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NATURAL GAS





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Institution of technical and scientific, educational, and charitable nature created on December 20, 1944 as a private legal entity with the purpose of fully acting in all scientific matters, and emphasizing in the field of social sciences: administration, law and economy, thus contributing to the country's social and economic development.

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Introduction

FGV Energia was created in the beginning of 2014 driven by Getúlio Vargas Foundation's view of taking part in the main debates related to the energy industry. Then, FGV Energia started immersing in the Natural Gas sector by preparing this Booklet. Given the remarkable potential impact of the gas in several sectors and geopolitics, both global and regional, we consider the issues related to Natural Gas as a priority in our discussion agenda.

Through this Booklet, we provide the first piece for a sound and well-founded construction of policies for this sector in Brazil. We seek to consolidate the bases by passing on some of the Natural Gas industry's principles and mapping the characteristics this industry undertakes in the country. This is a sector with a high level of complexity; therefore, we understand that an open and unbiased dialogue with all agents would be a fair way of ensuring coherence of goals. All of this, after identifying where we stand, and what do we want to reach and what we can achieve. Thus, the primary goal of this work was to survey the major themes affecting the Natural Gas industry in Brazil and provide alternatives and scenarios for discussion and resolution of key issues.

In this sense, we thank everyone who contributed to this endeavor, especially to Ieda Gomes who helped us making this project come true. We hope to continue this work counting, once again, with the participation of opinion makers from the sector to start promoting the creation of clearer development policies for Natural Gas in Brazil. With the feeling of having launched a new path that may bring promising contributions to the country, I wish everyone a good reading and reflections on this theme.

Sincerely,

Carlos Otávio de Vasconcellos Quintela
Director of FGV Energia

Acknowledgements

This Booklet was only possible thanks to the cooperation of several professionals who follow and work in the Natural Gas industry. On behalf of FGV Energia, we would like to thank for the generosity of those who accepted sharing their knowledge and professional experience gathered during many years of work and dedication to the sector, by spending their time talking and giving interviews. We also thank those who, even though not experts in the sector, provided their economic and legal knowledge for our research. Our sincere appreciation to Aduino Pereira, Adriano Pires, Antônio Muller, Armando Guedes Coelho, Ashley Brown, Augusto Salomon, Bernardo Sicsú, Carlos Augusto Pereira, Carlos Eugênio da Costa, Cynthia Silveira, Fernando Matsumoto, Giovani Machado, Helder Queiroz Pinto Junior, Hugo Repsold, Ivan Simões, José Alcides Santoro Martins, José Cesário Cecchi, Leonardo Calabró, Luciana Nunes, Luciano Veloso, Luis Henrique Guimarães, Marcelo Menicucci, Marco Antônio Martins de Almeida, Maria D'Assunção, Mario Menel, Matheus Bodnar, Melissa Mathias, Paulo Pedrosa, Pedro Camarota, Renato Bertani, Ricardo Lamassa, Ricardo Pinto, Symone Araújo, Wagner Freire, Winston Fritsch, and other professionals who contributed to this project.

Our special thanks to the valuable contribution of our esteemed collaborator and associate researcher Ieda Gomes, to whom we owe not only for her guidance throughout this work, but also for her preparation and development. Eventual errors and omissions, however, are our own responsibility.

Last but not least, we would like to thank the many contributions of those who work daily with us at **FGV Energia**. From several discussions and everyday conversations full of questions and divergences, we were able to enrich our work and develop a broader and multidisciplinary view on the sector.

Camilo Poppe

Researcher **FGV Energia**

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Coordinator of Research **FGV Energia**



Why talking about Natural Gas?

“Brazil needs to talk more about Natural Gas. And, above all, act more decisively.”

Consecutive government plans were initiated from the second half of the 80s when agreements for the purchase of Natural Gas from Campos basin to São Paulo were signed. The Natural Gas National Plan (PLANGAS) was launched in 1987 by the Department of Mines and Energy and did not obtain conclusive results. It was followed by a second plan, started in 1992, with the purpose of expanding the Natural Gas' participation from 2% to 12% by the end of the 90s.

In 2006, Petrobras launched another PLANGAS, the Natural Gas Advanced Production Plan, comprising Natural Gas exploitation and production, processing and transport projects focused on increasing the offer of Natural Gas for 55 million cubic meters per day (MMm³/day) by the end of 2010.

None of these plans achieved the goals set.

Opinions converge largely on the importance of having Natural Gas in the Brazilian energy matrix, because of its characteristics of clean and flexible fuel, and the need to encourage its use in order to improve environmental quality in metropolitan regions and to ensure competitiveness of the Brazilian industry. Natural Gas has been mentioned, more recently, in the generation of electricity because of its fundamental role in ensuring energy supply in Brazil at a time when hydroelectric plants from the Southeast, Midwest and Northeast find themselves in a critical level. However, opinions are similar in what regards to the best profile of gas use in this segment; some of the currents defend generation in the basis, and others understand that Natural Gas generation should only supplement hydroelectric plants.

Until 2011, Natural Gas was mainly consumed in the industrial sector, which consumed about 66% of the gas offered to the market. The situation changed in 2013-2014. The power sector accounted for 47% of the consumption and gave rise to the need of importing Liquefied Natural Gas (LNG) with prices 50% above the prices of national gas and the gas imported from Bolivia. LNG is imported through spot and short-term agreements once thermal plants are not deployed at the base and prices in electricity auctions do not recognize the need to fully compensate fixed gas supply costs when plants are not deployed. If and when reservoirs recover, the situation could be reversed again; thermal plants will be operating solely at the peak. The need to ensure capacity payment for gas thermal plants still needs to be considered, once electricity auctions have privileged intermittent energy sources, such as wind, which requires the construction of an additional thermal backup once the construction of power plants with reservoirs is not allowed.

The increasingly hydrothermal profile of the Brazilian energy matrix requires good integrated planning of the gas and electricity sector. In case economic signs to build gas plants are not given, an alternative will be to build coal and oil fuel plants, which pollute more and are less efficient.

