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Brazil:

Country of the future or has its time come for natural gas?

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About the Author

Ieda Gomes is Senior Visiting Research Fellow at the Oxford Institute for Energy Studies. Her areas of expertise include natural gas and LNG market fundamentals as well as energy pricing, policy and regulation particularly in developing countries in South Asia, the Middle East, Africa and Latin America. Ieda's career in the gas and energy industry spans more than 30 years. She worked for nearly 14 years at BP plc as Vice President for new ventures and market development on several international assignments and for 19 years at the largest gas distribution company in Brazil, Comgas. She has been a key participant and shaper of events in Brazil's gas industry – from the introduction of natural gas supplies in Sao Paulo to the negotiating and signing of the domestic and Bolivian gas supply agreements, the privatization of Comgas and the establishment of the Brazilian Association of Gas Distribution Companies (ABEGAS). Ieda is based in the UK and sits on the board and advisory council of various companies and associations. She writes a bimonthly column for *Brazil Energia*. Ieda holds a BSc in chemical engineering and an MSc in energy and environmental engineering.

Preface

I suspect I am amongst a significant majority of people who were not aware, prior to reading this paper that Brazil's natural gas industry dates back as far as 1851. In the past few years Brazil, has received much attention in macro-economic circles as one of the high growth BRICS countries. Its performance has waned of late, apparently due to lack of internal reforms and infrastructure bottlenecks, and as this paper demonstrates, these factors certainly 'read across' to Brazil's natural gas sector.

Initial excitement in the wake of Brazil's offshore pre-salt hydrocarbon discoveries in 2007 and 2008 raised the prospect of the country becoming an LNG exporter. Following further appraisal and market developments this prospect has receded and managing the country's gas balance has been further complicated by low rainfall (and hence hydro availability) in recent years. For these reasons Brazil has had to import LNG at Asian-equivalent spot prices to meet requirements which are difficult to forecast.

In short Brazil is a market which any observer of the natural gas world is required to develop a working understanding of: in view of its scale, its potential for growth and its impact on the global LNG market. However, its circumstances and specificities make such an understanding extremely difficult without expert assistance.

In this regard who better to author this paper than Ieda Gomes, who spent 19 years of her career in Brazil's largest gas distribution company and who was a key participant and instigator of sector development and modernisation? I am extremely grateful to Ieda for her comprehensive, lucid and perceptive assessment of the evolution, status and future challenges of Brazil's gas sector. The OIES Natural Gas Programme is particularly committed to undertaking research which advances understanding of the important growth markets which impact tomorrow's gas world, and I am delighted that her paper admirably fulfils this aim.

Howard Rogers
Oxford
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1. Introduction

Natural gas plays a relatively modest role in Brazil's energy mix, accounting for less than 12% of the domestic energy supply and 7.2% of the country's final energy consumption[1]. This is due to the predominant role of hydroelectricity in Brazil's power generation, the country's relatively undeveloped gas infrastructure, government subsidies for LPG and the monopoly of Petrobras, which contributes to balancing the supply of competing fuels – natural gas and low-value fuel oil.

In 2013 final gas sales totalled 32.7 Bcma, including 4.6 Bcma consumed by Petrobras refineries and 12 Bcma used in E&P operations and flaring. Brazil is a net gas importer: 12 Bcma was imported from Bolivia in 2013 and 5.3 Bcma of LNG. The country has three floating LNG import terminals – one each in the states of Ceara (2.5 Bcma), Rio de Janeiro (7.7 Bcma) and Bahia (5.1 Bcma), all owned and operated by Petrobras. The dry season in 2012 and 2013 prompted Petrobras to source LNG to meet the needs of its gas-fired power plants. Petrobras is also currently building its credentials as an LNG trader; in 2013 it bought nearly 100 cargoes of LNG, around 4.4 mtpa, of which nearly 80 cargoes were imported into Brazil, several traded externally and one half of one cargo re-exported to Argentina in a gas swap with a Brazilian power plant on the Argentine border. The continuation of the dry season combined with the need to 'keep the lights on' during the World Cup in June/July 2014 and major elections in October will mean that similar amounts of LNG will be imported in 2014.

After nearly 40 years of state monopoly, the government began to gradually liberalise the oil and gas sector. In 1999 the National Petroleum Agency (ANP) launched the first E&P tenders which received bids from local and international players. As of 2013, there were more than 70 private companies active in the upstream sector, either operating alone or partnering with Petrobras; of these, 29 are already producing small volumes of natural gas, most of which is sold to Petrobras owning to lack of access to the market. A growing number of private producers are positioning to market their production independently in the medium term if they are given access to the pipeline infrastructure.

The oil and gas fiscal regime in Brazil is based on 30-year tax-royalty concessions for E&P. However, in 2008 the government decided that the huge deepwater pre-salt[2] resources in the offshore Santos and Campos basins should be developed under PSCs with Petrobras as the operator with a minimum participation of 30%. In order to allow the discussion and approval of a separate law for pre-salt blocks, the government suspended the annual upstream exploration auctions in 2008; these were resumed only in May 2013. Currently Brazil operates under three separate exploration regimes: concession contracts for all areas except pre-salt, PSCs for pre-salt blocks and hybrid contracts for a small number of pre-salt blocks granted exclusively to Petrobras under a rights transfer agreement with the Brazilian government.

Petrobras' previous forecasts indicated that the company would be producing 6 million bbl/d of oil and 80 Bcma of domestic gas by 2020, most of which would be associated gas from pre-salt discoveries. In this scenario Brazil would become a net gas exporter. This prompted Petrobras and its partners to

[1] (EPE , 2013).
[2] Pre-salt refers to the geological strata beneath salt layers. Some petroleum that was formed in the pre-salt layer has not migrated upwards to the post-salt layers. This is especially common off the coast of West Africa and Southeast Brazil.

commission a FEED study in 2009 for a 2.7 mtpa FLNG to be built offshore Rio de Janeiro. Petrobras originally planned to start LNG exports in 2016.

Delays in several upstream projects, uncertainty over gas reinjection volumes and the quality of pre-salt gas (which is thought to have a high CO_2 content), and the increasing demand for gas in power generation led to major changes in the supply and demand forecasts for natural gas. The FLNG project was suspended in 2010 and Petrobras increased its LNG import capacity, with three FSRUs commissioned between 2009 and 2014. Only recently, the industry agreed a forecast for domestic gas production, which is expected to grow to approximately 50 Bcma by 2020, of which 31.4 Bcma will be available for sale[3]. Thus in the long term Brazil will continue to depend on imported gas to meet domestic demand. If the seasonal scarce rainfall persists in coming years and if there is no policy change promoting base-load gas generation, Brazil will continue to be a significant player in the LNG spot market.

In 2013 the Brazilian government resumed E&P leasing auctions. In May of that year, 142 onshore and offshore blocks were awarded at a concession auction to 39 companies that together paid signature bonuses in excess of $1.3 bn. In October Brazil completed the first pre-salt bid under the new PSC regime; only one consortium – formed by Petrobras, Shell, Total and CNPC – took part. In November the ANP offered another 240 onshore blocks for auction, but the response was limited.

This paper provides an overview of the natural gas market fundamentals in Brazil – supply, demand and pricing – as well as a supply and demand forecast to 2025. It reviews the outlook for unconventional and pre-salt gas in Brazil and the current status of and prospects for gas trading (imports and exports) with Bolivia and Argentina. In addition, it discusses key issues impacting on the penetration of natural gas in the industrial, power and NGV sectors: price competitiveness, access to infrastructure and the challenges in increasing the share of gas-fired power generation in the hydro-dominated power mix, including matching LNG contractual terms with the unpredictable dispatch of gas-fired power plants.

2. Brazil in Context

Brazil is the fifth-largest country in the world in terms of surface area (8.5 million km^2), larger than either the continental US or Western Europe. Its population of approximately 201 million[4] lives mainly in coastal areas – vast swaths of the country remain covered by the Amazonian forest. Brazil is a federation of 27 states, each of which has its own constitution and elected local parliament (State Assembly). The federal government system is a presidential one in which the elected head of state has a four-year mandate. The parliament is made up of a lower chamber (Congresso Federal) and an upper chamber (Senado), which represents the federal states.

Brazil's economy is the seventh-largest in the world: in 2013 GDP amounted to $2.2 trillion[5]. Owing to several setbacks, the economy is predicted to grow by only 1.67% in 2014, significantly below the record 7.5% growth in 2010.

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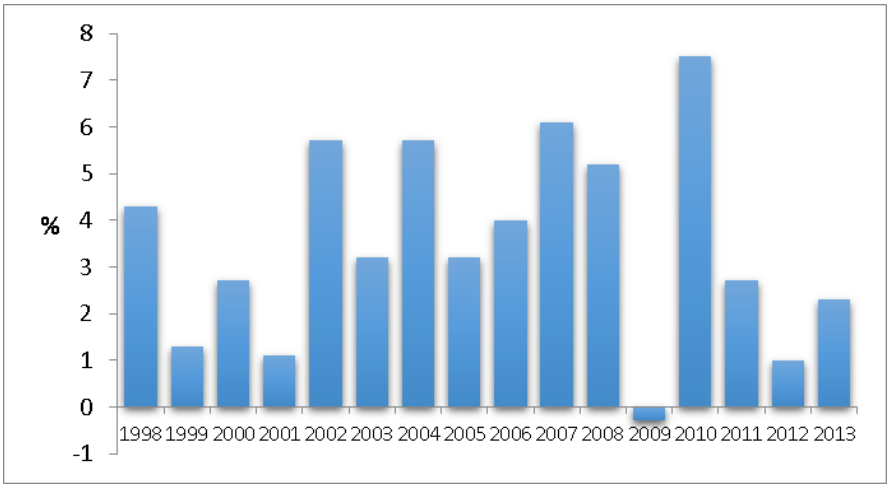
[3] The balance is to be used for oil field reinjection and production facility fuel gas.
[4] http://g1.globo.com/brasil/noticia/2013/08/populacao-brasileira-ultrapassa-marca-de-200-milhoes-diz-ibge.html
[5] IMF: http://www.imf.org/external/pubs/ft/weo/2014/01/weodata/weorept.aspx?pr.x=55&pr.y=14&sy=2012&ey=2019&scsm=1&ssd=1&sort=country&ds=.&br=1&c=223&s=NGDP_R%2CNGDPD&grp=0&a=

Brazil's economy is quite diversified: the services sector accounts for 59% of GDP, followed by industry (21%) and agriculture (15%). Similarly the industrial sector is very diverse, catering for the domestic and export markets and encompassing segments ranging from aerospace to automakers, consumer goods, ship-building, chemicals, aluminium, ceramics, glass and textiles. However, Brazilian industry has been struggling to compete with cheaper Chinese manufactured products while at the same time being faced with a strong domestic currency (Brazilian Real) and high energy prices and taxes.

Brazil is an important exporter of agricultural products, in particular soya beans, sugar cane, maize and wheat. It is also one of the world's leading producers of iron ore, manganese, bauxite, nickel and limestone.

Figure 1: Brazil's GDP growth, 1998–2013



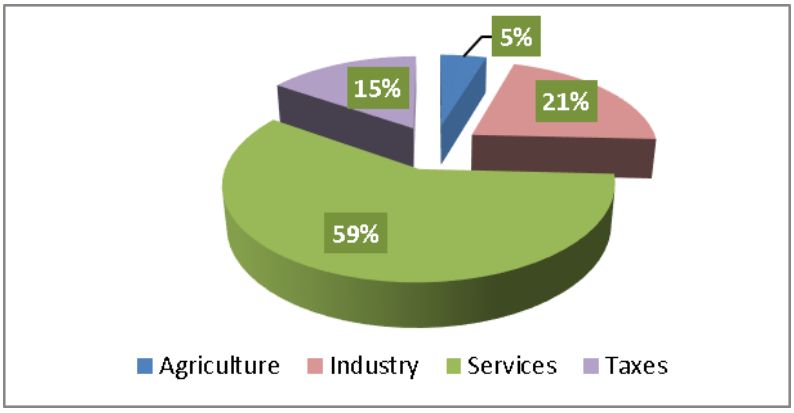
Source: http://g1.globo.com/economia/noticia/2014/02/economia-brasileira-avancou-23-em-2013-diz-ibge.html

The city of Sao Paulo is the largest financial market in South America and one of the largest in the world. However, there are 15 other cities in Brazil with more than 1 million inhabitants[6].
Following are other important factoids about Brazil:

- It is the world's fourth-largest market for bulk and passengers transportation vehicles and the third-largest for computers.
- It has the largest private helicopter fleet and the second-largest executive jet fleet in the world.
- In 2010 Brazilian consumers purchased 12 million TV sets.
- In 2011 there were 215 million mobile phones in operation in Brazil, making it the fourth-largest mobile phone market in the world.
- Brazil is the 11th-largest oil producer in the world and the second-largest producer of hydroelectricity.

[6] http://exame.abril.com.br/brasil/noticias/as-300-cidades-mais-populosas-do-brasil-em-2013

Figure 2: Composition of Brazil's GDP, 2013



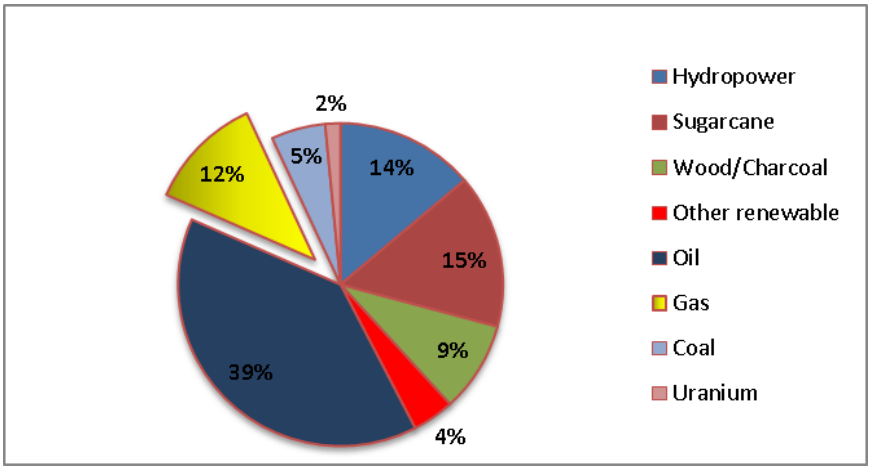
Source: http://g1.globo.com/economia/noticia/2014/02/economia-brasileira-avancou-23-em-2013-diz-ibge.html

Brazil is a member of the Mercosur free trade area, which comprises Argentina, Uruguay, Chile, Paraguay and Venezuela as well as Bolivia as an acceding member. The purpose of Mercosur is to promote free trade and the free movement of goods, people and currencies.

2.1 Brazil's energy matrix is becoming less green

Brazil's energy policymakers are very proud of the country's 'green' energy credentials: renewable energy plays a large role if the share of hydropower and biomass[7] is taken into account. Wind power is not yet significant, despite an increase in wind projects being built in the northeast region over the past 10 years. However, the share of renewable energy in the overall energy mix decreased from 44% in 2011 to 42.4% in 2012 owing to the decrease in the consumption of ethanol and the increase in the consumption of petrol, diesel and natural gas[8]. The share of renewable energy, particularly hydropower and ethanol, is expected to decrease further but still be significantly larger than the world average of 13.2%[9]. In 2012 the primary energy offer was 283 MTOE.

Figure 3: Brazil's primary energy mix, 2012



Source: (EPE , 2013)

[7] Figures include sugarcane ethanol.
[8] (EPE , 2013).
[9] http://www.iea.org/aboutus/faqs/renewableenergy/

Natural gas accounts for 12% of Brazil's primary energy consumption, while oil accounts for 39%. Oil products are used primarily in the transportation and residential sectors. Despite the significant role of anhydrous ethanol, which is used in a 22% mixture with petrol and as a popular standalone fuel in flexi cars[10], the Brazilian fleet is highly dependent on diesel and petrol, while bottled LPG is the main fuel used for cooking.

In order to shield the country from the 2008–09 world economic crisis, the Brazilian government embarked on a policy of fuelling domestic demand by facilitating credit to families, increasing the distribution of cash grants to the poor and reducing taxes and customs duties for consumer-oriented industries such as automakers and white-good manufacturers.

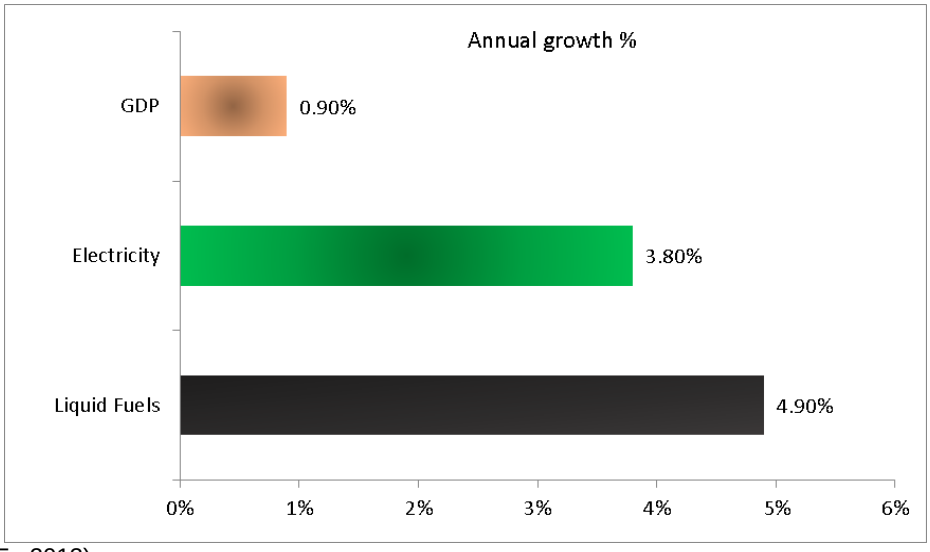
From 2001 to 2012 Brazil's vehicle fleet jumped from 34.9 million to 76.1 million – an increase of 138%, compared with population growth of 11.8% in the same period[11]. At the same time, there was a sharp increase in the purchase of home appliances and equipment such as computers, mobile phones, refrigerators, TVs and air-conditioning sets.

To rein in demand-driven inflation, the government froze Petrobras' ex-refinery petrol and diesel prices and ended a compensation mechanism (CIDE) previously used to neutralising currency and price fluctuations. The freeze on petrol prices impacted negatively on the ethanol industry because ethanol prices are pegged to petrol prices and producers could no longer compete with the price of petrol ex pump. As regards the power sector, the Ministry of the Environment established new rules for permitting power projects that virtually prevent hydroelectric power plants with reservoirs from being built. Previously, such plants were built with firm energy equivalent to 55% of their total capacity. Nowadays hydro power plants are only built as "run-of-the-river". The new environmental rules contribute to reducing the availability of hydropower during the dry season.

Overall, the consumption of energy increased 3.4% in 2011–12, while losses in transformation rose 8% owing to the increase in thermal power generation.
Despite very modest GDP growth of 0.9% in the period 2011–12, the government policy of fuelling domestic demand resulted in disproportionately high growth in the consumption of electricity and liquid fuels, as Figure 4 below shows. The consumption of petrol alone increased 17% in 2011–12.

[10] A 'flexi-car' can burn any mixture of hydrated ethanol and petrol. This development has slowed down the conversion of cars to natural gas in Brazil.
[11] (Instituto Nacional de Ciencia e Tecnologia, 2013)

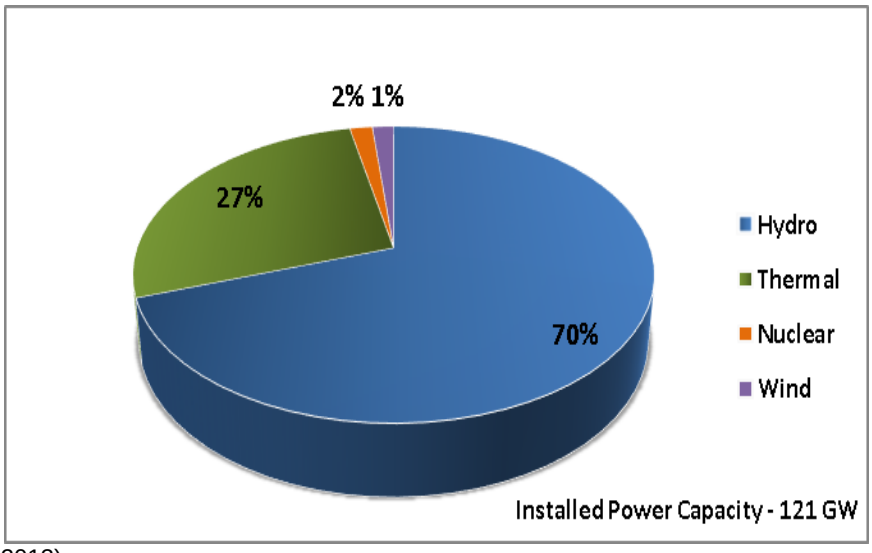
Figure 4: Comparative energy and economic indicators, 2011–12



Source: (EPE , 2013)

Brazil's total installed capacity in 2012 was close to 121 GW, compared with 89 GW in the UK[12]. Hydropower plants account for approximately 84 GW (70%) and thermal plants (gas, oil and coal) for 32.5 GW. The share of hydro in the power generation mix decreased from 464.2 TWh in 2011 to 455.6 TWh in 2012 owing to the unusually long dry season and the reduction in storage capacity.

Figure 5: Brazil's power generation capacity, 2012



Source: (EPE , 2013)

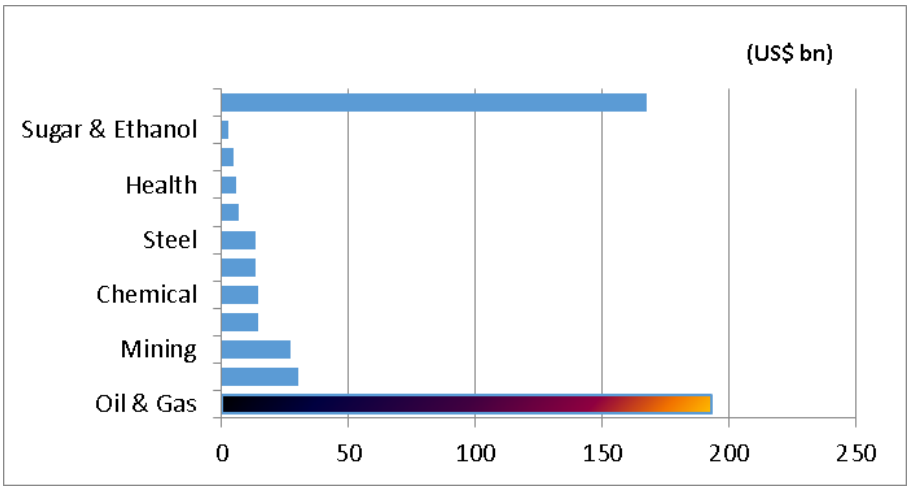
The power sector in Brazil is reeling from the damaging impact of several developments: the recurrence of abnormally dry seasons, which has resulted in the reduced availability of cheaper hydropower; losses of profitability for power generation and distribution companies owing to higher generation costs and the government's mandatory reduction in electricity tariffs in the period before the 2012 municipal elections; and mismatch between demand and contracted power, causing a 'hole'

[12] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/279546/DUKES_2013_Chapter_5.pdf

of 3000 MW that was covered by distribution companies through purchases on the spot market. According to power sector specialists, in 2015 Brazilian consumers will have to pay an additional $18–23 bn in order to contain the haemorrhage in the sector[13].

