to 10% of load requirements from DG projects to be flexible, opens a window of opportunity for attracting distributors themselves into investing in cogeneration projects. This is particularly true in regions where, for technical, economic or environmental licensing reasons, the distribution infrastructure restricts expansion of capacity.

In addition to questions of regulation, problems exist concerning the competitiveness of cogeneration projects meant for DG in Brazil. Firstly, equipment has to be imported, particularly natural gas motors and absorption chillers. This increases the initial

investment costs because of the weakness of the Brazilian currency and because of import tax. A federal government initiative could help here by implementing incentives to encourage local manufacture of equipment for export. Production could benefit from Brazil's competitive advantages of the availability and low cost of raw materials and labour. In the case of natural gas-fired generation, such an initiative could be made part of the Program for Mobilizing the Brazilian Oil and Natural Gas Industry, which is sponsored by the Ministry of Mines and Energy and whose objective is to consolidate the domestic goods and services industry.

Another measure, this time at the state level, would be to give companies breaks on the value-added tax (ICMS, Tax on the Circulation of Goods, Interstate and Intercity Transportation and Communication Services) when they buy equipment for installing cogeneration units. The tax break could last for a fixed period and could make the environment for projects brought on stream over the medium term as favourable as possible.

However, factors other than cost are on the list of questions that companies ask themselves when deciding what the most attractive alternative is for purchasing their principal utilities. Public image and reliability of supply are examples. These factors are rarely evaluated but should be quantified to provide answers to technical and economic questions in a realistic feasibility study.

Finally, bearing in mind that utility outsourcing contracts are for the long term, taking real options into account in these contracts would greatly reduce the risks to customers when changing suppliers. A real option clause extends the concept of a customer's financial option to tangible (non-financial) assets such as a cogeneration plant. For example, by signing a utility supply contract, the customer would have an alternative in the future of expanding or downsizing the project's range of power capacity, or even of abandoning the project altogether. Such a clause would grant the customer an exit option to change the plant's utility supplier before the long-term contract expires, in the case of, for instance, the project failing to reach its performance criteria. This would make the contract more flexible and less risky from the customer's perspective, and as a result could strongly influence the customer's decision-making on the utility outsourcing contract.

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NOTES

1. Average demand is the amount of power required in MWh divided by the duration of operation in hours.
2. Petrobras (2004). Potential for natural gas-fired cogeneration in Brazil: outlook for 2015 for selected sectors. Study carried out by COPPETEC-UFRJ.
3. This work has benefited from the support of numerous colleagues from Petrobras and COGEN-SP. José Ricardo Uchôa and Newton Paterman Brasil have been kind collaborators, sharing ideas and providing information on the topics addressed in this paper.

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