The same lack of long-term visibility has been affecting investments for use of Natural Gas Vehicle (NGV), which had several high and low-point phases since the beginning of the 90s. Gas and fuel distribution companies made huge networks and gas stations infrastructure investments; the number of vehicles reached 1.7 million with thousands of stations spread all over the country. Hydrocarbon sector's nationalization in Bolivia, in 2006, has generated insecurity in terms of gas supply to Brazil and, consequently, the deceleration of vehicles' conversions to Natural Gas. More recently, freezing of gasoline prices has been hindering the consumer's economic decision to convert his/her vehicle to Natural Gas despite Brazil imports increasing amounts of gasoline.

Concern about the growing loss of competitiveness of the Brazilian industry due to lack of energy at competitive prices and particularly before the United States, which starts to attract investments of large industrial groups due to the availability of plenty and cheap Natural Gas has been hovering the industrial sector.

As well as it has been happening with oil derivatives, Brazil has been increasing its dependence on imported Natural Gas. In August, 2014, the offer of imported gas reached an average of 52 MMm³/day, about 53% of the volume offered to the market, which makes it difficult for the sector agents to decide on long-term investments because of the lack of visibility regarding the offer. Suspension of oil and gas exploration rounds for five years, in addition to interrupting investments from oil companies, should have an impact on medium and long-term national gas availability. There are still doubts about Bolivia's capacity to keep the volumes currently supplied to Brazil, about 30 MMm³/day, when the supply agreement expires in 2019 once the country has the commitment to supply Argentina and the local market and has not managed to attract substantial investments in exploration and development.

While Brazil has decided to interrupt the established practice of annual E&P rounds in 2008, which had been taking place continuously since 1999 - which by the way attracted investments for the current pre-salt development and production - the United States encouraged independent production of shale gas, passing from importer to exporter of Natural Gas in the short period of 10 years.

Due to this myriad of issues and challenges, Brazil needs to talk more about Natural Gas. And, above all, act more decisively.

Public health matters are also imposed in addition to economic matters. According to a study recently published by University of São Paulo, the air pollution should be the cause for death of up to 256 thousand people and the hospitalization of 1 million people within the next 16 years in the State of São Paulo. This study calculates an estimate of public expense above R\$ 1.5 billion related to the impacts in the health of the population in this period. Similar situations can be anticipated also for other Brazilian metropolitan regions. The use of Natural Gas, as substitute for liquid and solid fuels, could contribute to alleviate this situation especially if used in the transport and industry sector.

The sector's agents - producers, distributors and consumers - need long-term economic signs regarding the offer and prices of gas in order to make investment decisions for the next 10-20 years. Investments in Natural Gas infrastructure are substantial in capital with long-term maturation. There is a lack of visibility regarding the offer of both imported and national Natural Gas. And there is a lack of visibility of demand due to uncertainties as to the prices matrix and the role of the gas for power generation.

FGV Energia took the initiative to lead the debate in order to obtain proposals and constructive alternatives for a sustainable gas sector in Brazil. By critically questioning its team of researchers and conducting interviews throughout six months with experts and leaders of the sector, **FGV Energia** prepared a broad picture on the main problems that are impacting the sector's development and the main concerns of investor agents.

All agents who participated have an opinion almost unanimous and convergent on the need for an integrative and participative planning aimed to the sector, as well as the urgency to develop a practical and constructive agenda.

The launching of the Natural Gas Booklet is a first step for such a reflection work, which will be followed by the deepening of the major themes in specific work sessions during 2015. Such an initiative by **FGV Energia** will certainly contribute to elucidate the question of why one should speak and act on Natural Gas.