Petrobras – the main E&P investor in Brazil – is also the largest gas-to-power generator. Be that as it may, the oil and gas sector is expected to play a big role in Brazil's economy in the short and long term. Planned investment in oil and gas for the period 2013–16 will total approximately $200 bn, exceeding combined investment in the other industrial sectors. The Ministry of Energy's 10-year Plan for 2012–22 estimates that $550 bn will be needed to increase the availability of electricity, oil and gas and biofuels. According to the plan, the power sector will require investment totalling $124 million to increase capacity from almost 121 GW currently to 183 GW in 2022[14].

Figure 6: Planned investment in Brazil by sector, 2013–16



Source: (EPE , 2013)

2.2 The Brazilian gas industry: Genesis and evolution

The Brazilian gas industry was founded in 1851, when the Baron of Maua, a Brazilian entrepreneur, signed a contract to provide street lighting in the city of Rio de Janeiro[15]. In 1854 the Rio de Janeiro Gas Company – later known as CEG (Companhia Estadual de Gas) – was incorporated. This was followed by the incorporation of the Sao Paulo Gas Company (Comgas) in 1872 and several city gas distribution companies in other Brazilian cities. Medium calorific gas was produced through the distillation of coal in retorts. The advent of electricity in the early 1900s contributed to the collapse of all city gas companies except for Comgas and CEG, both of which continued to produce medium calorific gas from coal for cooking purposes until the 1960s, when they switched to naphtha. Until the late 1980s, city gas in Brazil was a mix of methane, hydrogen and carbon dioxide distributed to a small number of households and industrial consumers. CEG and Comgas were state-owned companies that had very limited market reach owing to the lack of gas supplies and funding.

In 1953 the nationalist government of President Getulio Vargas established a state-owned oil company, Petróleo Brasileiro S.A. (Petrobras), following a country-wide campaign under the motto 'O

[13] http://noticias.r7.com/economia/conta-criada-no-setor-de-energia-pode-ir-a-r-52-bilhoes-10042014-1
[14] (EPE, 2013).
[15] https://www.gasnaturalfenosa.com.br/br/conheca-nos/quem+somos/historia/1297092019569/historia+rio.html

petróleo é nosso'[16]. The monopoly of Petrobras in the oil and gas sector, except in gas distribution and importation, was subsequently enshrined in the Brazilian Constitution. Petrobras started to prospect for and find oil in onshore locations in northeast and southeast Brazil and to market associated natural gas to industrial consumers near its oil fields.

From 1960 to 1984 two gas distribution regimes existed in Brazil: city gas[17] distribution in the cities of Sao Paulo and Rio de Janeiro and natural gas industrial distribution by Petrobras in eight states in the north-eastern part of the country and in the interior of the state of Rio de Janeiro. Following the discovery of large offshore oil fields in the Campos Basin (Rio de Janeiro), which provided large volumes of associated gas, Comgas and CEG entered into negotiations with Petrobras and signed gas supply and purchase agreements allowing them to expand the distribution network. The governments of several states particularly those served by Petrobras' gas distribution system, established their own city gas distribution companies (LDCs) in a bid to exert more control over the expansion of the natural gas grid. At the same time, the federal government wanted to provide incentives for private investment in oil and gas E&P because of Petrobras' limited investment capability and Brazil's continued dependence on imported crude.

Initially, Petrobras was very reluctant to supply gas to the LDCs as it competed with low-value fuel oil produced at Petrobras' 11 refineries. In 1995, following a campaign by the LDCs to be allowed to import gas from Bolivia, a constitutional amendment ended Petrobras' monopoly by allowing private and state-controlled companies to explore for, produce, transport, and import and distribute petroleum and natural gas. The Petroleum Law (9478) of August 6, 1997 created a regulatory body, the ANP, and established a regulatory framework for the petroleum sector, which was later expanded to biofuels. Meanwhile, the distribution of natural gas remained within the competence of the federal states.

Even after the formal end of its monopoly, Petrobras continued to play a huge role in controlling Brazil's gas industry and infrastructure and to dictate both the pace of infrastructure expansion and gas pricing. This prompted another campaign to reduce Petrobras' grip on the gas sector, which resulted in the enactment of the Gas Law (11909) of March 4, 2009, which is yet to be fully implemented.

During the period 1997–99 the states of Sao Paulo and Rio de Janeiro privatised their gas distribution companies, while other states decided in favour of a tripartite ownership model in which the state government, Petrobras and private investors were shareholders. All states granted a 30–50 year exclusive geographical franchise to gas distribution concessionaires. The states of Sao Paulo, Espirito Santo and Rio de Janeiro regulation allow large consumers to become so-called free consumers after the 11th anniversary of the concession contract, but even free consumers are obliged to pay a distribution fee regulated by the state's regulatory agency. Since Petrobras remains the only supplier of gas and since the same distribution fee must be paid by free and captive consumers, there is no incentive to become a free consumer.

Despite all the setbacks and the lack of a clear government policy to provide incentives for the production and utilisation of natural gas, the Brazilian gas industry has witnessed some progress, particularly between 1999 and 2005 following the commissioning of the Bolivia-Brazil gas pipeline.

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[16] 'The petroleum belongs to us'.

[17] Medium calorific value city gas was manufactured from naphtha.

Gas consumption increased from 1 Bcma in 1980 to approximately 33 Bcma in 2013 while the number of consumers rose from under 500,000 in 1999 to 2.4 million in early 2014[18].

3. Key Industry Players and Regulation

Following the enactment of the 1997 Petroleum Law and the creation of the ANP, Brazil initially granted a transition period for the exploration blocks held by Petrobras and then developed the rules for holding E&P auctions on a yearly basis. The first pre-salt blocks were auctioned in the second exploration bidding round, which took place in 2000, when there was still little knowledge of the country's resource potential. The auctions attracted a significant number of domestic and international oil companies. Currently, 77 companies – both domestic and international – hold 329 exploration concessions.

The sedimentary basins in Brazil cover an area of 7.5 million km^2. Little is known about the resource potential of several offshore and onshore basins, particularly in the north of the country. Out of Brazil's 27 federal states, only 10 are gas-producing, with 66% of overall production concentrated in three basins – Campos, Urucu (Amazonas state) and Espirito Santo.

3.1 Brazil's E&P fiscal regime

The E&P fiscal regime in Brazil follows three models:

- **Royalty-tax concessions**, for all exploration contracts signed before 2012 and new exploration blocks that are not part of the pre-salt.

- **Hybrid (Transfer of rights)**, under which the federal government granted exclusive rights to Petrobras to explore a number of pre-salt blocks.

  In 2010 the federal government granted Petrobras exclusive rights to produce up to 5 bn BOE over 40 years in seven pre-salt areas and prospects, in six definitive blocks and in one contingent block][19]. Petrobras paid BRL74.8 bn ($42.5 bn) to the federal government for the transfer of rights, implying an average price of $8.51/BOE.

  Petrobras and the ANP hired, respectively, DeGolyer and MacNaughton and Gaffney, Cline & Associates to certify 2C contingent (best estimate)[20] and prospective resources in the assigned discoveries/prospects and to conduct a discounted cash flow analysis of the net present value of hydrocarbons in situ. Gaffney, Cline estimated 2C contingent resources and best-estimate prospective resources of 7.05 bn BOE, with an NPV ranging from $6.39/BOE to $11.76/BOE at a 10% discount rate[21]. After negotiations with the government, Petrobras agreed to pay $42.5 bn for the rights. Petrobras then issued shares to pay for the rights and to finance part of its ambitious investment programme; a 2010 share issue raised $71.6 bn – the largest-ever sum to be raised by this means. In practical terms, the share issue increased

[18] (ABEGAS, 2014) (BP , 2013).
[19] Tupi Sul, Florim, Tupi Nordeste, Peroba, Guará and Franco e Iara are the definitive blocks and Peroba the contingent block.
[20] 'Those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations by application of development projects, but which are not currently considered to be commercially recoverable due to one or more contingencies.' (Gaffney, Cline & Associates, 2010).
[21] (Gaffney, Cline & Associates, 2010).

the Union's shareholding in Petrobras from 39.8% to 48.3%, diluted minority shareholdings and contributed to creating a surplus on the 2010 primary account.

- **Production Sharing Contracts (PSC)**, for all pre-salt blocks granted after 2010 and for new 'strategic areas'.

  According to the new legislation approved by the Congress in 2010 Petrobras is the sole operator with a minimum 30% interest in all PSC blocks. The first pre-salt block (Libra) in the new PSC regimen was auctioned in October 2013, although there was only one bidder – the consortium formed by Petrobras, Shell, Total and CNPC. The signature bonus was $6.8 bn and the bidder offered the minimum profit oil percentage of 41.65%. The ANP expects the Libra block to contain 8–12 bn BOE.

Table 1: Blocks granted to Petrobras via transfer of rights

Block	Volume (MMBOE)	Price ($/BOE)
Florim	467	9.01
Franco	3058	9.04
South Guara	319	7.94
Entorno de Yara	600	5.82
South Tupi	128	7.82
Northeast Tupi	428	8.54
Peroba	tbd	8.53
Total	5000	8.51

Source: (Rocha, 2011)

In Brazil the exploration bidding round consists of a pre-qualification stage, in which investors may qualify as operator type A (any area, including deepwater), B (shallow water and onshore), C (onshore) or non-operator, and the depositing of a bank or parent company guarantee. On the day of bidding, which is a public event, bidders are asked to make bids for the following:

- Bidding bonus (which should be equal to or exceed a pre-determined value);
- Percentage of local content (percentage for the exploration stage differs from that for the development stage).

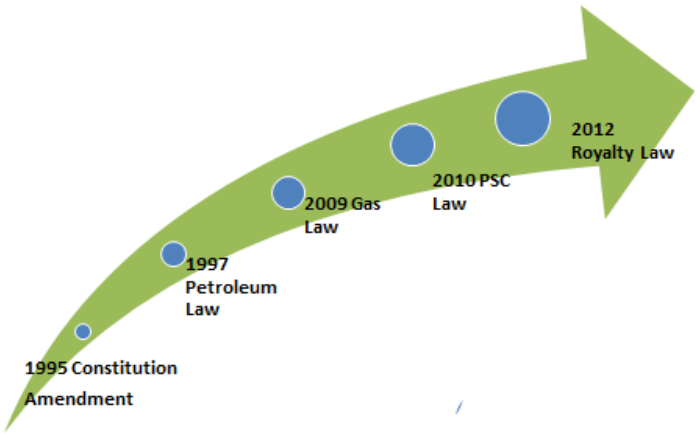
The winner is immediately awarded the block(s) and must sign a concession contract within one month of the bidding date. There is no restriction on the number of bids per bidder and companies are allowed to form consortia, provided they meet the pre-qualification criteria. As regards bids for pre-salt blocks, the government fixes the bidding bonus and the percentages of local content and cost oil. The bidder is asked to make a bid for the percentage of profit oil to be transferred to the federal government.

In 2008, following the pre-salt discoveries, the government suspended the annual auctions and sent a bill to the Congress providing for a new fiscal regime for pre-salt and strategic blocks. At that time, it was estimated that the pre-salt blocks could hold reserves of 30–50 bn BOE and that the exploration risk was very low, which justified increased control and a larger government take. Law No 12.351 of December 22, 2010 introduced the pre-salt regime, created a new state company to manage the government's interests in PSCs – Pre-Sal Brasil S. A. – and granted additional rights to Petrobras. Also, a new law on royalties was enacted in 2012 under which all Brazilian states receive royalty revenues – the previous relevant legislation had benefited only the producing states – and pre-salt royalties can be used for education and health. In 2013 the government launched new bidding rounds. Hence, all in all, the review of legislation on pre-salt and strategic blocks resulted in a five-year hiatus that has unpredictable consequences for future supplies of oil and gas in Brazil.

To summarise, the main changes introduced by the new petroleum legislation are:

- Pre-salt and strategic blocks are to be allocated under a production-sharing regime. All other blocks are to be allocated through concession licences. Pre-salt blocks allocated before the enactment of the new legislation will continue to be explored under concession licences.
- The government has created a new state-owned company – Pre-Sal Brasil S.A. – to represent the government's interests in pre-salt contracts. This company will have majority and veto rights in all pre-salt joint operating agreements
- Petrobras will be the sole operator of all pre-salt blocks with a minimum stake of 30%.
- The Congress has approved the creation of a special fund to invest pre-salt revenues in health and education.
- Producing and non-producing states will share equally the royalty proceedings which in the past were allocate only to producing states. Although there is no fixed percentage of local content established by law, the ANP has maintained a high threshold for bids, despite the conclusions of a study from ONIP[22] showing that local providers usually supply goods at higher cost than international suppliers. .

Figure 7: Evolution of Brazil's oil & gas legislation



Source: Author

3.2 Natural gas regulation

In Brazil there are two distinct jurisdictions for the regulation of the natural gas industry. The federal government sets all policy and regulation on the upstream and midstream, while the state governments supervise distribution activities and approve end-user prices.

[22] (Oportunidades, desafios e competitividade para a rede de fornecedores de O&G no Brasil, 2013).

Federal level

- The Ministry of Mines and Energy (MME) sets sector policies, executes high-level planning, authorises the import and export of natural gas; the MME is also in charge of putting in place a 10-year plan for the expansion of the gas transportation system;
- The National Council of Energy Policy (CNPE) approves the exploration blocks to be auctioned by the ANP (see immediately below) and sets guidelines for the development of Brazil's energy resources;
- The National Petroleum Agency (ANP) organises E&P auctions and gas transportation bids, monitors the execution of E&P activities, authorizes the construction of LNG import terminals and mediates conflicts involving producers, transporters, distributers and users;
- The Energy Planning Company (EPE) is responsible for forecasting long term energy demand as well and organise auctions for three and five year power capacity and availability, respectively A-3 and A-5 auctions.

States level

- The regulatory agencies of the states approve distribution margins and tariffs and monitor LDC concession contracts.

Apart from the restrictions governing the participation on the pre-salt blocks, any company established under Brazilian law can participate in any activity in the gas value chain. E&P concessionaires are allowed to dispose freely of their share of natural gas and oil.

According to the 2009 Gas Law, two regimes exist for the construction and operation of gas pipelines: international pipelines are authorised by the MME, whereas domestic pipelines fall under a regime whereby concessions are granted to the bidder offering the lowest tariffs. The owner of pipelines built or authorised before 2009 are granted 10-years' exclusivity. There is no open access to LNG terminals.

Gas distribution concessions are granted by individual states. Most states have established energy regulatory agencies to ensure quality of service and approve the margins and tariffs of concessionaires. The states are not obliged to follow a uniform federal framework, which causes some discomfort for large industrial end-users that have premises in more than one state since they have to abide by more than one set of rules and price levels.

In the downstream segment, there are 27 gas distribution companies (LDCs). Most states have just one LDC, while Sao Paulo has three and Rio de Janeiro two. According to the Brazilian Constitution, the states either operate gas distribution services directly or grant concessions to third parties. As noted above, gas distribution concessions award exclusive geographical franchise rights for 30–50 years. End-user prices are either bundled or cost of service, depending on the legislation of the relevant state, and readjusted on a yearly basis.

Table 2: Key players in Brazil's gas value chain[23]

	Investors	Regulation
Upstream	Petrobras Brazilian & international companies	Policy set by Ministry of Mines & Energy (MME) Federal regulator: National Petroleum Agency (ANP)
Midstream	Petrobras controls all existing pipelines and LNG terminals Private companies free to invest in pipelines (PL) and LNG terminals	Concession regime for new domestic pipelines & authorisation for international pipelines and LNG terminals MME promotes PL expansion (PEMAT) ANP regulates access and tariffs for new PLs Negotiated tariff for existing PLs
Downstream	27 private and state concessionaires (gas LDCs) Petrobras is shareholder in most LDCs	Concessions granted by state governments State regulatory agencies approve prices and concession contracts LDCs exclusive geographic franchise: 30-50 years

Source: Author's research

Figure 8: Geographical location of LDCs in Brazil

Source: http://www.abegas.org.br/Site/?page_id=839

[23] PEMAT: MME 10-year Plan for the expansion of natural gas pipelines.

4. Brazil's Gas Reserves: Significant Growth

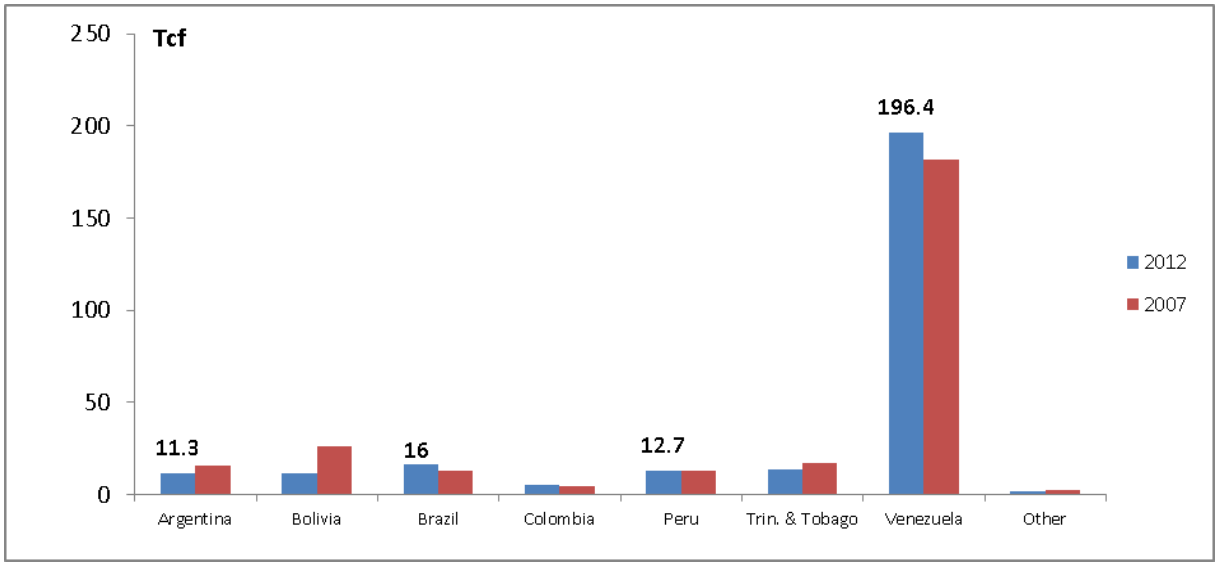
Brazil's gas reserves, though dwarfed by Venezuela's, have increased 25% over the last five years thanks to Petrobras and private companies investing in oil and gas exploration and development. In fact, Brazil, Peru, Venezuela and, to a certain extent, Colombia are the only countries in South America to have seen growth in gas reserves, while traditional exporters such as Bolivia and Argentina are experiencing a dramatic change in fortunes. Bolivia's takeover of foreign oil companies' assets and the nationalisation of gas reserves in 2006 have resulted in a sharp reduction in E&P investment. As a consequence, Bolivia's gas reserves more than halved over the last five years – from 26.13 Tcf in 2007 to just 11.2 Tcf in 2012[24]. According to the *Oil & Gas Journal*, its proven reserves are only 9.9 Tcf, whereas the US Energy Information Agency (EIA)[25] estimates that its technically recoverable reserves are 48 Tcf. Argentina is suffering from the same problem: its gas reserves fell from 15.5 Tcf in 2007 to 11.3 Tcf in 2012.

The Global Petroleum Survey 2013 of the Fraser Institute polled the views of 864 respondents representing 762 companies in the oil and gas sector[26]. The survey ranked Bolivia and Salta Province in Argentina among the 10 least attractive regions for investment out of 147 global jurisdictions. The ranking is based on five commercial environment index factors: fiscal terms, taxation in general, trade barriers, quality of infrastructure, and labour availability and skills[27].

The state-owned Yacimientos Petroliferos Fiscales Bolivianos (YPFB) is trying to develop E&P partnerships with foreign companies in a bid to double natural gas production by 2015. According to the EIA, YPFB aims to negotiate and approve 18 exploration contracts and drill 14 wells by 2015. Following the development of a new service contract model, a few deals were inked in 2013 with international companies, including the south-eastern Azero block (Gazprom/Total/Tecpetrol) and the Cedro and Huacareta areas (Petrobras and BG Group respectively).

[24] (BP, 2008) (BP , 2013).
[25] (US Energy Information Administration, 2012).
[26] (Fraser Institute, 2013).
[27] (Wilson, 2013).

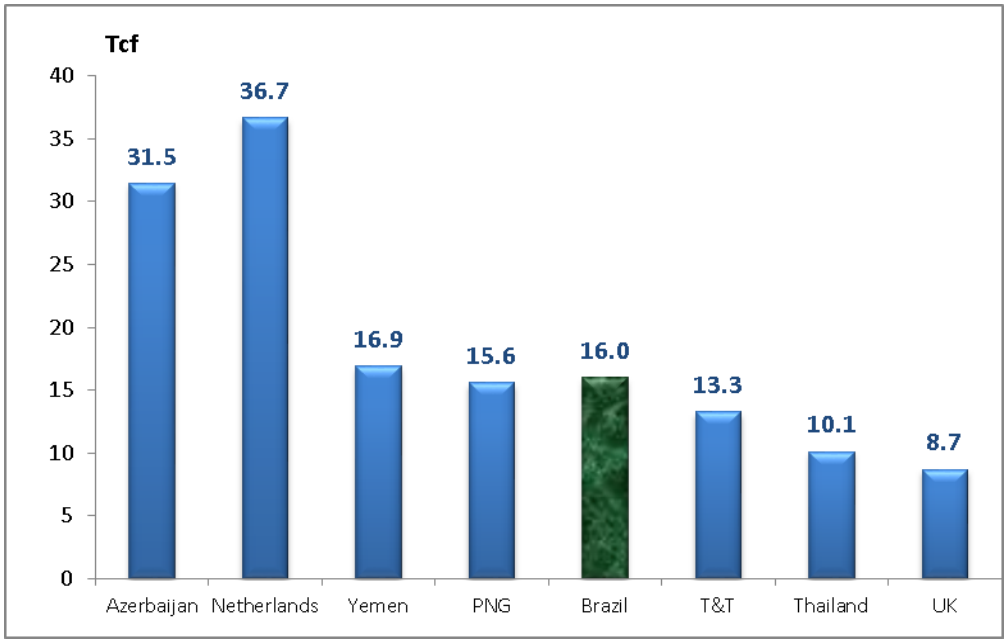
Figure 9: Evolution of gas reserves in South & Central America



Sources: (BP , 2013) (BP, 2008)

At 16 Tcf, Brazil's gas reserves are larger than those of Trinidad & Tobago, twice the size of the UK's and half of Azerbaijan's. Although the gas R/P in 2012 was 26 years, Brazil's domestic gas production is insufficient to meet its gas demand.

Figure 10: Gas reserves of Brazil compared with other selected gas producers, 2012



Source: (BP , 2013)

4.1 Domestic gas production

As of January 2014, Brazil had 329 blocks in the exploration phase, 72 fields in the development phase and 437 concessions in the production phase –– operated by 23 companies. There were 8,980 producing wells, of which 8213 were onshore and 767 offshore[28].