Ieda Gomes

PART

1





Principles of
Natural Gas



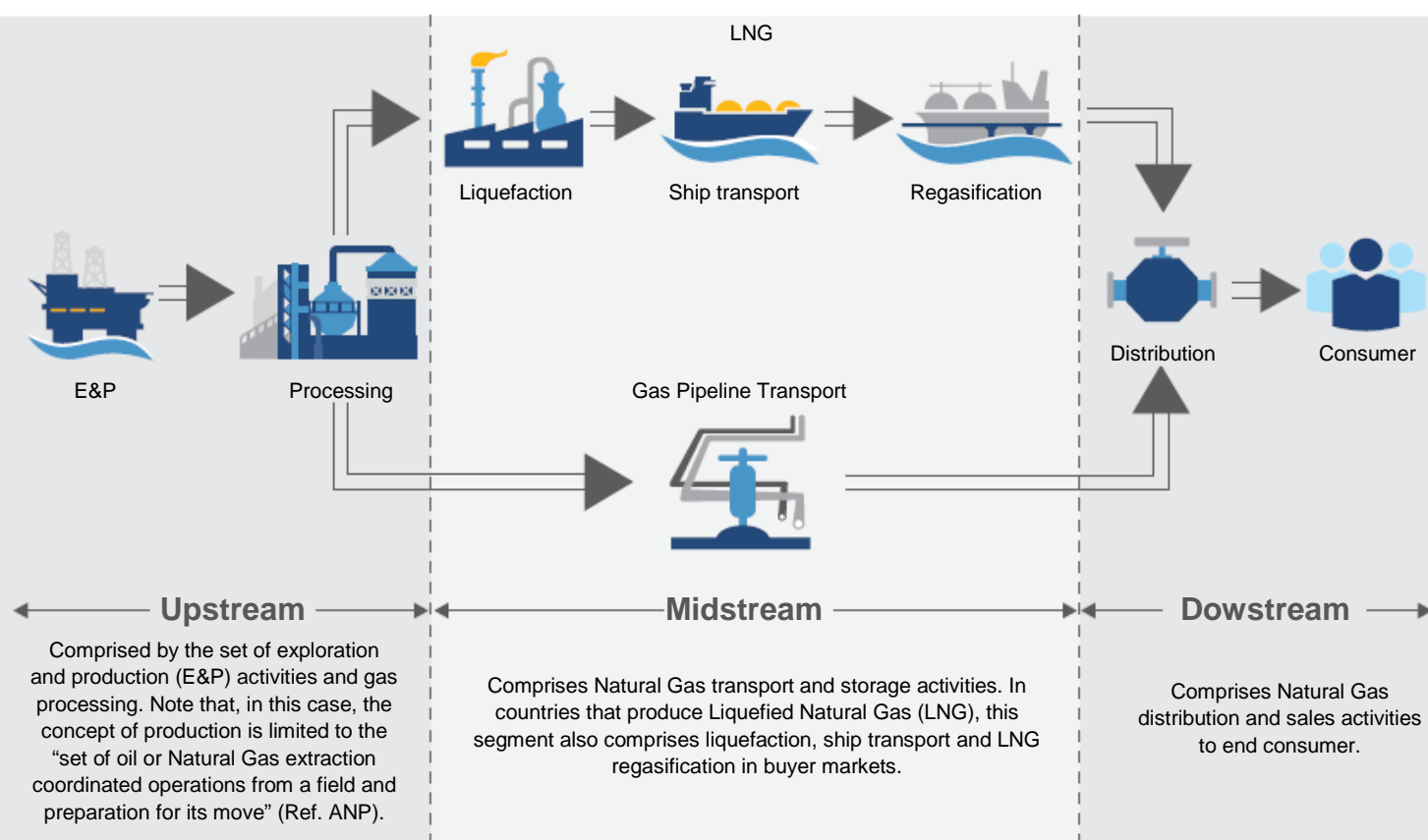
Natural Gas Value Chain

Natural Gas is the cleanest and most efficient fossil fuel. It is produced both in association with oil (associated gas) and independently (nonassociated gas). Compared to oil, the commercial consumption of Natural Gas is still a recent phenomenon. Natural Gas started to be progressively incorporated to the energy matrix of countries only after the decade of 40-50, primarily driven by the progresses made in conditioning and transport technologies. Due to its physical and chemical properties and ongoing technology evolution, the Natural Gas may be used in several sectors of the economic activity: in power production, industrial processes, trade, houses and transport sector. But, where does the gas we consume come from and how is it produced?

Conceptually, the Natural Gas value chain follows a structure that is similar to the oil chain and is equally divided into three segments: upstream, midstream and downstream.

► FIGURE 1

Natural Gas Value Chain



Source: Prepared by the author

► Upstream

Exploration is a hydrocarbon accumulation research process, both onshore and offshore. Production is the process of extracting, recovering and processing Natural Gas on commercial scale. An average of 77.2 Mmm³/day of Natural Gas was produced in Brazil, in 2013, out of which 56.6 MMm³/day was offshore and 20.6 MMm³/day onshore¹. Total production reached 90.9 Mmm³/day in August, 2014, out of which 23.5 MMm³/day was onshore and 67.4 MMm³/day offshore.

The exploration phase is typically characterized by a high degree of risk, especially linked to the uncertainty of the discovery of a field in areas with geological knowledge that is still limited and, thus with high investments and operating costs.

The steps of geological and geophysical (G&G) mapping and processing that precede exploration wells drilling contribute to reduce the risk and increase the successful rate in the search for new fields.

1. *Boletim Mensal de Acompanhamento da Indústria de Gás Natural, MME* (January and September, 2014).

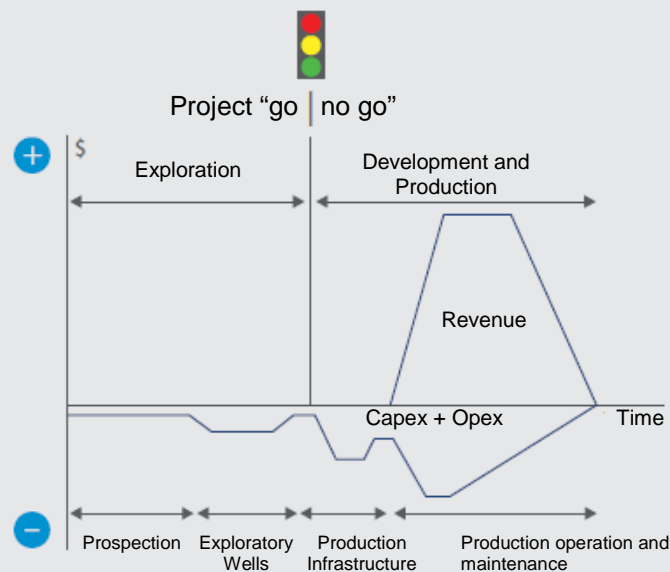
However, the real sizing of the reservoir and its commercial feasibility analysis only take place upon an expensive wells drilling, completion and assessment campaign in areas of interest defined by the companies' G&G group. Managing this exploration risk and the campaign operating costs until the conclusion of the assessment step is the main challenge faced by the upstream segment.

The largest parcel of the E&P global investment is associated to the development and production step². Execution of this step; however, is conditioned to the declaration of commerciality³ of the explored fields.

The development of new technologies has enabled gas extraction in "unconventional" reservoirs, such as shale gas, coal mines and low permeability reservoirs, and also in "areas of technological borders" as ultra-deep waters and arctic regions. Unconventional gas fields have become commercial producers in the first decade of 2000, and came to represent 39% of total gas production in the United States, in 2012, thanks to the use of technologies as hydraulic fracturing and intensive directional drilling⁴.

► FIGURE 2

Cash flow of an E&P project



Source: Prepared by the author from reference [1]

2. Here, the cash flow of an economically feasible project is considered.
3. The commercial aspect of a field is assessed during the Discoveries Assessment Plan (PAD) execution when the operator of the exploratory block evaluates the characteristics of the reservoir found, its potential production value and operating and extraction costs in the region altogether. Then, a Final Discoveries Assessment Report (FDAR) is prepared adding the entire technical framework justifying the declaration of commerciality or eventual return of the exploratory block.
4. US Energy Information Administration Report, "North America leads the world in production of shale gas". EIA (10/23/2013): <http://www.eia.gov/todayinenergy/detail.cfm?id=13491>.

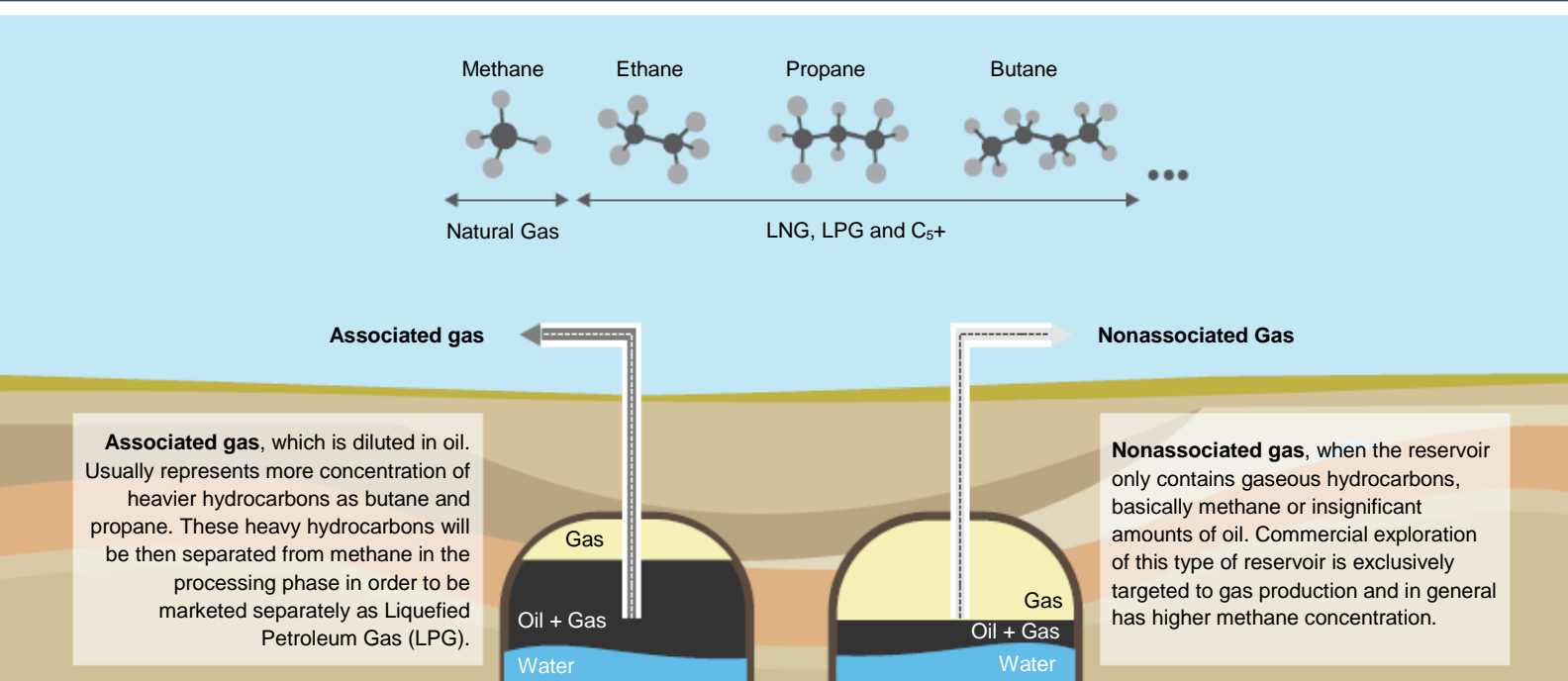
Just as the unconventional gas is changing the gas production scenario in the US, the technologies that made possible activities in deep waters have been opening new fronts for gas production in Brazilian pre-salt. In 2010, the pre-salt contributed to only 2.0 MMm³/day of the Natural Gas production in Brazil. On May, 2014, such production achieved 16.1 MMm³/day, thus representing 19% of the Natural Gas national production⁵; however, this participation in gas supply is still modest due to difficulties and costs of logistics.

After produced, the gas needs to be processed⁶, transported and distributed to end consumers. The Natural Gas is conditioned in the processing phase in order to meet specifications of the transport system. This processing is conducted in the so-called Natural Gas Processing Units (UPGNs). In these units, the gas will undergo a “drying” process consisting in separating methane from other elements present in raw gas (LNG, LPG, water, etc.). Besides “drying”, the treatment in UPGNs serves to eliminate impurities and contaminants (such as sulfur, carbon dioxide and heavy metals) and also to make the gas compliant with the regulations of consumer markets in what regards to its physical and chemical properties.

Some clarifications on the difference between raw, recently extracted, and ready-for-use Natural Gas should be provided at this point.

► FIGURE 3

How can natural be found in nature



Source: Prepared by the author

5. *Boletim de Exploração e Produção de Petróleo e Gás Natural n° 27, MME (May, 2014).*

6. In the case of gas produced offshore, it still needs to be drained from the production platform through drainage pipes before getting to a UPGN in the continent.

Marketable Natural Gas is primarily comprised by methane with specification of its other properties established by ANP through Ordinance no. 41, dated April 15, 1998. On the other hand, raw Natural Gas composition varies from one reservoir to another, and may be classified into two main groups: Associated and nonassociated Gas. About 67% of gas production in Brazil in 2013 was of the associated type, and only 33% was extracted from nonassociated gas reservoirs⁷.

► Midstream

Choosing a form of moving the gas between the producing field and consumer market is a strategic matter for the Natural Gas industry. Historically, difficulties in gas transport were so significant that they ended up driving most of the gas production to burning when it was associated gas, or field abandonment when nonassociated gas was found. Today, however, there are transport modes to meet several offer and demand scenarios.

Liquefied Natural Gas (LNG), for example, can be transported for long distances and is usually associated to sea transport by LNG carriers. However, Natural Gas liquefaction cost is high: approximately US\$ 1200-1400/ton⁸ is estimated for projects built from 2011 to 2015, which can turn the product less competitive in some markets.