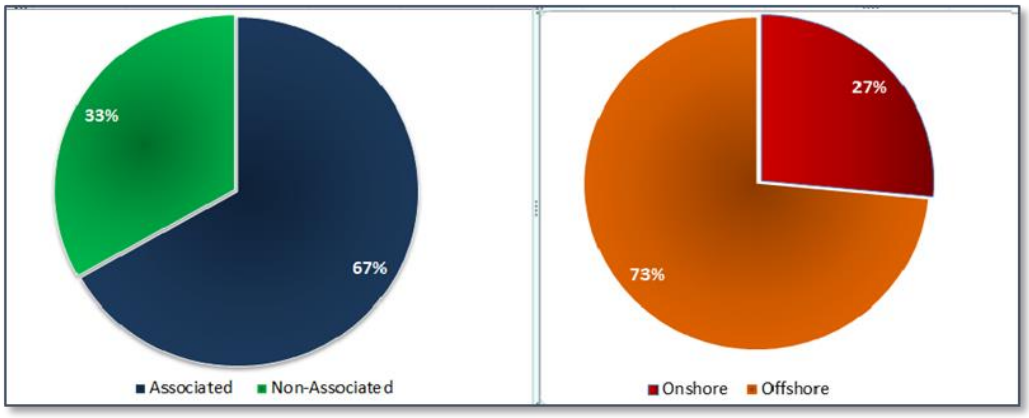
Figure 11: Brazil's E&P sedimentary basins

Source: Petrobras (http://www.fool.com/investing/international/2014/05/17/will-petrobras-production-grow.aspx)

In 2013 Brazil produced on average 77 MMm^3d of natural gas (27.8 Bcma). Approximately 67% is associated gas, while 73% of is produced offshore. In January 2014 Brazil's gas production reached 80.4 MMm^3/d (29.3 Bcma); the field with the largest production was the pre-salt oil field Lula, which produced 2.4 Bcma, of which 0.4 Bcma was flared. According to Petrobras, in March 2014 Brazil's domestic production reached a record 100 MMm^3/d (35 Bcma)[29].

[28] http://www.anp.gov.br/?pg=70027&m=&t1=&t2=&t3=&t4=&ar=&ps=&cachebust=1395447983965
[29] Presentation by Petrobras at the CWC Rio Gas Forum, April 10, 2014.

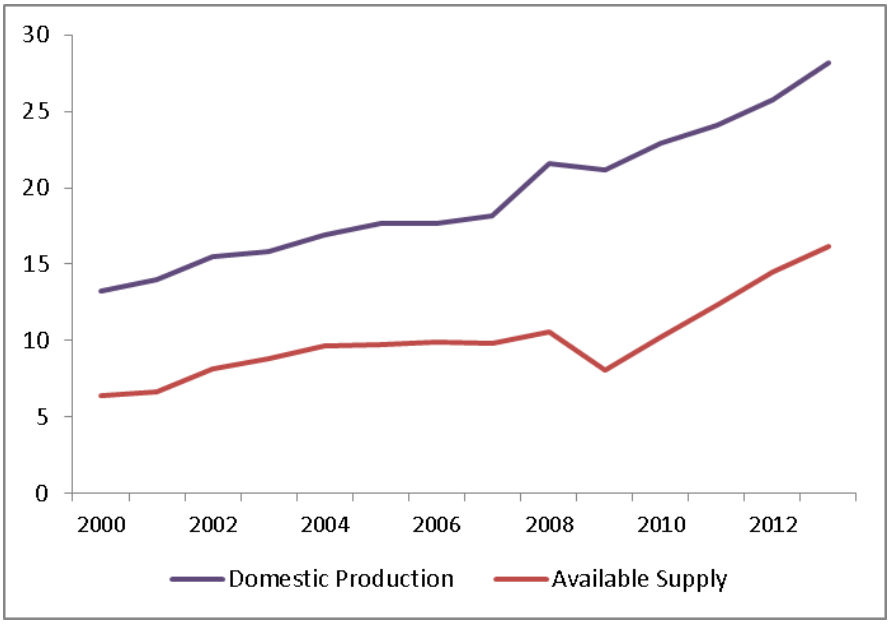
Figure 12: Breakdown of Brazil's gas production, 2013



Source: (MME, 2014)

In 2013 only 57% of Brazil's domestic gas production reached the market. Approximately 12 Bcma are used by Petrobras in E&P operations and at its gas processing units or re-injected and flared. Petrobras also uses a large share of the marketed production at its refineries and fertilizer plants (4.6 Bcma).

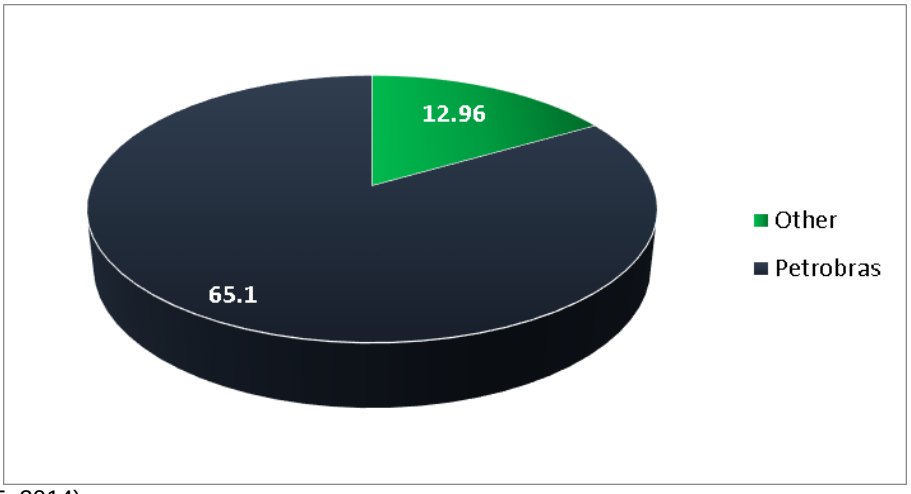
Figure 13: Brazil's domestic natural gas production vs available supply



Sources: (ANP, 2008) (MME, 2014)

Gas production in Brazil is dominated by Petrobras, which accounts for 83.4% of the country's total output. There are currently nine private companies producing gas, most of which in partnership with Petrobras. Only one consortium sells gas independently; the others sell to Petrobras at the wellhead.

Figure 14: Breakdown of Brazilian gas production by company (MMm^3/d)



Source: (MME, 2014)

Several major IOCs are currently active in Brazil, most of them in the exploration or development phase: BG, BP, Shell, Exxon, Chevron, Total, GDF Suez, GALP, Repsol and Statoil.

Table 3 below shows the companies that are producing gas in Brazil alongside Petrobras, albeit in significantly smaller volumes than the Brazilian NOC. Six of the smaller producers are independent Brazilian companies.

Table 3: Gas production in Brazil by producer, 2013

Producer	Gas Producer (Mm^3/d)	Type of company
Parnaiba Gas	3.92	Brazilian independent
Queiroz Galvao	2.79	Brazilian independent
BG Brasil	1.77	IOC
Petra Parnaiba	1.68	Brazilian independent
Brasoil Manati	0.62	Brazilian independent
Petrogal Brasil	0.62	IOC
Rio das Contas	0.62	Brazilian independent
EP Energy	0.59	Brazilian independent
Repsol Sinopec	0.35	IOC
Petrobras	65.1	Brazilian NOC
Total	78.06	IOC

Source: (MME, 2014)

4.1.1 Brazil's pre-salt hopes

Brazil's pre-salt blocks consist of several clusters on the continental shelves offshore the Campos and Santos basins, in south-eastern Brazil. The hydrocarbon formations are buried under a 2000m layer of salt at a water depth of 2000–3000m. It is estimated that pre-salt covers an area of 122,000km^2, of which 41,000km^2 have already been allocated for exploration/development. Brazil's pre-salt oil is of good quality (28–31^0 API) and has a gas-to-oil ratio of 250–300m^3 of gas/m^3 oil and CO_2 content of 8–15%[30]. The Santos Basin Pre-Salt Cluster comprises six blocks operated by Petrobras with various

[30] (Pre-salt Production development in Brazil, 2011).

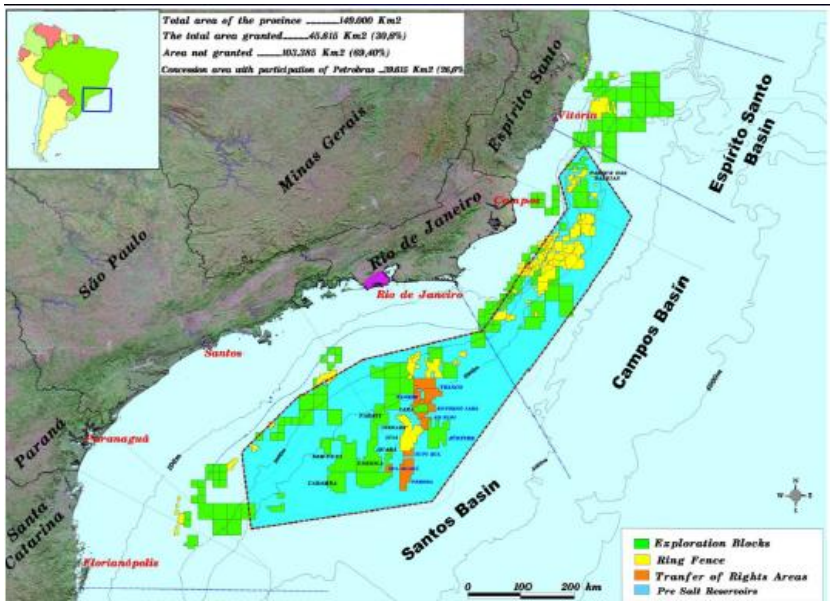
partners: GALP (Caramba and Jupiter), Shell and GALP (Bem-Te-Vi), BG and Repsol (Carioca and Guará), BG and Partex (Parati), BG and GALP (Lula, Cernambi and Iara. Six other blocks have been allocated to Petrobras under the transfer of rights regime, while another block (Libra) was auctioned under the PSC regime in 2013. More than 30 pre-salt blocks have yet to be auctioned. The Lula and Cernambi fields contain estimated recoverable reserves totalling 8.3 bn BOE, while Brazil's entire pre-salt may yield more than 50 bn BOE.

Assuming that by 2020 the pre-salt blocks are producing 2 MM bbl/d the gross production of associated gas is estimated at 79–95 MMm^3 /d. After subtracting volumes used by Petrobras internally and taking into account the removal of CO_2, the total volume available for sales would be from 35-42 MMm^3/d.

In 2009 Petrobras and its partners (BG, GALP and Repsol) awarded FEED contracts to three consortia: Saipem (Italy), SBM (Switzerland)/Chiyoda (Japan) and Technip (France)/JGC (Japan)/Modec (Japan)[31] to develop a floating LNG unit that would process 5.1 Bcma of pre-salt associated gas to produce 2.4–2.8 mtpa of LNG and LPG. Petrobras aimed to execute an EPC contract by mid-2011 with the objective of starting to produce LNG by the end of 2015. At that time Petrobras, very encouraged by the outlook for pre-salt, announced it would be commissioning the first FLNG in the world, ahead of Shell's Prelude. However, in 2011, it issued a statement saying that it was not proceeding with the FLNG project and would instead build three pipelines delivering the pre-salt gas to processing facilities in Sao Paulo and Rio de Janeiro. Among the reasons cited for that decision was the need to supply ethane to a Petrobras-led petrochemical project in Rio and uncertainties over CO_2 removal and gas needs for reinjection.

As of March 2014, Petrobras was producing nearly 400,000 bbl/d of oil at pre-salt fields and 2.3 Bcma of associated gas, of which 17% was being flared.

Figure 15: Pre-salt clusters in southeast Brazil



Source: (Fraga, 2012)

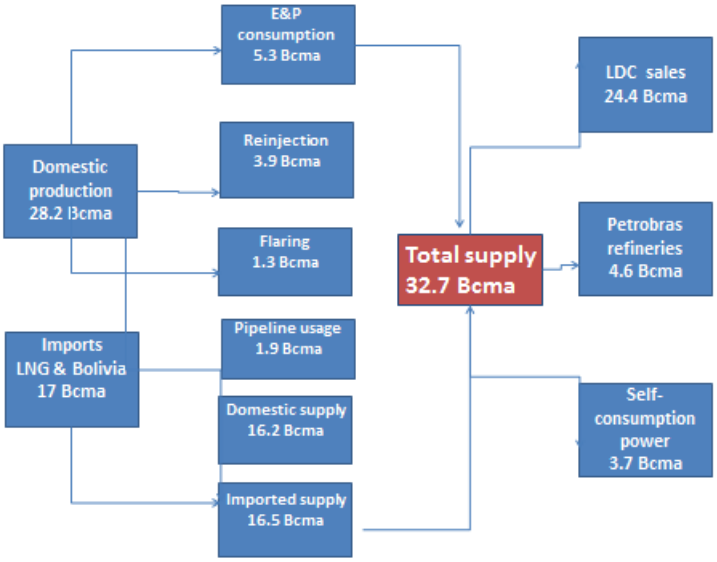
[31] http://www.rigzone.com/news/oil_gas/a/84447/Petrobras_Awards_FEED_Contract_for_Floating_LNG_Unit

4.2 Natural gas balance

Despite the size of Brazil's economy and its large population, domestic consumption of natural gas is relatively modest when compared with that of the country's smaller neighbour, Argentina, or other emerging markets, such as Turkey and India. A relatively mild climate (which means no need for space heating), insufficient investment in infrastructure and lack of interest in the exploration and development of non-associated gas are among the reasons for the modest role of natural gas in Brazil.

LDCs control most of the downstream market and accounted for 73.3% of natural gas consumption in 2013; the remainder is used by Petrobras at its refineries, fertiliser and power plants.

Figure 16: Natural gas balance in Brazil, 2013



Source: (MME, 2014)

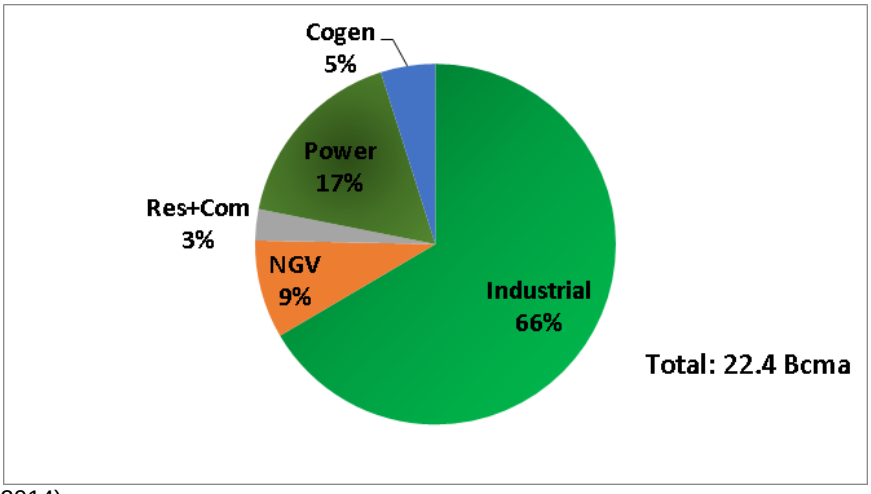
Brazil began importing natural gas in 1999, initially from Bolivia and from 2000 onwards from Argentina as well; LNG imports started in 2009. After deducting volumes used internally by Petrobras, the supply of domestic gas is now slightly less than that of imported gas.

4.3 Gas demand by sector

The consumption of natural gas has been growing steadily in Brazil since the commissioning in 1999 of the Bolivia-Brazil pipeline. The compound average growth rate was 10.8% for the period 2000 – 2013. The gas consumption pattern in Brazil differs from that in other emerging countries in the sense that the industrial sector accounts for the bulk of demand while power sector demand is extremely variable and highly dependent on rainfall and the availability of hydropower.

For example, in 2011 the industrial sector accounted for 66% of total gas marketed in Brazil and the power sector just 17% (see Figure 17 immediately below).

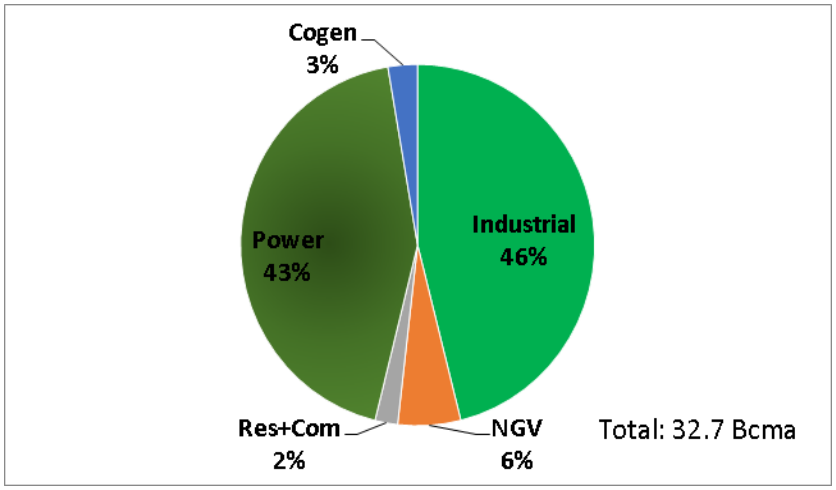
Figure 17: Brazilian gas consumption by segment, 2011



Source: (MME, 2014)

In 2013, however, the power sector accounted for 43% and industry for 46% of consumption (see Figure 18 below). The share of other market segments dropped in terms of percentage but was virtually unchanged in absolute terms.

Figure 18: Brazilian gas consumption by segment, 2013



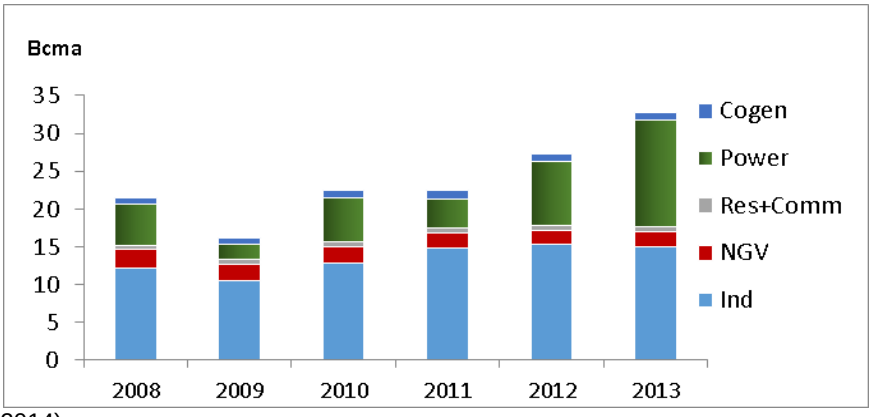
Source: (MME, 2014)

In 2013 the LDCs were responsible for the sales of approximately 74% of natural gas supply in Brazil. The country's 27 LDCs supplied gas to 2.44 million consumers[32], the majority of which are located in the states of Sao Paulo and Rio de Janeiro.

Several of Petrobras' power plants and refineries are classified as self-consumers and receive gas directly from Petrobras. The first independent gas production and supply project in Brasil was commissioned in 2013 in the northern state of Maranhao. It integrates gas production from the onshore Parnaiba block with an 845 MW power generation complex, which consumes 2 Bcma and dispatches mostly on base load.

[32] (ABEGAS, 2014).

Figure 19: Evolution of Brazilian gas consumption by sector

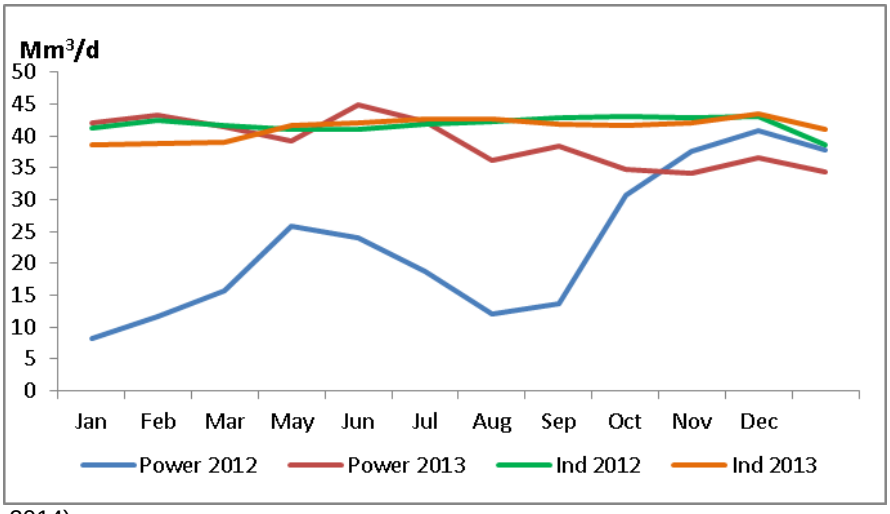


Source: (MME, 2014)

The 19.5% growth in consumption in 2013 compared with 2012 can be explained by the decision of the National System Operator (ONS) to increase the dispatch of gas-fired power plants to mitigate the impact of the prolonged dry period, which severely depleted the reservoirs in the southern and south-eastern regions.

By contrast with the stable and nearly stagnant_consumption levels of the industrial sector, power-sector demand follows no predictable pattern: it jumped from 11.73 MMm^3/d in February 2012 to 25.86 MMm^3/d in April 2012 and sank back to 12.09 MMm^3/d in June 2012. The average consumption of the power sector in 2013 was 38.91 MMm^3/d.

Figure 20: Natural gas consumption in Brazil's power and industrial sectors



Source: (MME, 2014)

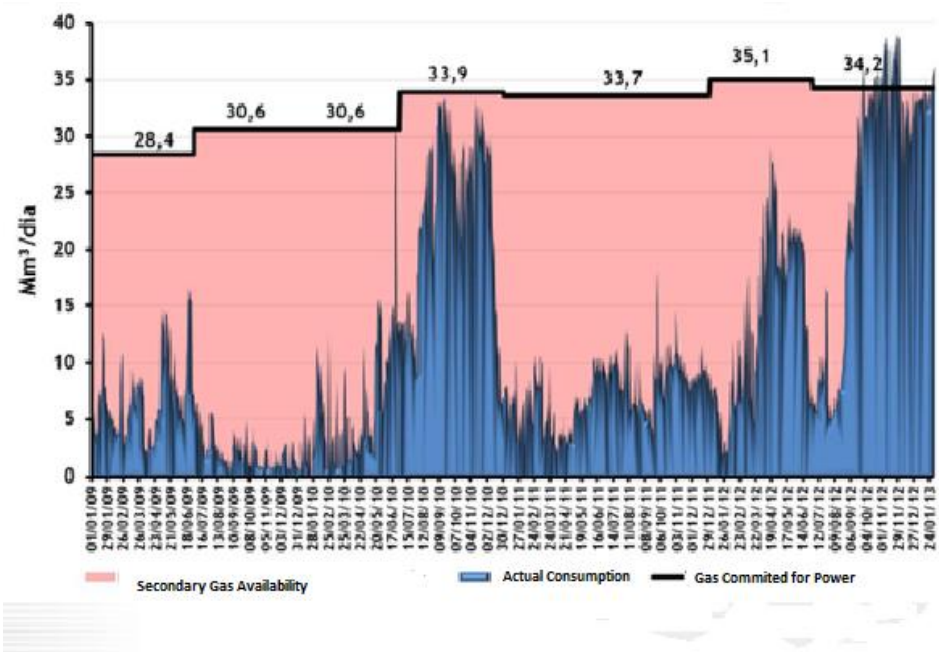
The irregular consumption pattern of the power sector makes it extremely difficult for private power-sector developers to secure long-term gas supplies because if they embed the costs of gas 'take or pay' (ToP) commitments in the fixed costs of the power plant they may not be able to win the long-term power auctions (A-5) [33]as their prices will not be competitive against those of smaller wind and biomass power plants.