Another modality used to transport Natural Gas is the high-pressure gas pipeline⁹. However, as well as oil pipelines that transport raw oil and other derivatives, gas pipelines that transport Natural Gas require a high investment in order to be installed. In addition, its design and layout should take into account simultaneously compliance with the uninterrupted flow of production and the demand of the consumer market.

Such a need for interaction with the upstream and downstream segment, associated to the high initial investment for installation, turns the feasibility of the pipeline network into a real challenge for the gas industry. However, once a minimal network is installed the ducts allow for its operator to obtain a significant scale economy as large volumes of gas are drained at a relatively low operating cost, at the same time as the need for investments in new facilities is becoming increasingly low with the expansion of the network.

A feasible alternative in some cases is to use the gas for power generation near to areas producer of Natural Gas and transport the power as

7. *Boletim Mensal de Acompanhamento da Indústria de Gás Natural, MME* (January, 2014)

8. Songhurst, Brian, LNG Plant Cost Escalation, The Oxford Institute for Energy Studies (February, 2014)

9. Usually between 60 and 100 bar (http://www.igu.org/sites/default/files/node-page-field_file/Natural%20Gás%20Unlocking%20the%20Low%20Carbon%20Future.pdf).

gas to wire. This a solution that has been proving itself especially effective in intermediary cases of volumes produced and distance traveled to the consumer market.

In Brazil, the pipeline network has a relatively reduced extension when compared to other countries of similar area, with only 9,244 km of pipelines primarily concentrated in the Southeast region/CO¹⁰. For comparison purposes, the United States have approximately 550,000 km of gas pipelines that cover practically the entire American territory, while Argentina has 15,437 km, almost two times more than Brazil. The incipient transport infrastructure is one of the factors that hinder the Natural Gas sector's development in Brazil.

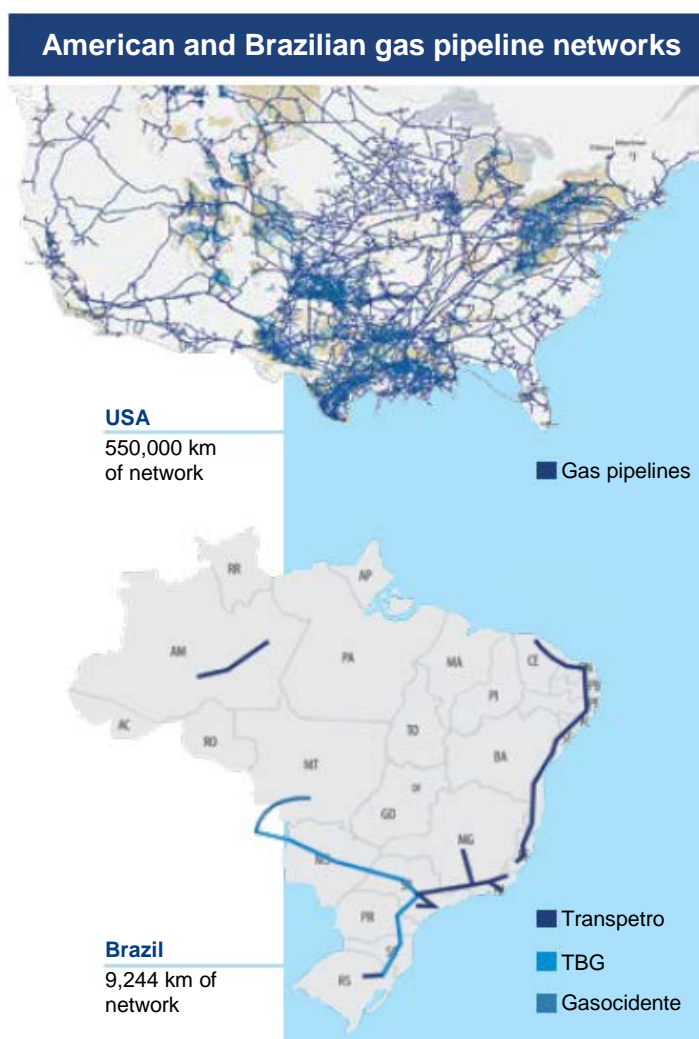
► **FIGURE 4**

► **Downstream**

The distribution process starts after the transport step, from gas receipt in the so-called city gates, which are Natural Gas pressure reduction and control, measurement and odorization installations.

From city gates, the Natural Gas is transported through pipelines to the several market segments: industrial, commercial, residential and power generation. Natural Gas can also be used in vehicles after its compression at 200-250 bar in gas stations, and stored in high-pressure cylinders. Natural Gas compressed at pressures higher than 200 bar (CNP) may also be transported in trucks with cylinder beams at high pressure for delivery to consumers in areas located far from distribution networks.

In countries that have LNG conventional regasification terminals, it is also possible to install LNG trucks loading stations. LNG is then transported



Source: Prepared by the author from EIA and GasNet data

10. *Boletim Mensal de Acompanhamento da Indústria de Gás Natural, MME* (January/2014)

by road to regions without Natural Gas transport and distribution infrastructure, being later regasified in end users' premises.

The distributor is the agent responsible for operating gas distribution networks and delivering the gas to the end consumer. Natural Gas distribution networks have natural monopoly characteristics, and are generally regulated. In Brazil, the distribution regulation is the responsibility of the State¹¹ and the Natural Gas distribution service is operated by - state and private - companies with exclusive geographical permit.

Thus, we map the Natural Gas value chain from its production to distribution and delivery to the end consumer. We will raise some of the characteristics inherent to this industry in Brazil, its form of operation, main agents and regulatory framework in the next chapters. Later, we will deepen our analysis on the major themes that affect the Brazilian gas sector nowadays.

11. Until the city gate, the regulation is federal in Brazil.



Overview of the Natural Gas Market - in Brazil and abroad

Projections for the global Natural Gas market look promising within the next decades. Gas consumption should be mildly increased in OECD Member Countries by 2040, and even faster in non- OECD countries, especially China and the Middle East. Consumption in China should grow from 297 MMm³/day, in 2010, to 1350 MMm³/day, in 2040. Most part of such growth should take place between 2010-2020¹². In this same scenario, the gas shows an increased participation in the global energy matrix, unlike the trend of other fossil fuel sources as oil and coal [Chart 2].

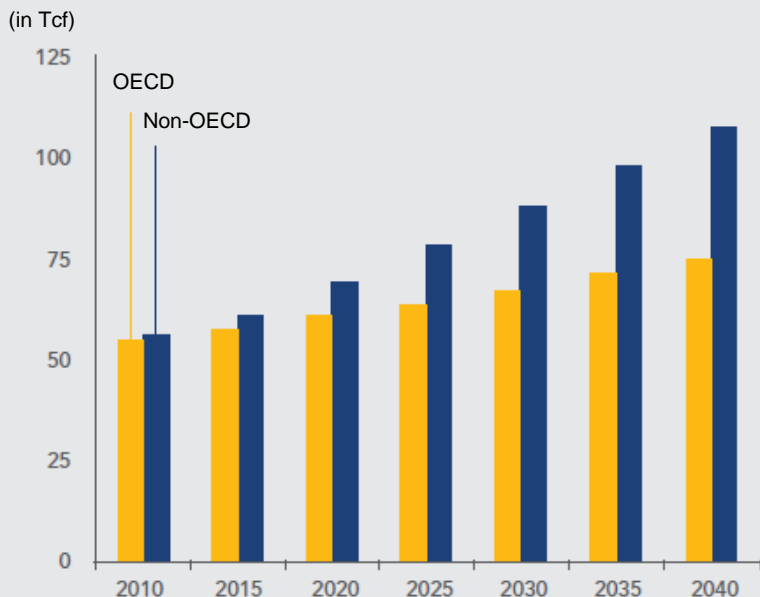
The gas geopolitical horizon has suffered major changes within the last few years and is still being drawn. With the revolution of unconventional gas in the US, its production is expected to increase continuously and LNG should be exported as of 2016¹³. In Europe, the recent political tension between Russia and Ukraine once again has brought up matters related to safety

12. International Energy Outlook, EIA (2013)

13. EIA Annual Energy Outlook, EIA (2014)

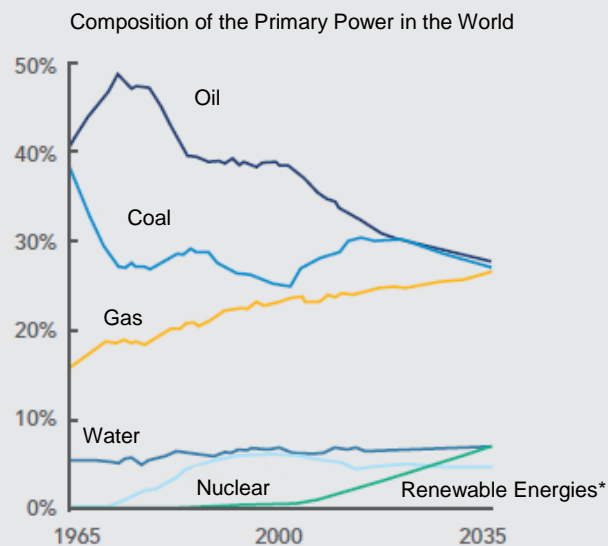
► CHART 2

Global Consumption of Natural Gas



OECD: Organization for Economic Cooperation and Development

Source: EIA

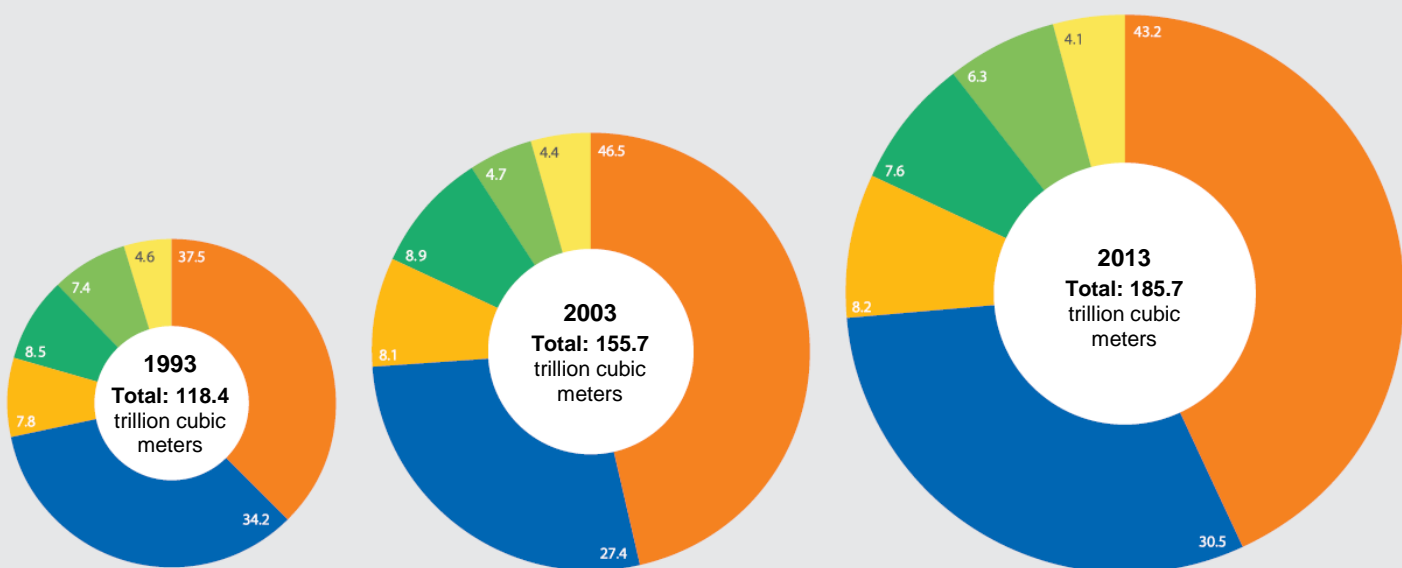


*Includes biofuels

Source: BP Outlook 2035

► CHART 3

Distribution of reserves proved in 1993, 2003 and 2013



■ Middle East ■ Europe and Eurasia ■ Asia-Pacific ■ Africa ■ North America ■ South and Central America