[33] A-5: power auctions designed to add new capacity within five years.

At the same time, unpredictable consumption levels in the power sector make it difficult for privately owned power plants to commit to ToP gas agreements – particularly those involving LNG, which requires 100% ToP. In 2013 average gas consumption in the power sector was 38.91 MMm^3/d; in 2012 the same plants consumed on average 23.03 MMm^3/d, which is 59% of 2013 consumption. The lowest level of consumption was registered in January 2012 – 8.15 Mm^3/d – which was just 21% of average 2013 consumption. Moreover, power plants cannot re-sell gas already paid for but not consumed in the secondary market.

It is for this reason that Petrobras, which owns most of Brazil's gas-fired power plants, is the only company that has a large portfolio of domestic and imported gas supplies with which the relatively low power price ceiling and conditions imposed by the MME can be met. Those conditions include the obligation to present 25-year gas supply agreements and to demonstrate that the gas supplier possesses reserves that will meet the 25-year supply obligation; the latter doesn't fit well with LNG portfolio suppliers which source LNG from various projects. The auction price is also too low to accommodate for LNG import prices. Once a power price is bid there is little flexibility to readjust the variable components. Most existing gas-fired plants were built in 2003/2004–, at a time when Brazil was still in the wake of the 2001 rationing of electricity and before such restrictive conditions were in place. As a result of current auction policies, only four gas-fired power plants are being built in Brazil, three of which belong to Petrobras and one by government-owned Eletrobras. Despite the increased need for thermal power, the government forecast is for just 1,450 MW of new gas-fired power plant capacity to be built by 2020, out of a total of 35,000 MW of new capacity added in the same period.[34]

Figure 21: Supply profile of Brazil's gas-fired power plants, 2009–2013



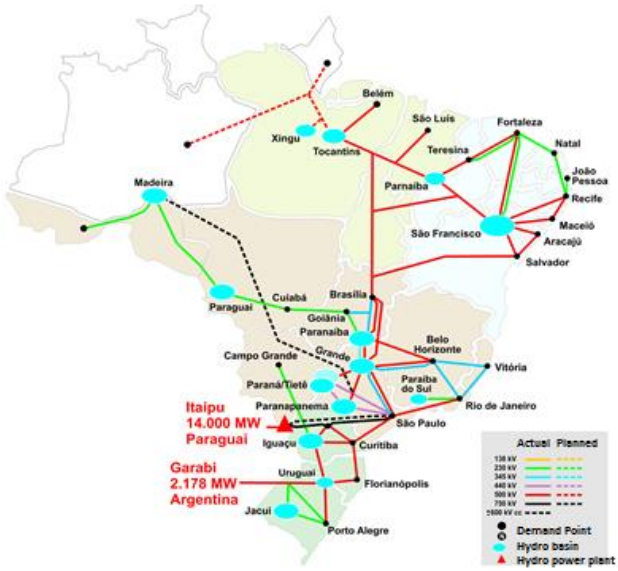
Source: (IBP, 2013)

[34] (EPE, 2013).

4.4 Brazil's power sector

Brazil's National Integrated System (SIN) comprises four sub-systems: Southeast/Midwest, South, Northeast and North; the two last-named have limited connectivity with the industrialized southern and south-eastern regions. Most of Brazil's electricity demand is from the southeast of the country.

Figure 22: Brazil's regional power transmission system



Source: http://www.ons.org.br/conheca_sistema/mapas_sin.aspx

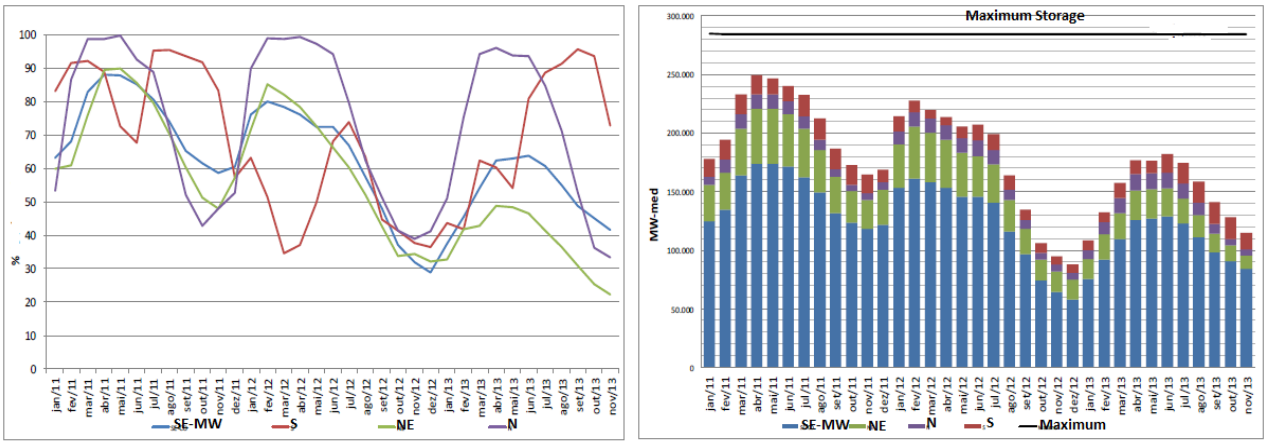
Brazil's generation system is 28.8% nuclear/thermal and 71.2% hydro/wind. Previously, the country's hydropower plants were built with large reservoirs with firm energy of 50–60% of total built capacity, which means they could stock lots of water that could be converted to power in the dry periods. In the last decade the government succumbed to environmental and social pressure by thus severely limiting the construction of power plants with reservoirs.

According to Brazil's electricity regulator (ANEEL), 42 power plants with a combined capacity of 28,835 MW were granted concession licences in the period 2000–12. Only 10 of those plants were authorised to build reservoirs (total capacity of 1,940 MW). The other 32 plants, (26,894 MW) were built without any storage capacity ('run of the river')[35].

After the rainy season, it is usual for Brazil's hydropower reservoirs to bounce back to 80–100% of their water storage level. But for the last three years, Brazil has suffered from low rainfall, which has resulted in the faster depletion of the reservoirs with very limited recovery. By mid-2013 the reservoirs in the south-eastern part of the country had recovered to only 64% of their water storage level.

[35] (Tancredi, 2013).

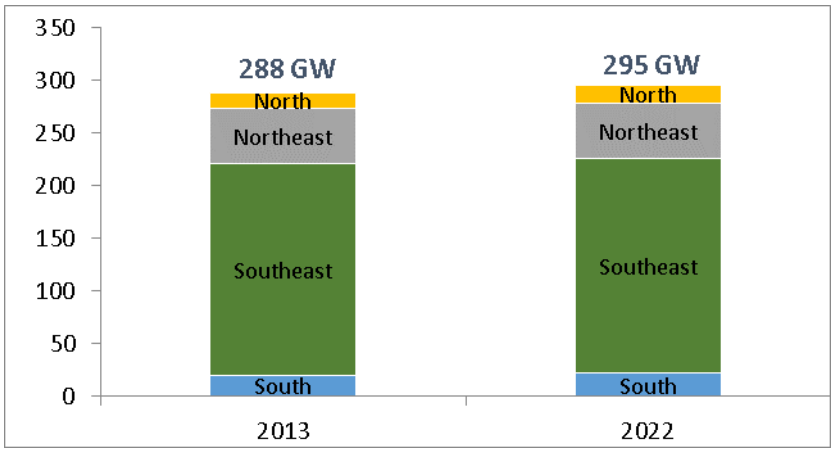
Figure 23: Brazil's hydropower reservoirs - Historical patterns



Source: (MME, 2014)

The maximum storage capacity in Brazil is 287,716 MW, of which 201,717 MW is in the southeast. Under Brazil's 10-year energy plan, very little storage capacity will be added to the SIN between 2013 and 2022 – just 7 GW, which is a mere 2.4% increase, compared with estimated demand growth of 51% during the same period.

Figure 24: Storage capacity of Brazil's hydropower reservoirs by region



Source: (EPE, 2013)

As of March 13, 2014, the energy stored in the Southeast/Midwest subsystem reached the very low level of 35.84% – equivalent to approximately 72 GW. In February 2014 the SIN registered record peak demand of 81,129 MW, which triggered the shutdown of 5,000 MW in several cities in the southeast for several hours.

Table 4: Stored Energy in Brazil's hydropower reservoirs*

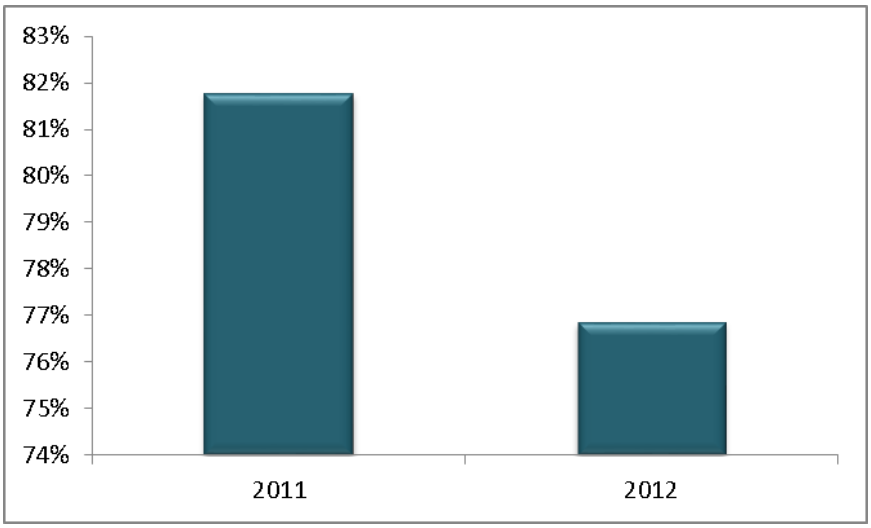
Subsystem	Stored energy (% of total capacity)
Southeast-Midwest	35.84
South	39.44
Northeast	42.13
North	83.2

* As of March 13, 2014.

Source: http://www.ons.org.br/home/

By the end of 2014 the installed capacity of gas-fired power plants in Brazil which are integrated with the SIN is expected to reach 11,483 MW. This is roughly 34% of Brazil's installed thermal capacity and 9.3% of its total installed power capacity. Gas-fired power plants operate in tandem with the availability of hydropower. In 2012 hydropower plants accounted for 77% of the total power generated in Brazil, compared with 82% in 2011.

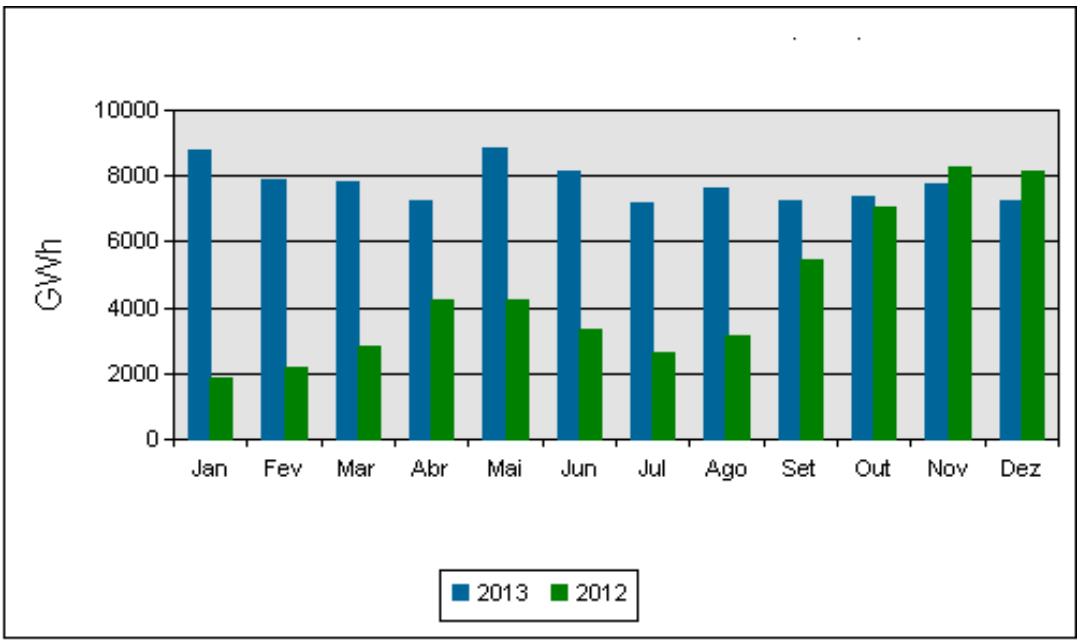
Figure 25: Share of hydro-power in Brazil's total power generation



Source: (EPE, 2013)

The hydrology situation in 2014, combined with the imperative that the government avoid blackouts during the World Cup and presidential elections, points to the need for increased dispatch of thermal power into the SIN. This will be accentuated in the winter months (June-August) since they are traditionally drier in the south and southeast than the summer months and owing to the lack of rain in the summer of 2013.

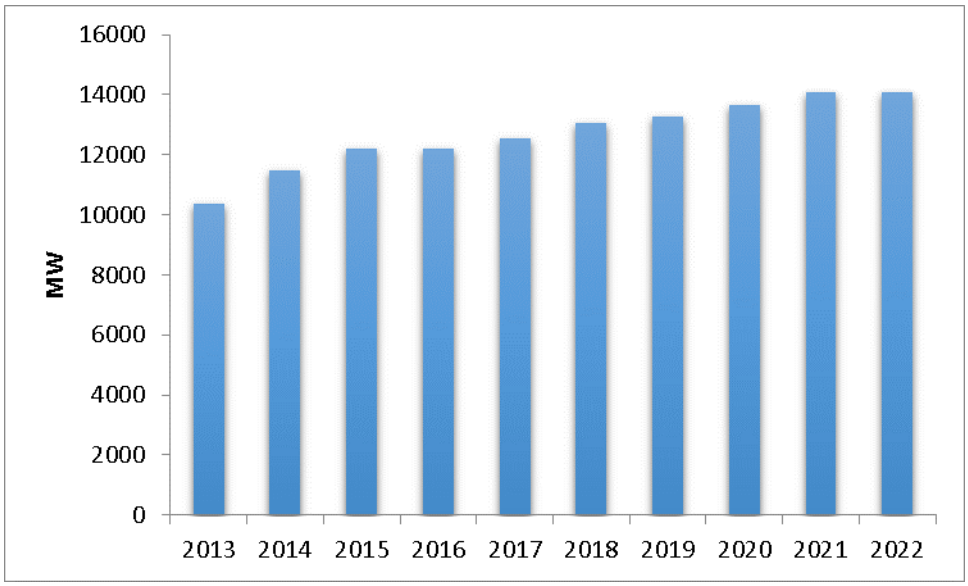
Figure 26: Brazil's thermal power generation (gas, oil and coal), 2013 vs 2012



Source: (ONS, 2014)

The MME projections for gas-fired capacity are very modest; in the short term, this is reflected in the latest power auctions, in which no gas-fired power plants were included. In the medium to long term, the MME expects less than 2,000 MW of new capacity at of gas-fired power plants during the period up to 2022.

Figure 27: Outlook for Brazil's gas-fired power plants



Sources: (EPE, 2013), (MME, 2014)

4.5 Stored energy vs LNG imports

As of December 2013, there were 36 gas-fired power plants operating in Brazil, with a total capacity of 10,366 MW, and another three under construction (1,117 MW). Those plants range from combined cycle gas turbines to stationary engines. At least 840 MW cannot be dispatched owing to lack of gas or disputes under contractual arrangements.

In January 2013 the gas-fired plants generated an average of 7,486 MW, which implies a load factor of 79%. Based on that month's average power consumption of 41.98 MMm^3/d, the unit average consumption was $5.6m^3/MW$.

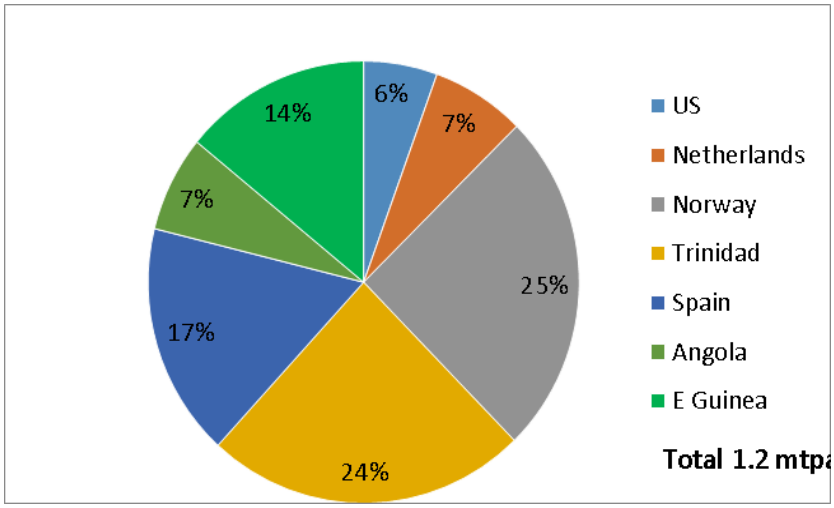
Also in January 2013, Brazil imported an average of 15.57 MMm^3/d of LNG, all of which was consumed by the power sector. Petrobras appears to be supplying approximately 23–26 Mm^3/d of domestic and Bolivian gas to the power sector, which allows 4,700–4,900 MW to be generated at a lower price with the balance of 2,600–2,800 MW covered by LNG imports.

As of April 15, 2014, the water storage situation in the southeast of the country had not significantly improved compared with the situation on March 13, 2014: reservoirs were filled to 36.91% of capacity[36]. Based on previous years, the south-eastern reservoirs should have been at 60–80% of capacity by that time. With the dry season now approaching, it seems unlikely that the levels can recover in 2014.

The lack of water storage implies the need to continue importing LNG. In 2014 Petrobras will have to import seven to eight cargoes per month; some sources suggest 15 will be needed in the peak months[37]. According to Platts, Petrobras had already imported 1.2 mtpa in the period from December 2013 to March 2014 – in which month LNG imports reached a new record of 0.69 mtpa[38]. Meanwhile, the MME reports that imports in January 2014 totalled 0.26 mtpa, with Petrobras paying on average $14.53/MMBtu FOB (Figure 28).

[36] http://www.ons.org.br/home/
[37] http://www.hellenicshippingnews.com/News.aspx?ElementId=35dfc488-f6cf-4c04-a9e6-05ecbbaf6485
[38] http://www.platts.com/latest-news/natural-gas/houston/brazil-lng-imports-hit-new-record-high-amid-drought-21430191

Figure 28: Breakdown of Brazil's LNG imports by source*



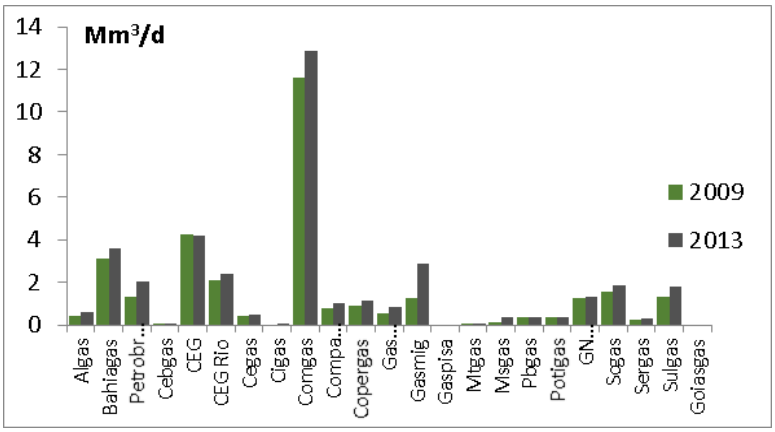
Source: (Young, 2014)

Despite the volatility in gas-fired power demand, there are currently no underground storage projects in Brazil. A study from San Paulo state research institute, IPT, suggested using 10 potential storage sites in an area in the state of San Paulo that is close to the Bolivia-Brazil pipeline[39]. In addition, several nearly depleted gas/oil fields in in the Campos basin and onshore blocks in northeast Brazil could be potentially used as gas storage; however, the high costs involved and the lack of a regulatory framework are impeding the development of gas storage projects in Brazil.

4.6 Gas Demand – LDCs franchise areas

The consumption of natural gas in the franchise areas of the LDCs nearly doubled from 2009 to 2013[40], increasing overall by approximately 11.8 Bcma and recording annual average growth of 15.84%. Most of the growth can be attributed to three or four LDCs – the others being too small to make a significant difference. The largest gas distribution company, Comgas, holds an exclusive franchise for the metropolitan area of Sao Paulo and neighbouring municipalities.

Figure 29: LDC gas sales, 2013 vs 2009



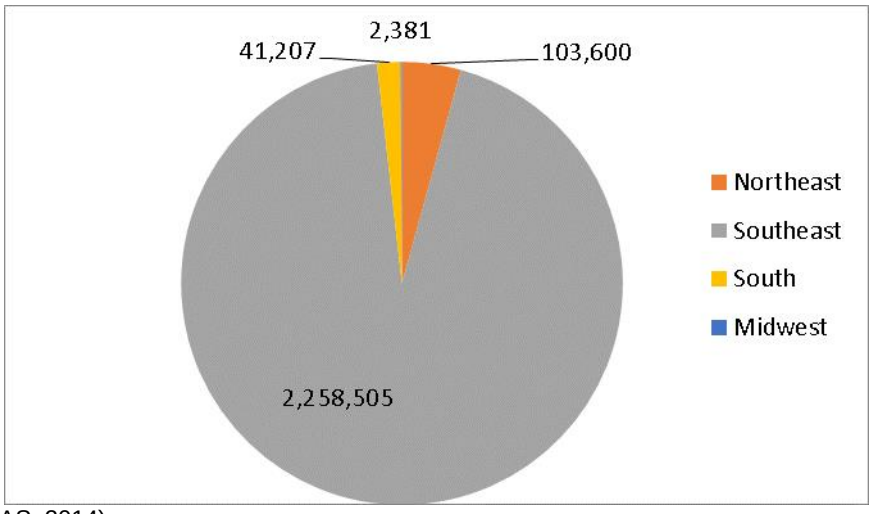
Source: (ABEGAS, 2014)

[39] Iyomasa, 2004.
[40] Figures do not include power generation.

4.6.1 Residential demand

Brazil has a population of 201 million and approximately 62.8 million households. The number of households served with natural gas is just 2.44 million or 3.8% of the total. As of January 2014, there were 28,227 consumers of natural gas in the commercial segment. The low penetration of natural gas in the residential and commercial segments can be attributed to several factors: Brazil's mild climate, the lack of urban and household infrastructure, subsidies for LPG (which is main competitor of natural gas in these two segments), high gas prices and the lack of funding from the smaller gas LDCs. The general public knows little about natural gas and its intrinsic advantages – namely, that it is clean, secure and flexible.