Source: Adapted from BP Statistical review 2014

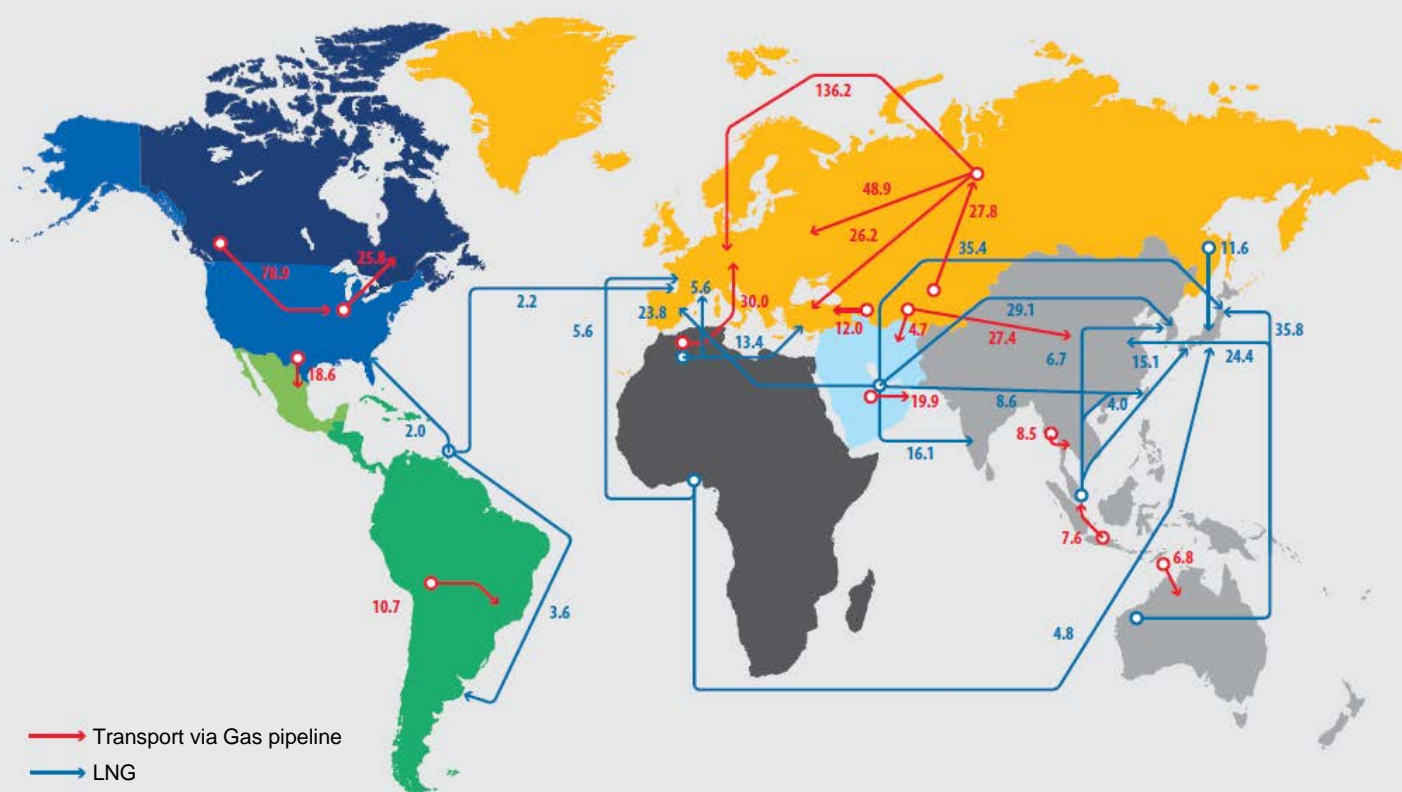
of supply and the importance of the Russian gas for European countries. China is estimated to hold most part of the global potential in unconventional basins, especially shale gas with technically recoverable resources of 31.6 trillion m³ (Tm³)¹⁴. However, the underdeveloped gas industry raises concerns on its capacity to explore such potential within the next years. In Latin America, Bolivia and Argentina have gas reserves in the order of 0.314 Tm³ each; however, the current low exploration investment level shows a low gas production outlook in the short-term.

Other countries as Canada, Mexico, Australia, India, Turkmenistan and Mozambique are seeking to develop their potential and define their form of participation in global gas geopolitics. In any case, the next 20-30 years show a perspective of increased global Natural Gas supply in a scenario in which China and the United States will have the key role as producer and also as consumer.

► FIGURE 5

Main NG commercial flows in 2013

Trade flows worldwide (billion cubic meters)