Figure 30: Breakdown of residential consumers by region



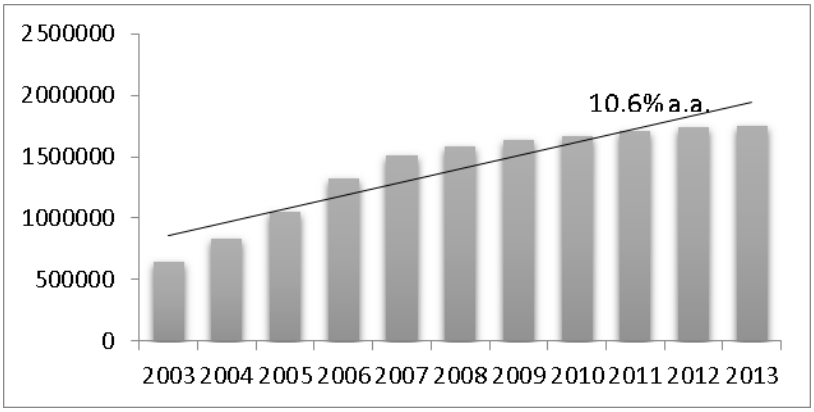
Source: (ABEGAS, 2014)

4.6.2 NGVs

As of January 2014, Brazil had 1,162 NGV stations supplying natural gas to nearly 1.8 million vehicles. While Brazil's NGV fleet ranks among the five largest in the world, it remains rather incipient, accounting for just 2.2% of the country's 81 million vehicles. In 2013 alone, some 4.74 million new vehicles were licensed in Brazil[41].

[41] (DENATRAN, 2014).

Figure 31: Historical growth of NGVs in Brazil



Source: (IBP, 2014)

In 2013 NGVs accounted for 6% (2 Bcma) of Brazil's total gas consumption. The price of natural gas at the pump is usually set at 60–70% of the price of petrol on an m^3/litre basis: in December 2013 natural gas at the pump cost R$1.792/$m^3$ compared with BRL 2.841/litre of petrol and BRL1.932/litre of ethanol[42].

Natural gas competes with ethanol in Brazil for the mantle of 'greener' transportation fuel. The advent of the flexi-car, which can burn any mixture of hydrated ethanol and petrol, gave a big boost to ethanol and slowed down the conversion of cars to natural gas. In addition, after the Bolivia nationalisation crisis in 2006 and amid renewed power-sector demand for gas from 2008 onwards, information about the availability of gas for vehicles was contradictory, which scared off consumers and reduced the momentum for car conversions.

Other factors contributing to the relatively low penetration of NGVs in Brazil's fleet are:

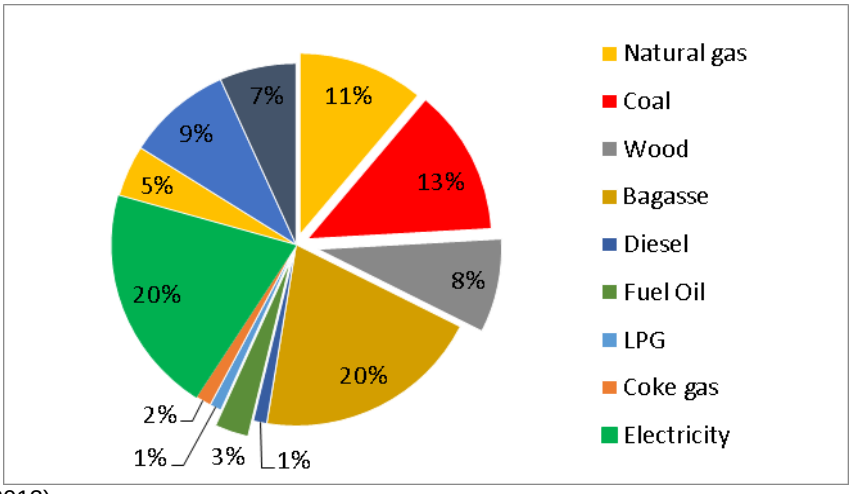
- Lack of country-wide infrastructure with adequate network pressure (>10 bar) to deliver gas efficiently to compressors at NGV stations;
- Continued reluctance among car manufacturers in Brazil, unlike in countries such as Italy and the US, to fit the NGV kits before the car leaves the factory so (consumers are penalised by losing their warranty once the car is converted to NGV;
- High-pressure cylinders occupying a large part of the car boot and still weighing quite a lot ('the extra passenger');
- Widespread concern in Brazil about the continuity of the NGV programme owing to uncertainty about gas supplies;
- Most Brazilian buses are diesel-cycle, meaning that natural gas cannot be used as standalone fuel (after two to five years, fleet owners resell buses to companies located in the interior of Brazil, where many locations do not have NGV fuelling stations).

4.6.3 Industrial demand

As of January 2014, there were 2,815 industrial gas consumers in Brazil, of which 1,349 were located in the state of San Paulo[43]. Demand is highly diversified, with consumers across all industrial segments: ceramics, glass, petrochemicals, steel, textiles, automakers and food and beverages, to name but a few.

[42] (IBP, 2014).
[43] (ABEGAS, 2014).

Figure 32: Breakdown of industrial energy consumption, 2012

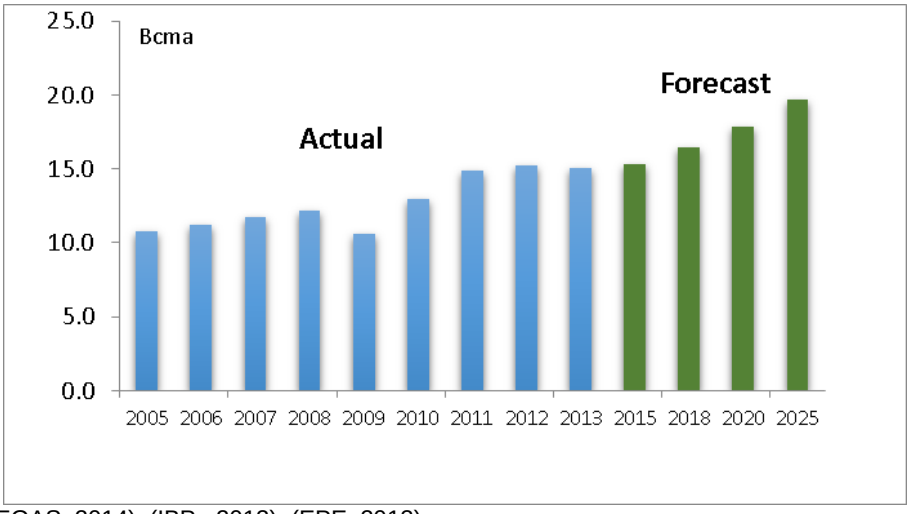


Source: (EPE , 2013)

The industrial sector consumed 15 Bcma in 2013[44] but industrial demand for gas has stagnated since 2011 owing to gas-price competitiveness and the plight of Brazilian industry, which has to endure high interest rates, heavy taxation, competition from cheaper Chinese goods and the appreciation of Brazil's currency, the Real. At the same time, the lower gas price in the US has been detrimental for investment plans in Brazil: several energy-intensive industries have announced plans to build new facilities on the US Gulf Coast. Looking forward, industrial gas demand in Brazil is forecast to grow to up to 20 Bcma by 2025 at a CAGR of 2.3%.

Increased penetration in the industrial sector depends on the ability of natural gas to compete with wood and coal, both of which play a bigger role in the industrial energy mix – not least in regions where gas infrastructure is under-developed.

Figure 33: Natural gas demand in industry – actual and forecast



Sources: (ABEGAS, 2014), (IBP , 2013), (EPE, 2013)

[44] This figure does not include Petrobras' refineries and fertiliser plants.

4.7 Natural gas infrastructure: The challenges of a continental country

As in the case of most emerging gas markets, Brazil lacks a comprehensive natural gas infrastructure. At the midstream level, there are 9,240km of transportation pipelines and three LNG terminals operated by Petrobras and 25,066km of distribution grids operated by gas distribution companies and mostly concentrated in the states of Rio de Janeiro and San Paulo. By comparison, Argentina has 15,437 km of transportation pipelines, 127,000km of distribution grids and two LNG import terminals[45],[46] as well as 8.2 million consumers.

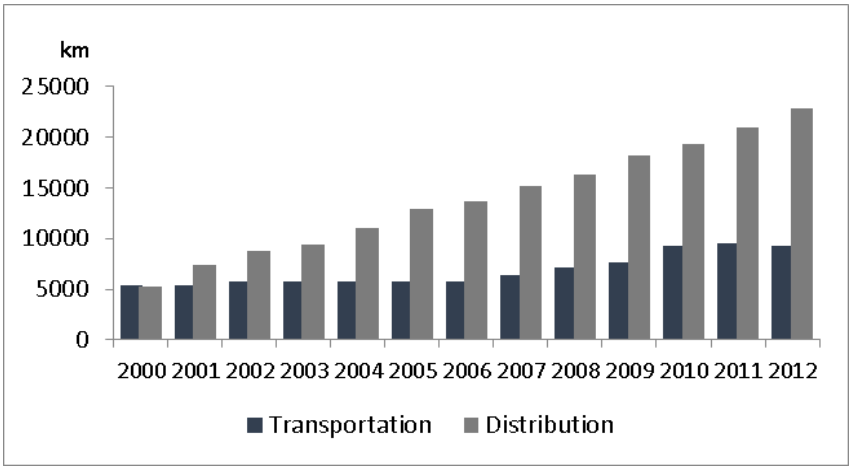
Table 5: Natural gas regional transportation and LNG infrastructure in Brazil (January 2014)

North	48km
Northeast	2835km
Southeast	19556km
South	2424km
Mid-West	204km
Total Brazil	25066km
Gas transportation pipelines	9244km
LNG import capacity (3 terminals)	15.3 Bcma

Sources: (ABEGAS, 2014), (MME, 2014)

The Bolivia-Brazil pipeline, commissioned in 1999, runs 3,000km from Santa Cruz de la Sierra in Bolivia to Porto Alegre in Rio Grande do Sul in southern Brazil, crossing five Brazilian states. It was designed to carry 11 Bcma. In addition, a 362km and 1.0 Bcma pipeline links Bolivia to a power plant in the mid-western region of Brazil, while a 450km pipeline connects Argentina to a power plant built by AES in southern Brazil. These two pipelines are currently idle owing to either lack of supply or issues related to power plants.

Figure 34: Evolution of Brazil's gas transportation and distribution infrastructure



Source: (ABEGAS, 2014) (MME, 2014)

[45] ENARGAS: http://www.enargas.gov.ar/Publicaciones/Informes/Anual/2012/Index.php
[46] ADIGAS: http://www.adigas.com.ar/industria_datos.php

Brazil's gas import capacity – both pipeline and LNG – is nearly 28 Bcma. There were trilateral discussions to build an intercontinental pipeline linking Venezuela to Brazil and Argentina; but owing to poor project economics and the lack of a strong project leader those plans came to naught.
So far, no new pipeline has been built in Brazil under the 2009 Gas Law. In fact, since mid-2010 only 150km of transportation pipeline have been added to the system.

4.7.1 The Bolivia-Brazil pipeline: Game changer

Bolivia and Brazil began discussing natural gas imports in the 1930s but the absence of key market fundamentals and the lack of a strong backer postponed the project for decades. In 1987, prompted by Comgas, which wanted to secure natural gas supplies, the former Governor of San Paulo sent a letter to the Minister of Energy requesting that negotiations on gas imports from Bolivia be restarted. That request was opposed by Petrobras, whose policy was to drip feed natural gas supplies into Brazil to avoid losing market share for its fuel oil – with its high sulphur content (up to 5%) and low market value, HFSO was sold to industrial consumers, most of which were concentrated in Sao Paulo[47].

A Brazilian ministerial mission to Bolivia in 1988 ended in stalemate: Brazil promised only to help Bolivia build gas monetization facilities – an iron ore plant and a petrochemical plant – on the Bolivian side of the border. The impending end of Petrobras' monopoly, combined with Comgas' plans to import LNG from Algeria, motivated Petrobras to re-launch negotiations with Bolivia in order to ensure that it had full control over Brazil's gas imports.

In 2003 Petrobras and Bolivia's YPFB signed a gas supply agreement (GSA) for an initial volume of 5 Bcma. The following year Petrobras selected the equity partners for the pipeline company known as TBG: the consortium BTB (comprising BG, BHP Billington and Tenneco/El Paso), in which Petrobras had a 51% share. For the Bolivian pipeline company, the Gas Transboliviano S.A. consortium was formed by Enron, Shell, and Bolivian pension funds. YPFB retained the role of gas aggregator with Bolivian producers while Petrobras assumed the role of shipper and marketer of the gas in Brazil. In 1996–97 Petrobras signed gas supply agreements with five Brazilian LDCs. Construction began later in 1997 and the first 2,000km to San Paulo were completed in 1999; the remaining 1,000km to the southern state of Rio Grande do Sul was commissioned in 2000.

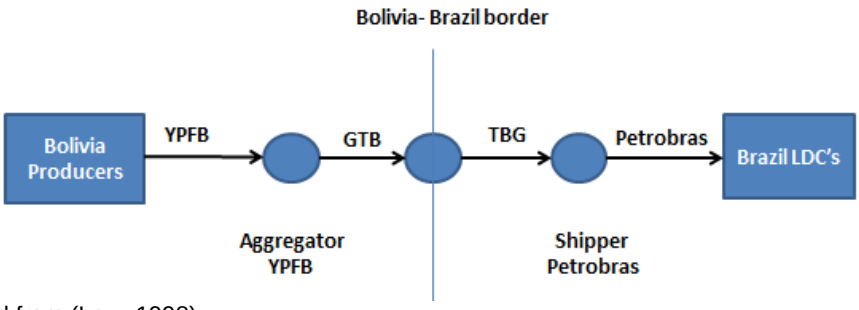
The $2.1 bn project was financed by several multilateral agencies – the World Bank, the European Investment Bank, Corporacion Andina de Fomento and the Inter-American Development Bank contributed 40% – while Petrobras arranged another 40% with bilateral agencies and the equity sponsors contributed 20%[48]. Its main features are:

- Total length: 3,150km, of which 2,593km in Brazil and 557km in Bolivia
- Contractual arrangements:
  - Transportation contract quantity (TCQ): initial contractual volume of 5.8 Bcma
  - Transportation capacity option (TCO): 2.19 Bcma of pipeline capacity in addition to TCQ
  - Additional transportation capacity: 2.19 Bcma of pipeline capacity in addition to TCQ and TCO
- Gas off-takers: LDCs of the states of San Paulo (Comgas), Parana (Compagas), Santa Catarina (SC-Gas), Rio Grande do Sul (Sulgas) and Mato Grosso do Sul (MS-Gas)
- Pipeline capacity: 11 Bcma

[47] (Gomes, 1996).
[48] (Law, 1998).

- Diameter: 32 inches up to Sao Paulo, thereafter telescopic ending (20 inches in Rio Grande do Sul)
- ToP of 80% for gas and 95% for pipeline capacity
- Postal transportation tariff for all off-takers regardless of distance

Figure 35: Commercial structure of the Bolivia-Brazil pipeline project



Source: Adapted from (Law, 1998)

The project proved a game changer for the Brazilian gas industry. Facing a rapid increase in gas supplies and hefty ToP obligations, the LDCs developed a substantial gas marketing campaign while Petrobras came up with its own marketing initiative to help promote the use of natural gas in Brazil. As a result, the share of natural gas in Brazil's final energy consumption rose from 2.2% in 1998 to 7.2% in 2012.

The pipeline, however, remains closed to third-party access. In 2001 the ANP tried to allow open access to the pipeline. BG, which owned the largest gas off-taker, Comgas, obtained a short-term interruptible capacity contract under which it paid monthly charges of $5 million; however, it did not succeed in securing capacity on the Bolivian side of the pipeline. More recently, buoyed by the possibility of open access provided for by the 2009 Gas Law, Brazilian gas trading companies made a bid to secure some capacity in the pipeline but were informed that Petrobras had just signed an additional GSA of 2.24 m^3/d with YPFB up to August 2014, which meant there was no spare capacity or supply volumes[49].

Post-2006 nationalisation, the Bolivian government strengthened YPFB's role as the sole export aggregator. As a result, Brazilian gas buyers cannot negotiate GSAs directly with private producers.

4.7.2 LNG infrastructure: Another game changer?

Brazil first toyed with the idea of importing LNG in the 1970s. Faced with the prospect of no domestic gas supply possibilities and the high costs of producing city gas from naphtha, Comgas started discussions on building an onshore import terminal. The company acquired a plot of land in the municipality of San Sebastiao (now a public beach) close to a major Petrobras oil terminal and launched talks with Algeria on LNG imports. Those talks stalled and were not revived until 1985 – before Comgas secured a 1.1 Bcma domestic gas supply contract with Petrobras. In 1999 BP and Shell began carrying out separate studies on LNG-cum-power projects in Northeast Brazil. The projects failed to materialize because it proved impossible to conclude the necessary GSAs to go ahead with the construction.

[49] Comment made during the CWC Rio Gas Forum on April 10, 2014 in Rio de Janeiro.

After Bolivia had nationalised its gas industry (in 2006), Brazil imported 50% of its gas supplies from the neighbouring country. Later Petrobras decided to follow a two-pronged strategy to diversify its supply sources: increasing the share of non-associated domestic gas and developing LNG import capacity.

There are currently three LNG import terminals in Brazil: the first was commissioned in 2009 in the state of Ceara (northeast Brazil), the second in in Rio de Janeiro and the third in 2014 also in the north-eastern state of Bahia. Talks on a fourth terminal are under way. In April 2014 Petrobras and Mitsui Group signed a MOU to carry out a study on building an LNG terminal in the country's southernmost state, Rio Grande do Sul. The study is to be completed within 12 months. Besides it trading capabilities, Mitsui is shareholder in seven gas LDCs in Brazil – in each case, in partnership with either a state government and Petrobras.

Table 7 immediately below shows Petrobras' current LNG import capacity.

Table 6: Petrobras' LNG import capacity

Terminal	Capacity (Bcma)	FSRU supplier	Storage capacity (m^3)
Pecém-Ceara	2.6	Golar Spirit	129,000
Guanabara-Rio de Janeiro	7.3	Excelerate Excellence	173,400
Bahia-Bahia	5.1	Golar Winter	138,000
Total	15.0		

Source: Author's research.

According to *GASTECH News*[50], Petrobras' lease of the Golar Spirit will end in 2018 and the Golar Winter in 2024. The 15-year lease for Excelerate ends in 2029.

In 2012 Petrobras announced the lease of two Excelerate LNG carriers – *Excelsior* and *Excalibur*, each of which has a capacity of 138,000m^3. This allows the company to import LNG on an FOB basis.

4.8 Natural gas prices

Brazil has a hybrid gas-pricing regime: producers, importers and transporters come under the jurisdiction of the ANP, while the gas LDCs are regulated by the regulatory agencies of the individual states. Producers and importers are able to freely negotiate gas supply prices with gas LDCs and potential free consumers. Imported gas prices are determined by the price formulae of the various GSAs, while Petrobras and other producers can freely negotiate the price of domestic gas.

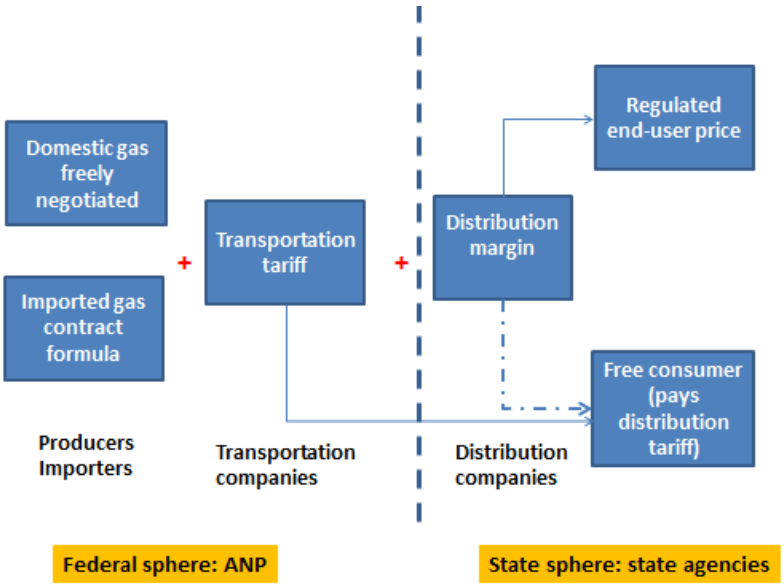
Before the enactment of the 2009 Gas Law, gas transportation companies (aka Petrobras) were free to negotiate transportation tariffs. The Gas Law stipulates that new pipelines are subject to tender and the winning bid is the one offering the lowest tariff. The ANP can intervene to mediate conflicts between suppliers and buyers.

[50] http://www.gastechnews.com/lng/petrobras-starts-up-brazils-third-fsru-import-facility/

End-user gas prices in Brazil are high compared with those in other South American and even European markets: large industrial consumers pay in excess of $16/MMBtu, whereas residential consumers pay $30-$50/MMBtu. Domestic gas prices at the wellhead and city gate are not regulated and range between $8/MMBtu and $12/MMBtu. Although these prices seem very attractive for gas producers and importers, it is uncertain whether other suppliers will be able to access the market place owing to the continued de facto monopoly in the pipeline infrastructure.

Domestic gas pricing is non-transparent: prices are bundled at the city gate and do not discriminate between the commodity and transportation components. Despite 70% of Brazil's gas being associated with oil and produced up to 300km from the consuming regions, domestic gas is more expensive than gas imported from Bolivia and has to be transported up to 3,000km to reach end-users. Following a campaign led by consumer associations and gas LDCs, Petrobras has begun granting a provisional discount on domestic gas.

Figure 36: Natural gas pricing structure and competencies in Brazil



Source: Author's research

The Bolivian gas price is formed of two components[51]:

$P_{\text{city gate}} = P_g$ (Gas commodity price at Rio Grande, Bolivia) + T_t (Transportation tariff, postal)

The commodity price is readjusted 50% quarterly and 50% every six months and is indexed to a basket of fuel oils (50% HSFO and 50% LSFO). The transportation tariff, which has a capacity component and a throughput component, is readjusted annually in accordance with the US purchasing price index (PPI).

Petrobras is currently the sole importer of LNG in Brazil and pays market prices. It imports only LNG to supply power plants. Following an acute power shortage and electricity rationing in 2001, the federal government established an emergency power programme (PPT) whereby power plants

[51] (Gomes, 1996).

commissioned by December 31, 2004 were to benefit from lower gas prices for 20 years. The price formula for PPT plants was set as following:

Price in Brazilian Real = 2.581 $/MMBtu * exchange rate (R$2.3436/$)[52]

The price is readjusted annually as follows: 80% in accordance with US PPI and 20% Brazil's wholesale price index IGPM-FGV. A compensation account is used to take into account variations in the exchange rate over 365-day periods.

Nineteen gas-fired power plants were built under the PPT regime, of which most now belong to Petrobras. The average contract price for PPT plants in 2013 was $4.56/MMBtu. It is unclear whether Petrobras is selling LNG to all its PPT plants at the lower and possibly subsidised prices. A newspaper article hinted that Petrobras had claimed that its supply commitment to PPT plants was just 12 MMm3/d, of which 60% was delivered to its own power plants[53]. Table 8 immediately below lists the gas-fired power plants owned by Petrobras.

Table 7: Gas-fired power plants owned by Petrobras as of December 2013

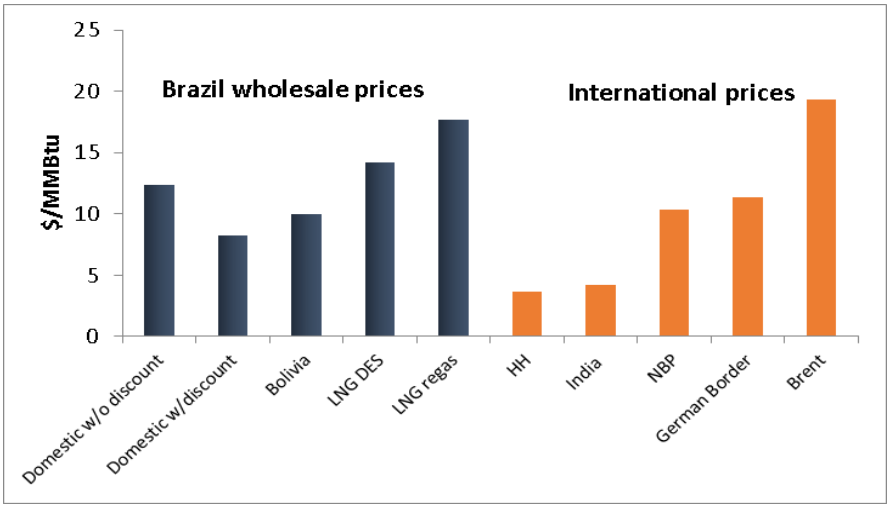
Power plant	Capacity (MW)	PPT commitment (MW)	Variable cost (R$/MWh)	Unit consumption (m^3/d)	Gas consumption at 80% load factor (MMm^3/d)
A. Chaves	226	212	102.84	4.36	0.79
Barbosa L	379	349	92.2	5.86	1.78
E. Rocha	250	206	98.96	5.28	1.06
F. Gasparian	565	357	70.16	5.02	2.27
L. Brizola	1058	998	147.74	4.89	4.11
L. Prestes	385	241	188.54	7.46	2.30
M. Lago	923	885	719.99	5.86	4.33
S. Tiaraju	161	147	N.A.	4.37	0.56
R. Almeida	138	125	58.89	6.24	0.69
C. Furtado	186	150	258.85	7.40	1.10
TermoCeara	242	217	37.8	6.56	1.27
Total	4513	3887			20.26

Source: (MME, 2014)

Figure 37 compares Brazil's wholesale gas prices with international gas prices as of December 2013. It is worth noting that gas prices in Brazil are similar to and, in some cases, even higher than wholesale prices in Europe[54]. LNG prices ex-regas approach oil parity, while domestic gas prices without discount are 20% higher than NBP prices. The average cost of supply in Brazil is $10.29/MMBtu (excluding tax as of December 2013) based on a mix of Bolivian gas, regasified LNG and domestic gas with discount. The price of the mix increases to $12.21/MMBtu if Petrobras decides to withhold the discount for domestic gas.

[52] (ANP, 2010).
[53] http://www.eletrosul.gov.br/gdi/gdi/index.php?pg=cl_abre&cd=gnlgeh8:%7DVehe
[54] Prices are excluding tax.

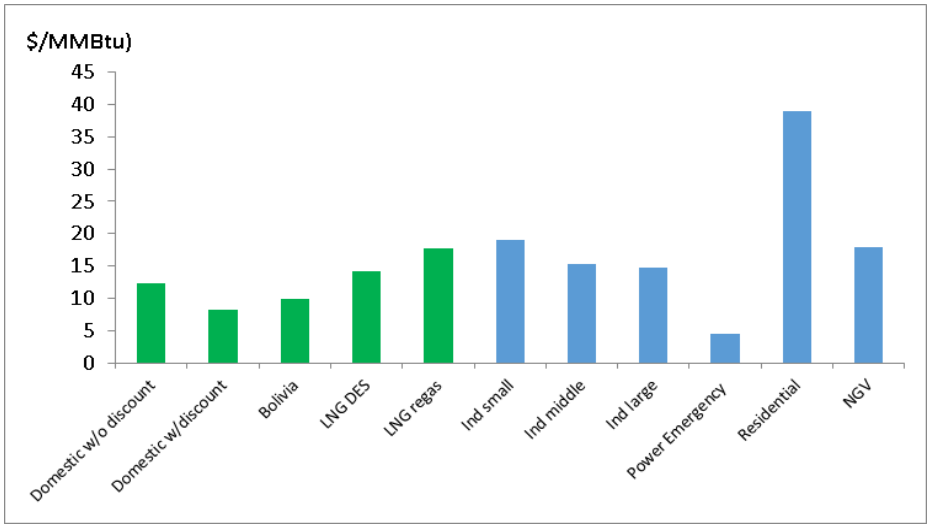
Figure 37: Wholesale gas prices in Brazil compared with international prices



Sources: Author's research and (MME, 2014)

Regulation at the state level allows LDCs to pass through supply prices to end-users and charge a distribution margin that takes into account the depreciation of the assets base, ongoing investments as well as operational and financial costs. The margin is adjusted annually to take into account inflation. Some regulatory agencies provide for a five-year margin review process and impose efficiency conditions.

Figure 38: Natural gas prices in Brazil: Wholesale vs end-user (December 2013)



Sources: (MME, 2014) MME (2014) and author's estimates

Natural gas prices to end-users are subject to federal taxes, including a 9.25% social contribution tax (PIS/COFINS) and VAT charged at 12–25% depending on the legislation of the individual state. For example, in addition to the $12.53/MMBtu price, a large consumer will pay 27% in state and federal taxes, some of which is not recoverable.

Figure 38 above compares wholesale and end-user gas prices as of December 2013. Except in the case of PPT plants, end-user prices are not subsidised and all costs, margins and taxes can be passed through.

There is no uniform gas distribution tariff in Brazil. Each state allows its LDCs to charge margins on a cost-of-service basis. In general, prices for industrial consumers are set to compete with HFSO, while NGV prices are offered at a discount to petrol prices. Smaller industries pay much more than HFSO prices because they have few alternatives, are under pressure from environmental agencies to meet air quality standards and are located in places where they cannot stock liquid fuels.

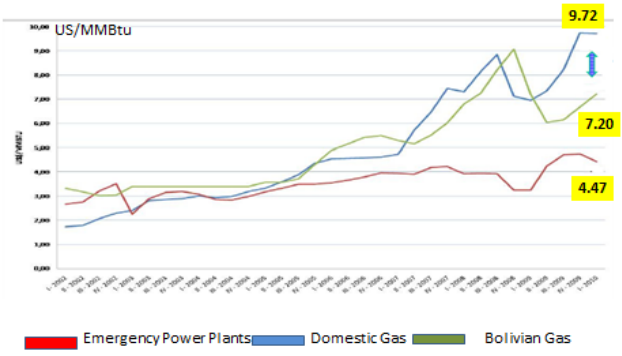
Table 8: Natural gas and fuel prices to end-users

Prices ex-tax ($/MMBtu) [55]	Northeast	Southeast
Small industry (>2,000 m^3/d)	11.19	17.20
Medium-sized industry (>20,000 m^3/d)	11.14	13.09
Large industry (>50,000 m^3/d)	10.41	12.53
NGVs	15.93	14.79
Residential	22.13	37.99
Power plant (PPT)	4.56	
Petrol pump prices	25.99	24.99
LPG	23.80	25.99
Fuel oil	11.14	11.07

Source: (MME, 2014)

Although the regulation in some states allows consumers above a certain threshold of gas usage to be free to choose their suppliers, there is little incentive for a consumer to be 'free'. This is because , the only gas supplier is Petrobras and the 'free consumer' is obliged to pay a distribution margin, which is usually the same as that paid by regulated consumers.

Figure 39: Increasing gap between power and gas (domestic and imported) prices



Source: (ANP, 2010)

The consumption of power plants is expected to increase as the economy slowly recovers. As long as the dry period continues, the gap between electricity wholesale prices and regulated PPT prices is expected to grow; and, with it, Petrobras' losses. This may explain why domestic gas prices are as

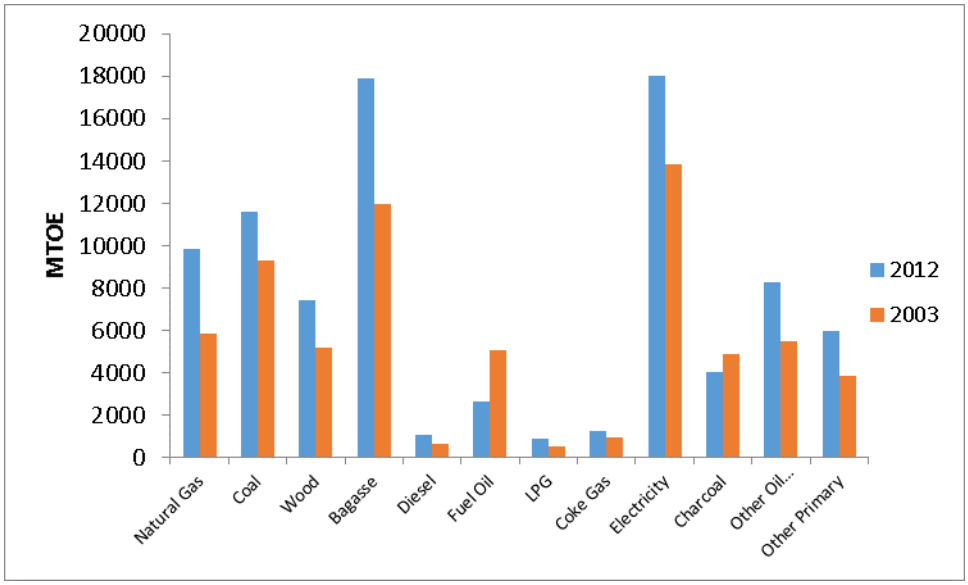
[55] End-user prices include taxes; w. Wholesale prices are excluding tax.

high as Continental European prices; indeed, it looks as if the price paid by PPT power plants is being cross-subsidised by other consumer segments.

The marginal operation cost shot up from $105/MWh in early December to $202/MWh in the last week of January 2014. Meanwhile, the spot power price in April 2014 reached $373/MWh.

While gas supply prices in Brazil are sufficiently high to attract private producers, the penetration of natural gas in the industrial sector is hampered by those high prices. There is not much room for gas to compete with oil products because most of Brazil's industries have already converted from fuel oil to natural gas and other fuels. According to Brazil's 2013 Energy Balance[56] the country's total consumption of fuel oil was equivalent to only 3 Bcma in 2012 – most consumers being located in regions without gas infrastructure.

Figure 40: Breakdown of fuel consumption by Brazilian industrial segment, 2012 vs 2003

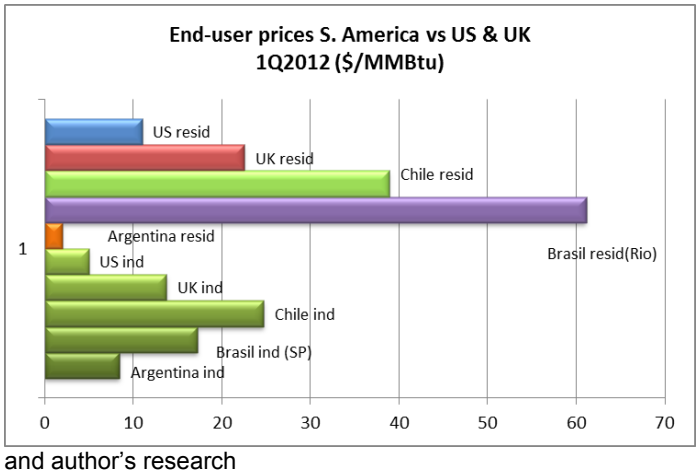


Source: (EPE , 2013)

Natural gas prices for Brazilian industry seem to have reached saturation levels: growth in this segment has been very limited since 2011. Owing to high gas prices, some energy providers are now offering pulverized biomass-to-boiler and wood-furnace solutions to compete with natural gas. The end-user price of natural gas is much higher in Brazil than in the US, Argentina and even the UK (but is lower than in Chile, which is a net energy-importing country).

[56] (EPE , 2013).

Figure 41: Comparison of natural gas end-user prices, Q1/2012



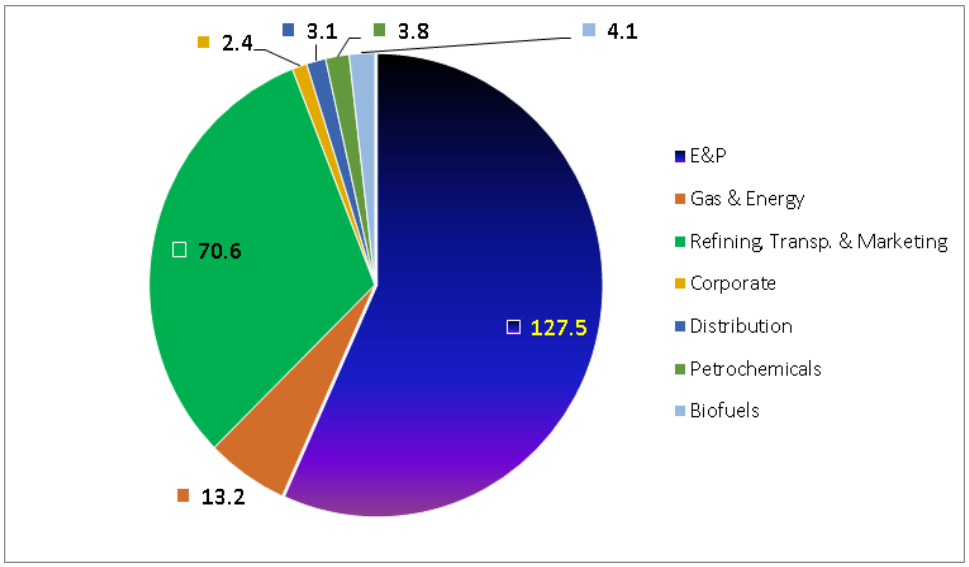
Sources: (Kozujl, 2012) and author's research

5. Gas Production Outlook for the Period 2020–30

Petrobras is the main player in Brazil's oil and gas industry. The state-owned company dictates the pace and quantum of the production of both types of fuel. It should be noted that most foreign oil companies are partners of Petrobras in prospective key areas such as the equatorial margin and pre-salt.

On July 26, 2011 the former President of Petrobras, Jose Sergio Gabrielli, announced a very bullish outlook for Petrobras and Brazil's oil and gas production, which was included in the Petrobras 2020 Strategic Plan.

Figure 42: Petrobras investment plan for 2011–15 ($ bn)



Source: Petrobras 2020 Strategic Plan

According to Gabrielli's 2011 presentation, Petrobras planned to invest $224.7 bn during the period 2011–15 – more than half of which in the E&P segment. This equates to nearly $45 bn annually, compared with Shell's $25–27 bn per year in its 2011–14 investment plan[57].

Petrobras' ambitious plan included investment totalling $13.2 bn in the Gas and Power segment, including pipelines, gas distribution, fertilizer plants, another two LNG import terminals and hydro- and thermal power plants. This demonstrates Petrobras' increased appetite to become a major integrated oil & gas company. To achieve that end, it planned to use third-party resources (debt) to fund 36% of its four-year investment needs.

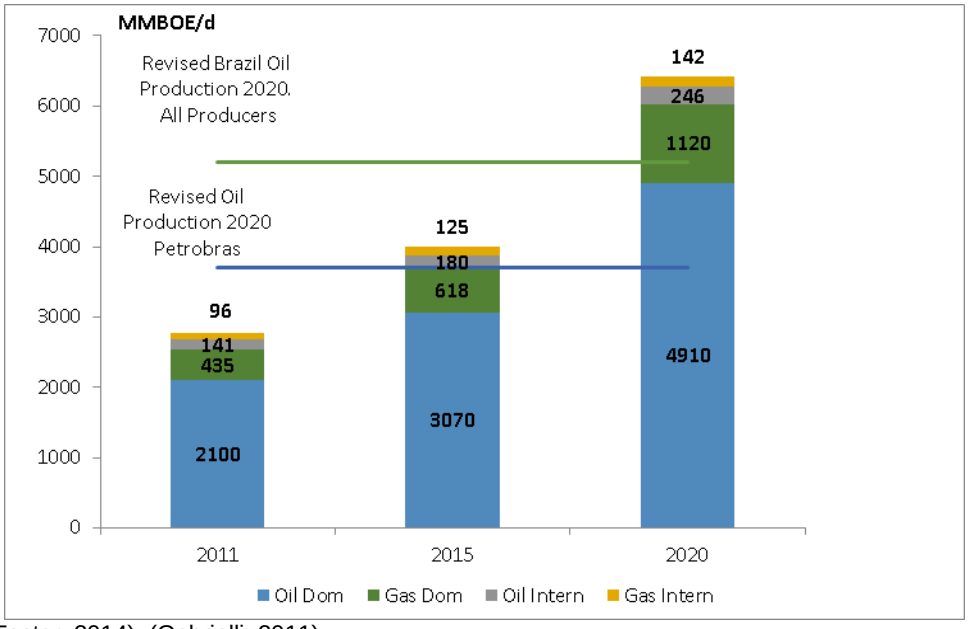
The 2011–15 plan also envisaged $127.5 bn in E&P, of which $64.3 bn was allocated to pre-salt – a jump of nearly 100% compared with the 2010–14 business plan (which earmarked $33 bn for pre-salt expenditure). At the same time, it foresaw hydrocarbon production increasing to 6.42 MBOE/d in 2020 from 2.77 MMBOE/d in 2011. Domestic oil production is forecast to increase to 4.91 MMbbl/d by 2020 and domestic gas production to 1.12 MMBOE/d (68 Bcma) from 435 MBOE/d over the same period. In 2012 the plan was revised down with projected oil production in 2020 at 4.2 MMbbl/d.

Petrobras' 2030 Strategic Plan, approved by the board of directors and announced in February 2014, offered a much more conservative scenario, with average Petrobras production of 2.9 MMbbl/d in the period 2013–20 and 3.7 MMbbl/d in the period 2020–30 – a significant reduction compared with the 2011–15 plan. For the first time, Petrobras provided an overview of third-party production in Brazil, forecasting total oil production of 5.2 MMbbl/d in the period 2013–20. Petrobras' target for its own production level by 2018 is 3.2 MMbbl/d[58].

The 2030 Strategic Plan foresees investment totalling $220 bn for the period 2014–18, of which $153.9 bn is earmarked for E&P – $80 bn in pre-salt and $10.1 bn in Gas & Energy. Indeed, despite reported financial problems, Petrobras is still planning to spend a staggering $45 bn/year, which it will continue to be hard pushed to achieve.

[57] http://s05.static-shell.com/content/dam/shell/static/investor/downloads/news-and-library/2011-strategy-webcastmediapresentation.pdf
[58] (Foster, 2014).

Figure 43: Petrobras production forecasts, 2014 vs 2011 plan



Sources: (Foster, 2014), (Gabrielli, 2011)

Although the various five-year plans provide a very high investment profile – more than $220 bn – the production targets for 2020 have slipped from 4.9 MMbbl/d to 3.7 MMbbl/d of oil & condensates. This highlights the increase in costs and project-management difficulties facing the company.

5.1 Natural gas supply-demand outlook

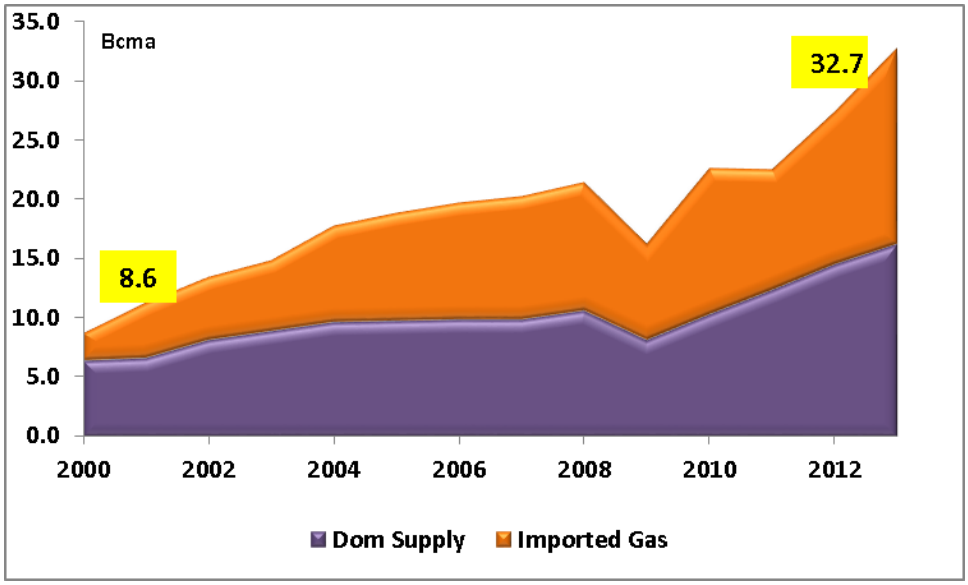
Brazil's domestic gas production increased on average 7.3% annually from 2000 to 2012, while average annual demand growth during the same period was 9.9%[59]. As mentioned above, Brazil started to import pipeline gas from Bolivia in 1999; there followed imports from Argentina from 2000 onwards and LNG imports from 2009.

In 2009 Argentina stopped supplying gas to Brazil owing to dwindling domestic gas supplies, which caused the shutdown of the AES 640 MW Uruguaiana power plant, located near the Brazil-Argentina border. The same year Brazil started to import LNG to complement the volumes imported from Bolivia and to increase the diversity and security of supply.

In 2013 the volume of gas imported into Brazil exceeded the volume of domestic supply by 7.5%. Will this trend continue? As a matter of fact, gas imports exceeding domestic supply is the norm rather than the exception – only in 2011 and 2012 was the volume of domestic supply larger than that of imports. And according to the Ministry of National Integration, the dry period will continue until 2015, requiring additional ('flexible') LNG imports.

[59] (BP , 2013).

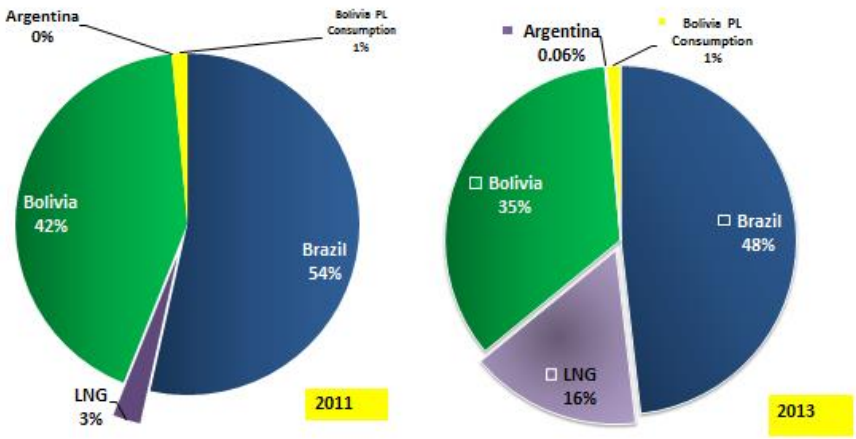
Figure 44: Evolution of domestic and imported gas supply in Brazil



Source: (MME, 2014) (ANP, 2008)

In 2013 domestic supply accounted for only 48% of the total consumption of natural gas in Brazil, compared with 54% in 2011. LNG's contribution to the energy mix rose from 3% in 2011 to 16% in 2013. LNG is sourced primarily to meet part of the flexible power generation demand which has no firm gas supply agreement – according to the MME this flexible power demand is 3500-4000 MW.

Figure 45: Sources of natural gas supply in Brazil, 2013 vs 2011

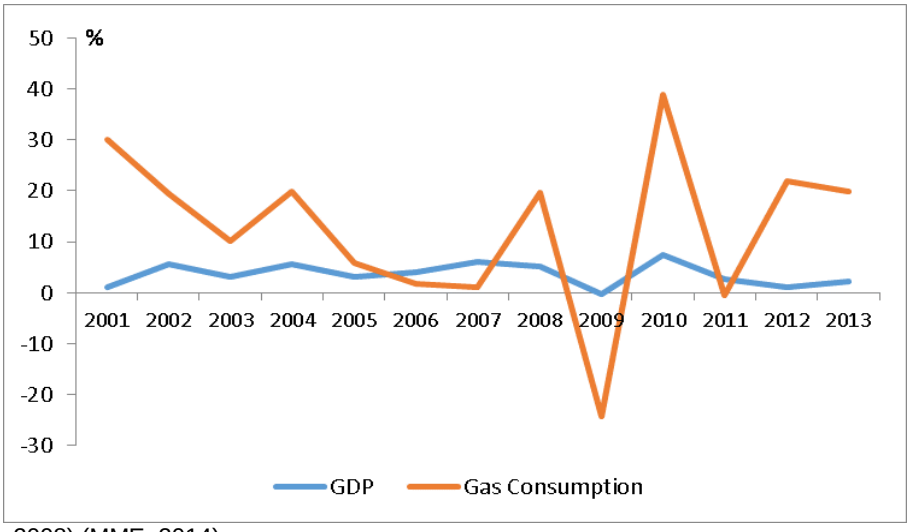


Source: (MME, 2014)

Until 2009 natural gas consumption in Brazil was loosely correlated with GDP owing to the preponderant contribution of the industrial sector. However, since 2010 this correlation has decoupled because of growing demand from the power sector, where the dispatch of gas-fired power plants depends on the seasonal factor and not necessarily on economic fundamentals. For example, in 2009 Brazil's GDP shrank only 0.3% as the country was reasonably protected from the world economic crisis. However, gas consumption dropped 24% because the exporting industrial sector was negatively affected by waning demand in foreign importing markets. In 2010 both Brazil GDP and gas consumption rebounded strongly, but the following year growth in consumption was hit by a

shrinking domestic economy and the lack of competitive domestic gas supplies. The growth in consumption in 2012 and 2013 can be attributed to the increased dispatch of gas-fired power plants met through LNG imports.

Figure 46: GDP vs gas demand growth in Brazil, 2001–13

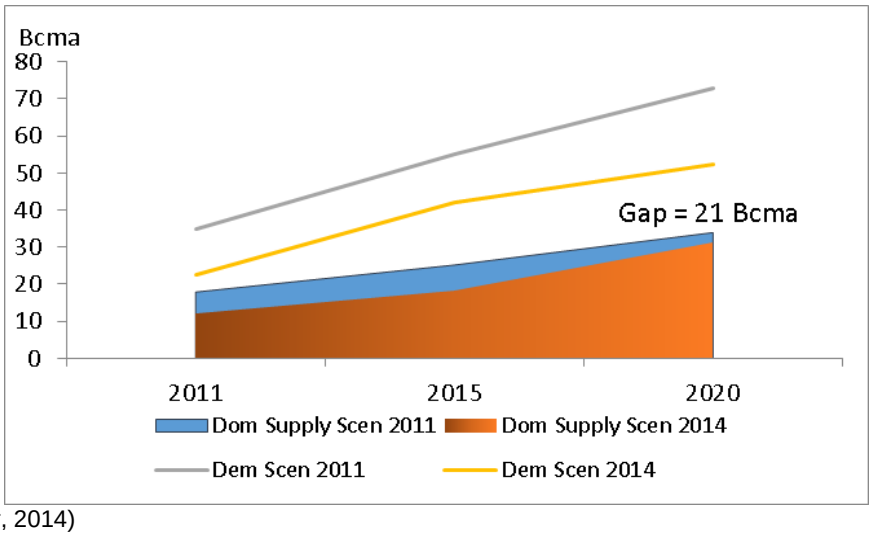


Source: (ANP, 2008) (MME, 2014)

Following the 2014 changes in its investment plan and the announced delays in reaching ambitious oil production targets, Petrobras issued a revised supply and demand forecast for natural gas. Gas demand was revised downwards from 73 Bcma to 52 Bcma in 2020 owing to the substantial reduction in Petrobras' planned investment in power generation, fertiliser plants and other downstream projects. Domestic gas supply, meanwhile, is projected to drop from 37.2 Bcma to 31.2 Bcma in 2020.

In both of the above scenarios, domestic supply will be insufficient to meet demand and Brazil will have to continue to import LNG and gas from Bolivia. This will be the case through 2020-25.

Figure 47: Petrobras scenarios for natural gas supply and demand



Source: (Foster, 2014)

According to Petrobras' and other industry projections, the supply of domestic natural gas is expected to reach 31 Bcma in 2020, after deducting the volume required for Petrobras' internal use and

reinjection. The Bolivia-Brasil GSA will expire in 2019, and it is expected that Petrobras will soon start negotiations on renewing the contract. Petrobras' supply projections suggest Bolivian imports will remain at the same level as today – around 11 Bcma – although it is questionable whether Bolivia's reserves will meet those requirements. Meanwhile, Petrobras has announced its intention to invest in new gas exploration areas in Bolivia in an attempt to reverse the decline in its neighbour's gas reserves.

In addition to its 11 Bcma contract with Brazil, Bolivia's YPFB has signed two supply agreements with Argentina's ENARSA: a firm supply contract with the obligation to deliver 13.9 Bcma by April 2015 and an interruptible contract under which 1.2 Bcma was delivered in 2013. According to YPFB, the firm contract with ENARSA expires in 2026 and provides for maximum annual supplies of 9.9 Bcma, subject to Argentina's expanding its transmission system in the northern part of the country to accommodate additional volumes.

If Bolivia increases gas supplies to Argentina to 7.3 Bcma in 2019 and maintains the same contract volume for Brazil as well as the same level of supplies to its domestic market and for E&P uses (4.3 Bcma), it would need to increase its reserves from the current 11 Tcf to 16 Tcf in order to commit to 20-year gas supply agreements.

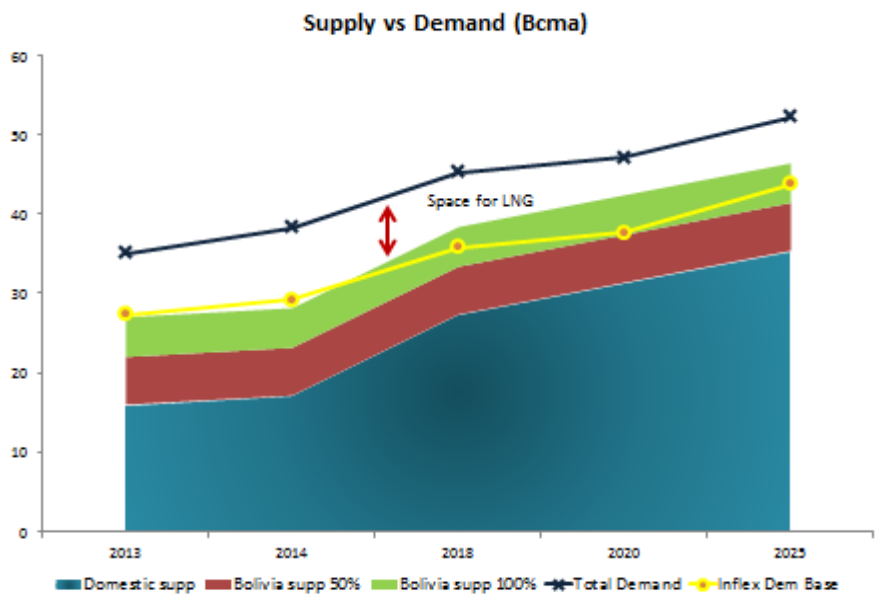
The supply-demand forecast shown in Figure 48 below assumes the following scenarios for the supply of gas from Bolivia and overall gas demand in Brazil:

- Supply Scenario 1: Bolivia's GSA with Brazil is renewed for 20 years with the same contract volumes as in the existing contract (11 Bcma)
- Supply Scenario 2: Bolivian annual supplies to Brazil drop to 5 Bcma
- Inflexible Demand Scenario: firm demand from industry, the residential sector and NGVs and inflexible power demand of 4 Bcma
- Flexible Demand Scenario: Additional volume of 13.8 Bcma for flexible power plants

Under Supply Scenario 1, Bolivian and domestic gas combined will be sufficient to meet all inflexible power demand. LNG imports to meet flexible power demand could be as high as 7 Bcma in 2018, dropping to 5 Bcma in 2020 as more domestic gas becomes available.

Under Supply Scenario 2, part of the firm demand will not be met by Bolivian and domestic gas, which means additional imports of LNG – totalling 13 Bcma in 2018 and 11 Bcma in 2020 – will be required to meet firm and flexible commitments. In 2025 the gap is expected to reach 12 Bcma. If Petrobras revises its oil-production forecasts downwards once again, the likely outcome will be not only increased LNG imports but also some demand destruction in the industrial sector owing to price competitiveness issues.

Figure 48: Natural gas supply-demand outlook in Brazil, 2013–25



Sources: Author's estimates, (Foster, 2014), (IBP , 2013) & (EPE, 2013)

5.2 Spot LNG: Expensive alternative for power generation

Owing to uncertainties over the dispatch of thermal power plants, Petrobras has been buying increasing volumes of LNG in the spot market or under short-term contracts.

Petrobras imports LNG FOB mainly from Trinidad & Tobago, Nigeria and Norway and has received several reloads from Europe. According to the MME, as of November 2013 Petrobras had spent $2.8 bn on importing 3.8 mtpa at an average FOB price of $14.19/MMBtu. If freight and regas fees are added, the total bill for 2013 could be as high as $3.5 bn. In February 2014 the average FOB price paid by Brazil was $14.53/MMBtu.

According to GIIGNL[60], Brazil imported 4.15 mtpa in 2013 – an increase of 1.7 mtpa over 2012. In addition to supplying Brazil's domestic market, Petrobras is buying cargoes for their international trade operations that do not necessarily involve Brazil. Besides Petrobras, there are several niche players in Brazil that have been trying to develop LNG import schemes to supply their own power projects. However, they have been deterred by the high price of LNG and have yet to provide LNG sellers with acceptable buyer credit guarantees.

[60] (GIIGNL, 2014).

Table 9: Brazil's LNG imports and re-exports

	Volume (mtpa)	LNG average price FOB ($/MMBtu)
LNG imports		
2009	0.33	5.44
2010	2.2	6.94
2011	0.56	12.69
2012	2.32	12.56
2013	3.78	14.19
Jan 2014	0.26	14.53
LNG re-exports		
2011	0.04	15.40
2012	0.23	11.53
2013	0.03	16.61

Source: (MME, 2014)

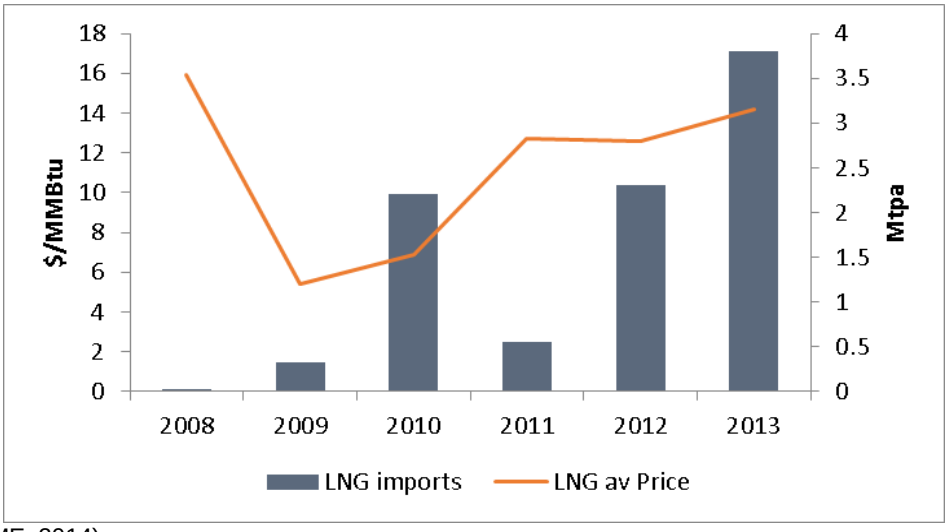
Despite buying increasing volumes of LNG and still enjoying an investment-grade credit rating[61], Petrobras is paying ever higher prices for LNG, as shown in Figures 49 and 50 below. Indeed, both Brazil and Argentina seem to be paying Asia-equivalent prices for LNG at a 40–50% premium over NBP and even higher prices than North Asia, given that most cargoes to South America originate in Trinidad & Tobago.

Figure 49: Average DES prices of LNG as of November 2013

Source: Adapted by author from (FERC, 2013)

[61] BBB- (Standard & Poor's).

Figure 50: Brazil's LNG import volumes and LNG FOB prices



Source: (MME, 2014)

There are a few alternatives to reduce Brazil's cost of LNG supply

1. Petrobras signs a long-term supply and purchase agreement for one of the brown-field liquefaction projects currently being developed in the Gulf Coast. This would enable Petrobras to procure LNG under a cost-plus pricing scheme rather than a market-based one.
   - Under the terms agreed with other buyers, the price of LNG FOB would be: P_{FOB} = 1.15 to1.25HH + $3.0
   - At HH = $5/MMBtu, the FOB price would range from $8.75/MMBtu to $9.25/MMBtu.
2. Brazil introduces long-term policies encouraging the development of domestic production. This would make it likely that gas supplies at the city gate would cost $7–8/MMBtu.

Table 1 shows the potential savings for each one of these approaches.

Table 10 : Gas sourcing options: Costs and savings (LNG imports vs domestic gas)

1. Business as usual	2. US Gulf LNG SPA	3. Domestic gas
Spot LNG	20-year SPA	20-year SPA
5 Bcma, 3.8 mtpa	5 Bcma, 3.8 mtpa	5 Bcma
$14.5/MMBtu FOB $17.7/MMBtu regasified	$8.75–9.25/MMBtu FOB $12.25–12.75 regasified	$7–8/MMBtu city gate
Annual cost: $3.1 bn	Annual cost: $2.1–2.2 bn	Annual cost: $1.2–1.4 bn
	Annual savings: $0.9–1.0 bn	***Annual savings: $1.7–1.9 bn***

Source: Author's estimates

Over 20 years, the implementation of the supply-sourcing alternatives shown in Table 10 would allow Brazil to save $18–38 bn, assuming Henry Hub remains at $5/MMBtu for the life of the LNG supply agreement. These savings are equivalent to 9–19 years' revenues from Brazil's largest power plant – the 14,000 MW Itaipu – which is also the second-largest power plant in the world and is shared by Brazil and Paraguay[62].

[62] http://memoria.ebc.com.br/agenciabrasil/noticia/2012-12-28/receitas-de-itaipu-ajudarao-garantir-reducao-media-de-20-na-tarifa-de-energia

6. Brazil and South America: Markets and Connectivity

The countries in the Southern Cone of South America are relatively well interconnected by pipelines and a growing number of LNG terminals. However, there is no such connectivity in the northern part of the continent.

A total of 13 international gas pipelines and six LNG import terminals are to be found in the Southern Cone, while one LNG terminal is under construction and another planned:

- 7 pipelines connecting Argentina to Chile, designed to transportation a total of up to 17 Bcma
- 1 pipeline connecting Bolivia to Argentina, capacity of 6 Bcma (increasing to 10 Bcma in 2015)
- 2 pipelines connecting Bolivia to Brazil, combined capacity of 13 Bcma
- 2 pipelines connecting Argentina to Uruguay, with a combined capacity of 4.7 Bcma
- 1 pipeline connecting Argentina to Brazil, capacity of 4 Bcma
- 2 floating LNG import terminals in Argentina
- 2 LNG import terminals in Chile, with another one planned
- 3 floating LNG terminals in Brazil, with studies into a fourth under way
- 1 LNG terminal being built in Uruguay

In addition, Peru LNG is the first LNG plant to have been built in South America, but its production has been directed to Mexico and Asia. Peru and Chile have a number of unresolved political issues that have so far prevented gas trade between the two countries. Meanwhile, Bolivia and Chile have a difficult relationship as the former claims a part of latter's territory that would give it access to the sea. In 2003 a consortium formed by BG, Pan American Energy and Repsol proposed a pipeline-cum-LNG project linking Bolivia and Chile (Pacific LNG). The project was an attempt to monetise the large gas resources found in Bolivia's Caipipendi region located a long way from the Bolivia-Brazil pipeline, which was controlled by Petrobras. Indeed, the possibility of exporting to Chile was the trigger for intense social unrest in Bolivia and led to the resignation of two of the country's presidents[63].

In 2006 Venezuela and Brazil started discussions on building a Pan-American Pipeline or North-South Gas Corridor. The proposed project entailed a 9,000km pipeline with a capacity of 55 Bcma connecting Venezuela, Brazil and Argentina and at the same time incorporating Peru and Bolivia. The project has never been implemented owing to the sheer volume of investment required, weak economic fundamentals, lack of leadership and the environmental challenge of crossing the Amazonian rainforest.

Until 2004 Argentina exported gas to neighbouring countries on a regular (uninterrupted) basis. That year the decision of the Argentine government to devalue the local currency and unpeg gas prices from the US dollar resulted in those prices dropping 70%; consequently, an increase in domestic demand could not be met by gas producers who were being paid very low Peso-denominated prices at the wellhead. Facing a gas shortage in the domestic market, the Argentine government issued an administrative ruling whereby gas could be exported only if domestic demand had been met. This was followed by the introduction of very stiff export taxes that made it uncompetitive to import gas from Argentina.

[63] http://www.libertaddigital.com/mundo/informe-el-plan-para-exportar-gas-detonante-de-la-crisis-1276204322/

Argentina went on to suspend exports to all three of its export markets (Chile, Uruguay and Brazil), except for small volumes supplied to residential consumers in Chile and Uruguay. Chile, which suffered most owing to the lack of alternative supplies, immediately started soon to develop LNG import projects. Uruguay followed Chile's example, but its single LNG import project has been developed at a slower pace.

The impact of the Argentine gas-export moratorium on Brazil was less severe because that country had imported smaller volumes to supply a single customer – an AES power plant built on the Brazil-Argentina border (Uruguaiana). However, the owner of the power plant made huge losses because it was not competitive to dispatch power using diesel as a replacement fuel.

Figure 51: Gas infrastructure and interconnectivity in the Southern Cone

Source: Adapted by the author from (Rudnick, et al., 2007)

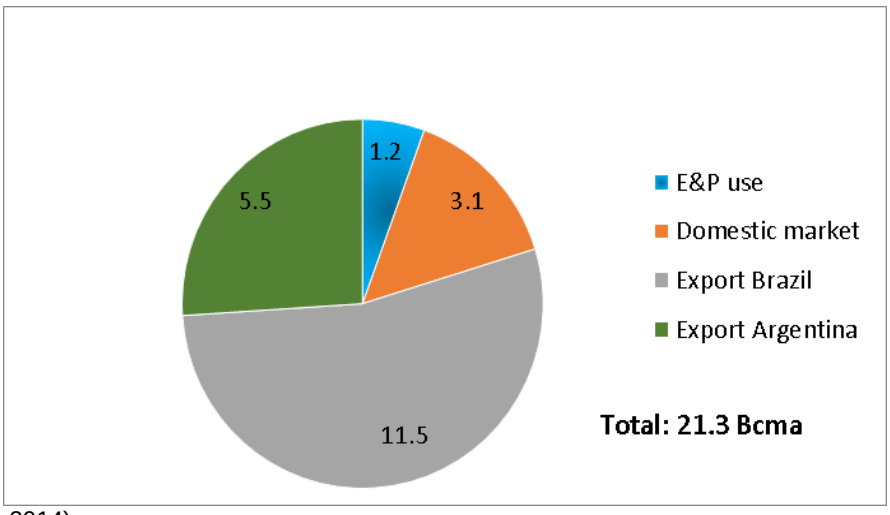
Meanwhile, the Bolivia-Brazil pipeline has been operating relatively smoothly since July 1999. The pipeline, the largest in South America, is 3,150km long (of which 557km are in Bolivia) and supplies gas to five states in south-eastern and southern Brazil. The first section of the pipeline (some 2,100 km) was commissioned in less than two years.

Figure 52: The Bolivia–Brazil Pipeline

Source: http://www.tbg.com.br/ra2012/tbg.html

Despite the 2006 nationalisation of Bolivia's natural gas industry, which caused a hike in the wellhead price, there has been no interruption of supply in the 15 years in which it has been operating. However, the slowdown in E&P investment together with the resulting drop in gas reserves raises the question of whether Bolivia will be able to maintain its current level of exports to Brazil and Argentina when its contract with the former expires in 2019.

Figure 53: Bolivia's gas balance, 2013



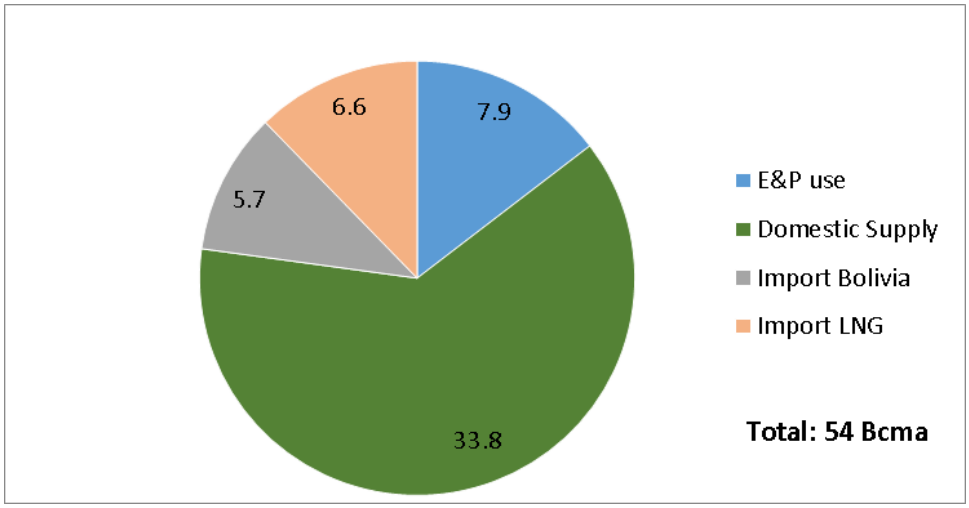
Source: (MME, 2014)

According to the CEO of YPFB, Carlos Villegas, speaking at the recent annual meeting of the Ministry of Hydrocarbons, Bolivia would be able to export up to 9.5 Bcma if Argentina were to invest in developing the gas infrastructure on its side of the border. He revealed that the contractual volume agreed by YPFB and ENARSA is 6.9 Bcma firm and 1.2 Bcma interruptible.

For its part, Argentina has been steadily increasing its imports of pipeline gas and LNG ever since it has been unable to stop the decline in domestic gas production (a decrease of 12.3% since 2003,

while domestic demand has increased 21% in the same period). In 2013 it imported 12.3 Bcma, of which 4.9 mtpa was LNG. Owing to the issues of credit rating and currency availability, most of the LNG is purchased via short-term tenders. On average, Argentina paid $17–20/MMBtu in 2013.

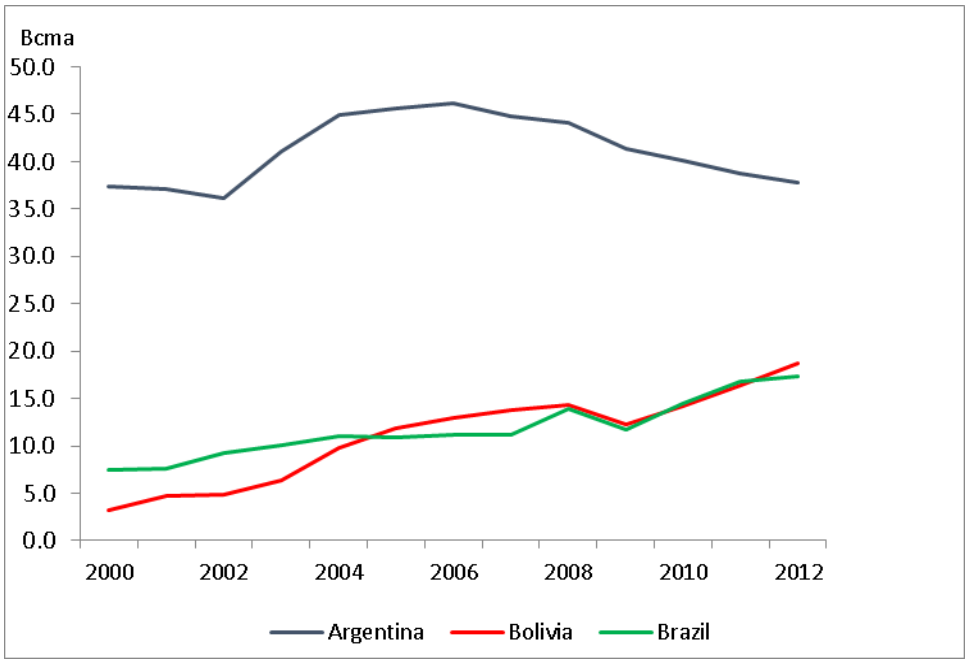
Figure 54: Argentina's gas balance, 2013



Source: (MME, 2014)

There is currently little hope of increasing natural gas trading between the countries of the Southern Cone of South America or even developing better interconnectivity. This is because the key regional markets are all net importers and increasingly dependent on LNG.

Figure 55: Evolution of natural gas production in Argentina, Brazil and Bolivia



Source: (BP , 2013)

Although Brazil and Bolivia have ramped up production since 2009, volumes are still insufficient to meet regional market demand without resorting to LNG imports.

Moreover, geopolitical factors are an obstacle to further natural gas integration in the region, particularly the long-term border issues involving Chile, Bolivia and Peru. It would be both logical and cheaper for Chile to import gas from Bolivia or LNG from Peru, instead of Trinidad & Tobago or Equatorial Guinea.

Combined, the Southern Cone countries aggregate to a sizeable gas import market that traded more than 33 Bcma in 2013 – a volume that is nearly equivalent to that of the individual markets of Malaysia, Spain or The Netherlands. All Southern Cone countries import gas at market or contract prices; and despite the disruption caused initially by the nationalisation of gas assets in Bolivia and Argentina, there has been no interruption in supplies since Argentina suspended exports.

In the meantime, GDF Suez and Marubeni won a tender to install a 3.6 mtpa FSRU in Uruguay (GNL del Plata). The terminal is due to be commissioned in 2015, with a bridging solution provided by GdF Suez Neptune, while a 263,000 m^3 storage facility is expected to begin operating in 2016. Besides supplying the Uruguayan market, the unit could export to Argentina via the Cruz del Sur pipeline, which connects the two countries and was originally built to export gas from Argentina.

In 2012 Chile's Gas Atacama awarded a contract to Golar for the Gas Atacama Mejillones FSRU, which is to be located near the existing terminal of Mejillones in the north of Chile. The initial term of the contract, in Gas Atacama's option, is for 15 years. The FSRU will have a storage capacity of 170,000 m^3 and will deliver 5 MMm^3/d of regasified LNG[64]. As a result, the total regasification capacity of the Southern Cone will reach 34.5 Bcma in 2016 (see Table 12 immediately below).

Table 11: LNG import capacity of the Southern Cone, 2016

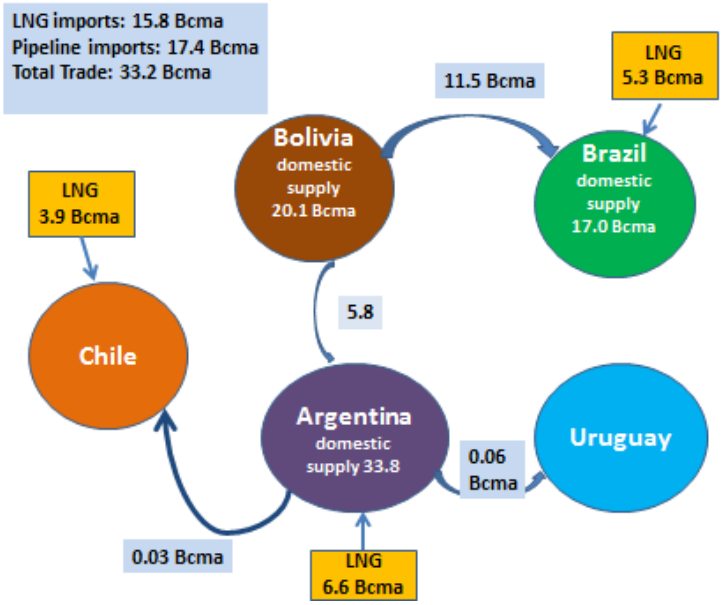
Country	LNG regasification capacity (Bcma)
Brazil	15.0
Argentina	9.9
Chile	6.0
Uruguay	3.6
Total	34.5

Sources: Author's research, companies' websites

There is a strong push for LNG in the Southern Cone, but the main importing markets – Brazil and Argentina – are unwilling to enter into long-term supply agreements. In Argentina, the credit rating and long-term payment capability of the sole buyer, ENARSA, seem to be deterrents to long-term contracts. In Brazil, uncertainty about demand from the power sector mitigates against such contracts, as does, possibly, the unwillingness of Petrobras to burden its balance sheet.

[64]http://www.golarlng.com/index.php?name=seksjon/Stock_Exchange_Releases/Press_Releases.html&pressrelease=1624765.html

Figure 56: Natural gas imports and exports in the Southern Cone (Bcma), 2013



Source: Adapted by the author from (BP , 2013), (MME, 2014) & (International Gas Union, 2013)

7. Can Unconventional Gas Play a Role in Brazil?

In 2013 the Energy Information Agency (EIA) of the US Department of Energy (DOE) commissioned a study from Advanced Resources International (ARI) on the potential of shale gas and shale oil in 41 countries and 95 shale basins. The 'World Shale Gas and Shale Oil Resource Assessment' concluded that Brazil has the 10th largest technically recoverable shale gas resources in the world – 245 Tcf, which is 15 times more than its proven conventional gas reserves as of December 2012.

Table 12: Technically recoverable shale gas resources

Country	Tcf
US	1161
China	1115
Argentina	802
Algeria	707
Canada	573
Mexico	545
Australia	437
South Africa	390
Russia	285
Brazil	245
Others	1535
Total	7795

Source: (Kuskraas, 2013)

The ANP has also conducted a preliminary assessment of Brazil's potential resources of shale gas, including observation 'in loco' of gas flaring and seepage on the surface in several regions. Although

the agency did not validate the EIA /ARI's figure of 245 Tcf, it provided its own estimate of 288 Tcf in areas that ARI had not included in the study. Thus Brazil's technically recoverable shale gas resources could range from 245 Tcf to 533 Tcf. If just 10% of Brazil's shale gas proved commercially viable, Brazil's proven gas reserves would double. And even at prices higher than those in the US, it might still be competitive with offshore gas and imported LNG.

Table 13: Breakdown of Brazil's potential shale gas resources by basin

Basin	Tcf
Parnaiba	**64**
Parecis	**124**
Reconcavo	**20**
Sao Francisco	**80**
Parana (EIA/ARI)	**245**
Total	**533**

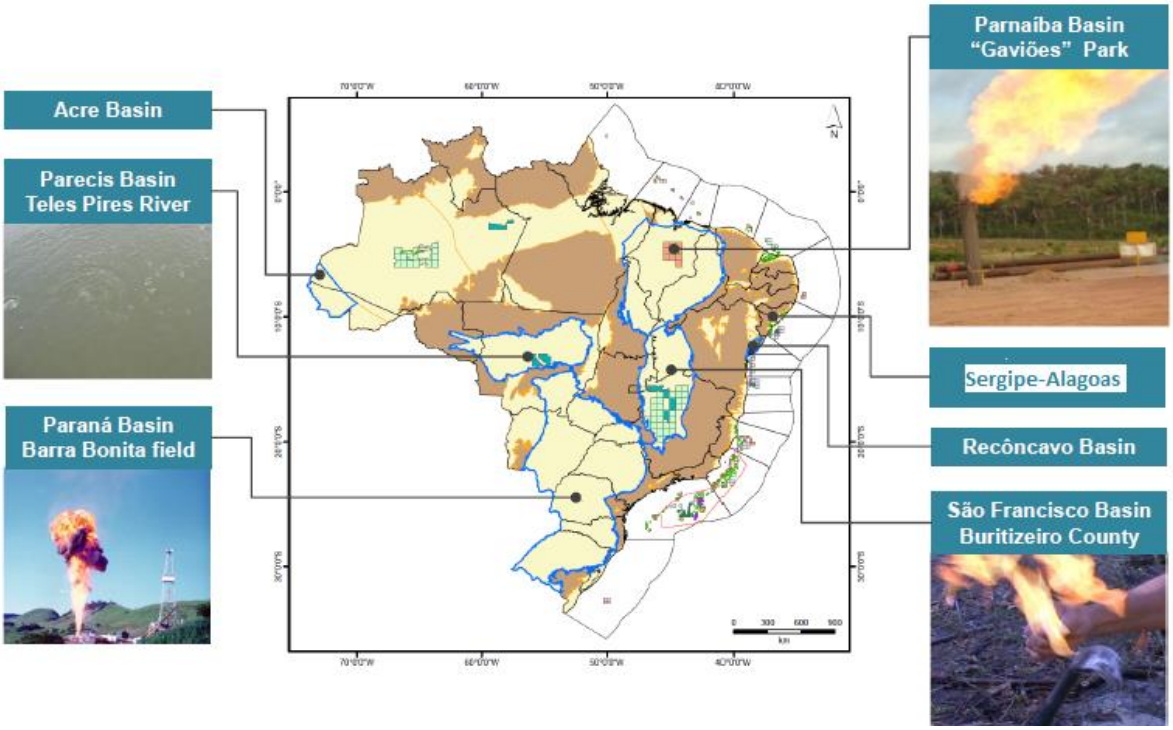
Source: (Chambriard, 2013)

Unfortunately, as Figure 57 below shows, most of the identified resources are located in regions that have no gas transportation infrastructure and are located a very long way from energy demand centres.

In November 2013 ANP auctioned 240 onshore gas blocks. The tender was scheduled to take place over two days but lasted only one day owing to the sheer lack of interest. Only 72 blocks were awarded, of which 49 went to Petrobras. Of the 21 companies that pre-qualified to bid, only 12 participated in the auction. And of those, only four were foreign companies: Alvopetro (Colombia), GDF Suez (France), Geopark (Bermudas) and Trayectoria (Panama). The reasons for the lack of interest is due to the uncertainties surrounding onshore gas in Brazil:

- Most blocks were located in remote regions or in producing areas that are close to depletion;
- The ANP has not yet issued regulations allowing hydraulic fracturing (those rules were still subject to public consultations at the time of bidding);
- Government studies suggested that several blocks overlap with environmental conservation areas and hydroelectric reservoirs, meaning it will be difficult to obtain environmental permits;
- It is uncertain whether shale gas can be used for power generation – the price set by the government at recent power auctions is too low to encourage gas producers;
- Independent companies, which were the engine for the success of the US shale programme, are facing their own economic challenges in the US and seem no longer interested in investing abroad;
- Brazil's unattractive fiscal regime, including very high local content, is an obstacle to importing available drilling rigs and does not acknowledge the need to import components crucial for hydraulic fracturing.

Figure 57: Overview of onshore unconventional gas blocks in Brazil's November 2013 tender



Source: (Chambriard, 2013)

The main challenge to the development of shale gas in Brazil remains the lack of in-house knowledge and equipment to develop those resources as well as insufficient transportation infrastructure to get the product to markets. For its part, the Brazilian Institute of Petroleum, Natural Gas and Biofuels (IBP) believes that Brazil is at least 10 years away from developing its unconventional gas resources[65].

There is little hope that Brazil will hold exploration bids in 2014, given that the country is holding the World Cup in June/July and presidential elections in October. After three bidding rounds having taken place in 2013, it seems that the virtuous circle of annual bidding rounds may have been broken once again.

In summary, Brazil seems to have the resource base to develop shale gas. However, the sheer size of the country, insufficient knowledge about the gas in place, nascent infrastructure and the lack of incentives provided by the government could mean that shale gas will not developed until beyond 2025.

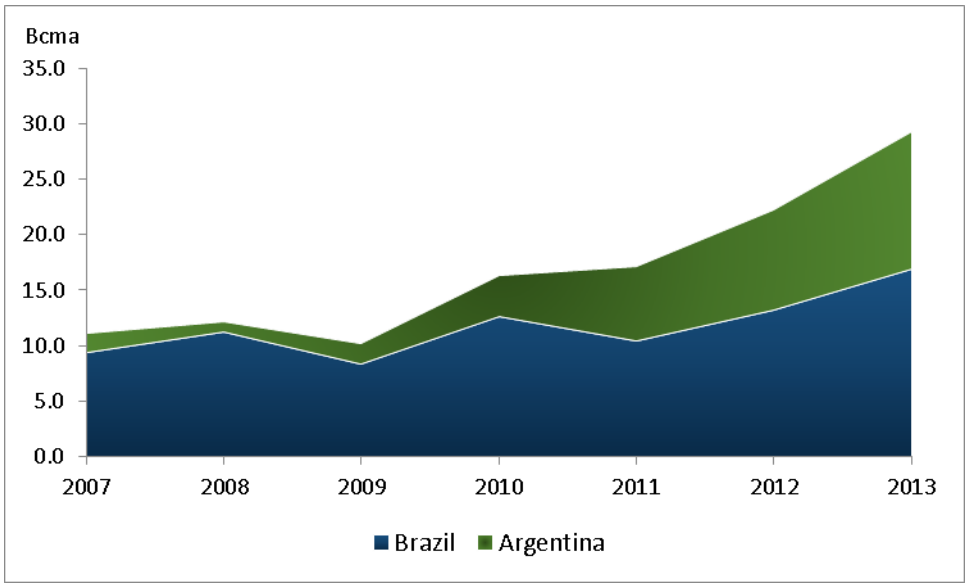
8. Conclusions and Insights

The main conclusion of this paper is that Brazil will not become an LNG exporter in the foreseeable future but rather will remain a lucrative market for LNG sellers. As long as LNG supply continues to be tight, sellers will be able to carry on charging prices as high as those paid by north Asian buyers,

[65] http://uk.reuters.com/article/2013/11/28/uk-brazil-oilauction-idUKBRE9AR0P420131128

Together, Argentina and Brazil are an increasingly important market for natural gas imports – which exceed 30 Bcma. In 2013 the combined import of LNG from these countries reached 9.1 mtpa and the trend is likely to be repeated in 2014. Both markets are also seasonally counter-cyclical with the northern hemisphere, offering additional seasonal arbitration opportunities.

Figure 58: Evolution of Brazil and Argentina's natural gas imports



Source: (MME, 2014)

There are no signs that Brazil will abandon its policy of 'run of the river" power plants, which means the need for thermal power back-up will increase. Dry seasons are now a constant feature of Brazilian life, as is the government imperative of not letting the lights go out at any cost. This year the World Cup and presidential elections take place; in 2016 it will be the Olympic Games followed by the municipal elections. All these events encourage the adoption of short-term and expensive palliatives.
Petrobras is well positioned to provide short-term thermal power back-up because it has a large gas portfolio, the physical and commercial import capability and a sizeable gas-fired power generation capacity installed near the main demand centres. There is little incentive for other players to enter the market; as a result, Petrobras will continue to dominate the market in the short term, except for an independent and integrated domestic gas-cum-power project in the northern state of Maranhao[66].
Next year, when electricity prices are to be adjusted, consumers will have to pay a hefty bill – one that could be as high as $23 bn[67].

A well thought-out gas policy encouraging long-term and lasting solutions and fostering competition in the supply of natural gas could help the country save $1–2 bn annually. Such savings are to be made principally by lowering LNG and gas supply costs. Alternative solutions will become available only in five to 10 years: neither long-term purchase from the US nor new domestic production will materialize before 2020.

[66] Owned by a consortium formed by ENEVA and E.ON.
[67] http://noticias.r7.com/economia/conta-criada-no-setor-de-energia-pode-ir-a-r-52-bilhoes-10042014-1

In the meantime, Brazil's natural gas market will be impacted by structural issues such as:

- Nearly stagnant industrial-sector consumption owing to price-competitiveness issues (most fuel oil demand is already being met by natural gas, which is too expensive to replace other fuels such as wood, coal and biomass);
- Slow demand growth in the automotive sector owing to consumer concerns about security of supply and the lack of factory-designed NGVs;
- No significant growth in the residential and commercial sectors owing to nascent distribution infrastructure in most states and low levels of household consumption;
- Unreliable demand from the power sector, which varies enormously from year to year and even from month to month;
- The lack of integrated government planning allowing for the development of infrastructure and the sharing of regulatory best practices;
- The lack of competition on the supply side and the monopoly in pipeline infrastructure are hurdles for the development of competitive supplies.

The implications are clear:

- Brazil will not become a gas exporter before 2025 as there will be no exportable surplus of domestic gas. Continued imports of LNG will be the norm.
- Despite a substantial increase in domestic gas supplies, which will nearly double by 2020, Brazil will continue to depend on Bolivian gas to meet part of its inflexible gas demand: industries, residential/commercial and inflexible power plants.
- From 2018 onwards the inflexible demand for natural gas could be met by an increase in domestic production and by importing just 50% of the volume currently being imported from Bolivia.
- If Brazil doubles domestic supplies by 2020 and renews its contract with Bolivia under the existing terms and conditions (11 Bcma, ToP 80%), the flexible market might be unable to absorb all these volumes under strict ToP conditions.
- On the other hand, if Bolivian gas supplies are halved, the flexible power market will need 10 to 13 Bcma of LNG by 2018–20.
- There are serious doubts as to whether Bolivia can continue to meet its supply obligations to both Brazil and Argentina as disinvestment in E&P and increasing export volumes are quickly depleting the gas reserves of the two countries.
- If the Electricity System Operator is willing to remain highly flexible over the dispatch of gas-fired power plants, Brazil will need to rely on flexible (spot) and more expensive imports of LNG.
- The volatility of demand in the power sector indicates the need for Brazil to develop underground storage projects. This will require an adequate regulatory framework, including on the pass-through of costs to power tariffs.
- As the gatekeeper of all gas import projects, Petrobras will continue to play a key role in all large gas transactions as well as being the dominant player in the production of gas and thermal power.
- After 2020 some domestic producers may help in the diversification of domestic supply by developing local projects aimed at supplying LDCs and large 'free consumers'.
- At current LNG spot prices into Brazil – around $14.2/MMBtu FOB – Brazil's total LNG bill will reach $3.1 bn by 2018 and $4.5 bn by 2020.

Both Petrobras and electricity and gas consumers would benefit enormously if the government embarked on drawing up a serious and effective policy for natural gas.

It is important to note that for its part, Petrobras would pay a much lower price for LNG if it entered into long-term contracts to purchase such gas directly from brown-field liquefaction projects being developed in the US. Take the example of GAIL of India, whose credit ratings are similar to those of Petrobras: GAIL purchased 3.5 mtpa from Sabine Pass under a cost-plus formula that exposes the

buyer to HH price volatility but whose gains remain significant as long as HH does not exceed $8–9/MMBtu. In order for Brazilian companies to be able to follow suit, the energy authorities in Brazil need to change the power auction rules so that natural gas and LNG projects can compete effectively. A second and no less important point is the need for Brazil to develop sound policies to promote the development of domestic gas – both conventional and unconventional – and to encourage existing producers to sell their gas to the market. This would require a full package of initiatives, including:

- Enhancing the terms of the fiscal regime by reducing taxes and duties as well as minimising the working programme burden in the exploration licenses , scrapping the payment of signature bonuses and reducing local content requirements for gas blocks, particularly those located in areas with no infrastructure;
- Improving cooperation between the energy sector and the various environmental agencies in order to speed up the permitting of gas blocks, power plants and pipelines;
- Providing bonuses and other incentives for early gas production;
- Mapping potential gas-bearing areas and assessing transportation infrastructure requirements;
- Simplifying the rules to allow the development of gas from wellhead to power and industrial projects;
- Promoting the transfer of technology for the exploration and development of unconventional gas;
- Creating real competition on the supply side (that is, encouraging gas producers to offer their gas to the market through independent gas tenders, arrange the financing of enabling infrastructure and the effective unbundling of marketing and transportation/distribution activities).

Glossary

AES	AES Corporation
ANEEL	Agência Nacional de Energia Eletrica
ANP	Agência Nacional de Petroleo, Gas Natural e Biocombustiveis
Bcma	Billion cubic metres per annum
Bbl/d	Barrels of liquid per day
BG	BG Group
bn	Billion
BOE	Barrel of oil equivalent
CAGR	Compounded Average Growth Rate
CEG	Companhia de Gas do Rio de Janeiro
CIDE	Contribuição de Intervenção no Dominio Econômico
CNPC	China National Petroleum Corporation
CNPE	Conselho Nacional de Politica Energetica
Cogen	Cogeneration
Comgas	Companhia de Gas de Sao Paulo
DES	Delivered Ex-ship
DOE	US State Department of Energy
EIA	Energy Information Administration
E&P	Exploration and production
EPC	Engineering, procurement and construction
EPE	Empresa de Planejamento Energetico
FEED	Front end engineering
FLNG	Floating liquefaction unit
FOB	Freight on board
FSRU	Floating storage and regasification unit
GALP	GALP Energy Group
GCA	Gaffney, Cline & Associates
GIIGNL	Group of Liquefied Natural Gas Importers
GSA	Gas supply agreement
GW	Gigawatt
GWh	Gigawatt hour
HFSO	High Sulphur Fuel Oil
IBP	Instituto Brasileiro de Petroleo, Gas Natural e Biocombustiveis
IGU	International Gas Union
IOC	International oil company
IPT	Instituto de Pesquisas Tecnologicas do Estado de Sao Paulo
K	thousand
KW	Kilowatt
KWh	Kilowatt hours
LDC	Local distribution company
LFSO	Low Sulphur Fuel Oil
LNG	Liquefied Natural Gas

LPG	Liquefied petroleum gas
m^3 /d	Cubic metre per day
MM	Million
MMBtu	Million British thermal units
MME	Ministry of Mines and Energy
Mtoe	Million tonnes of oil equivalent
MOU	Memorandum of Understanding
mtpa	Million tonnes per annum
MW	Megawatt
MWh	Megawatt hour
NBP	National Balancing Point (UK)
NGV	Natural Gas Vehicles
NOC	National Oil Company
ONIP	Organizacao Nacional da Industria do Petroleo
ONS	Operador Nacional do Sistema Eletrico
PEMAT	Plano Decenal de Expansão da Malha de Transporte Dutoviário
Petrobras	Petróleo Brasileiro S.A.
PL	Pipelines
PSC	Production-sharing contract
PPT	Emergency Thermal Power Programme
R/P	Reserves/Production ratio
SPA	Supply and Purchase Agreement
TBG	Transportationadora Brasileira Gasoduto Bolivia-Brazil S.A.
Tcf	Trillion cubic feet
ToP	Take or pay
T&T	Trinidad and Tobago
TWh	Terawatt hour
YPFB	Yacimientos Petroliferos Fiscales Bolivianos

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