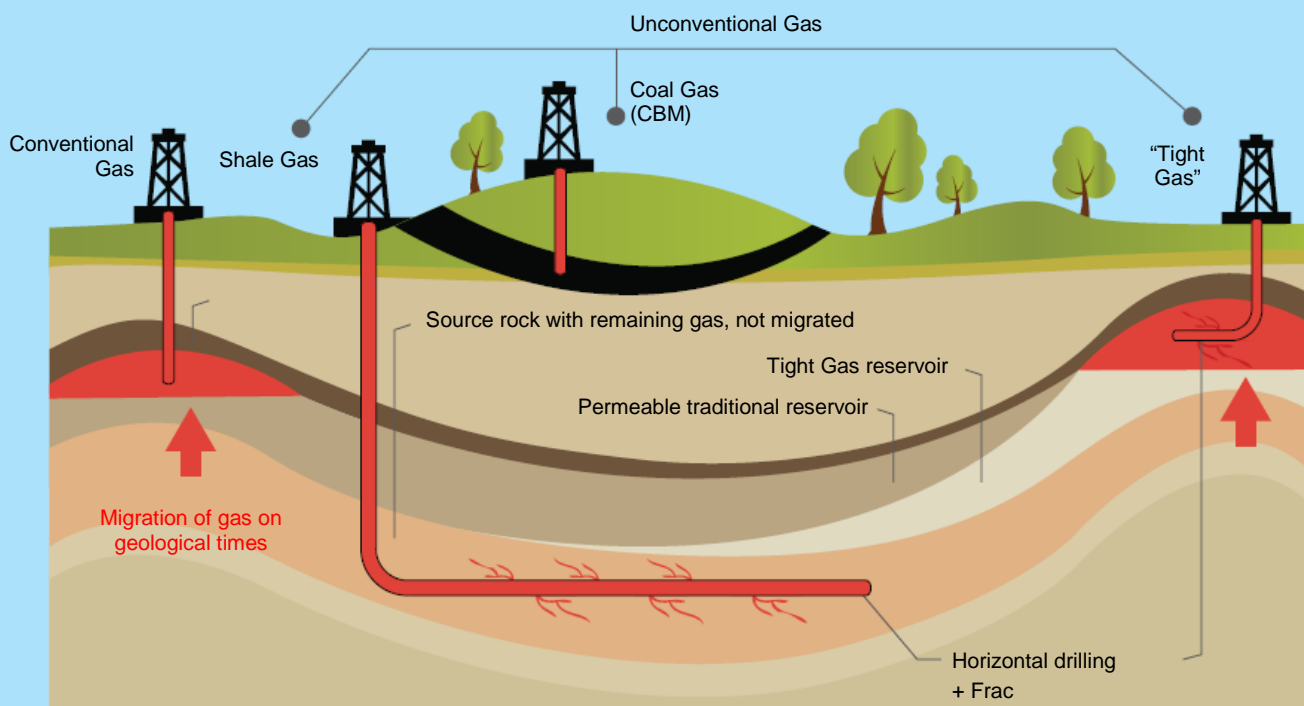
- United States
- Europe and Eurasia
- Canada
- Middle East
- Mexico
- Africa
- Central and South America
- Asia-Pacific

Source: BP Statistical review (June, 2014)

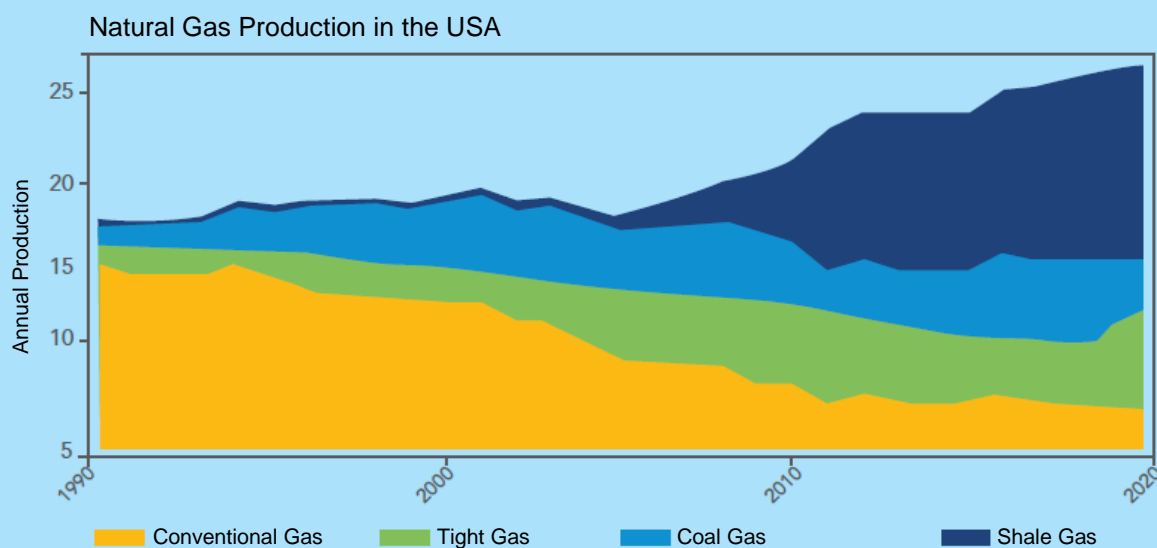
14. Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States, EIA (2013).

The Revolution of Shale Gas in the United States

THE REVOLUTION OF SHALE GAS in the United States has reached the headlines of the largest newspapers and magazines in the world within the last few years. It was extracted for the first time in 1821, but economically infeasible until the first decade of the 21st century, increased shale gas production has opened new doors for a declining E&P industry in the US. Given the depletion of conventional reservoirs with no further meaningful gas discoveries that generates a drop in production and rises prices, the development of shale gas has allowed recomposing the production and quickly became the new expansion frontier for the upstream American industry. After over 150 years being considered a marginal production, usually from natural fractures in unconventional reservoirs, over two decades of incentives to research and production in this type of reservoirs have generated technological developments that enabled the first trade wells, in Barnett's formation (North Texas), in 1998/99. Implementing the hydraulic fracturing at trade scale was the first successful factor, followed by developing and expanding the use of directional drilling as of 2000.



Source: Adapted from Total website



Source: EIA 2013

Growth in shale gas production caused notable impact in the United States' economic outlook, as well as in global scale. The abundance of Natural Gas in the US market ensured a broad supply and low prices horizon in a country that already has infrastructure, capacity for logistics, economic and tax conditions favorable to the business, as well as skilled workforce. Consequently, the chemical, refining, aluminum, steel, glass, cement and food industries that rely more on energy, became competitive once again in the country by attracting investments from around the globe. As a result, the new shale gas chain has generated over 2.1 million jobs in 2012, thus contributing to nearly US\$ 284 billion for the country's GDP and US\$ 74 billion in royalties and taxes. The generation of 3.9 million jobs is expected until 2025, thus contributing to US\$ 533 billion for the country's GDP and generating a collection of US\$ 1.6 trillion in royalties and taxes.¹⁵

Despite the positive impact on the economy, there is still considerable controversy regarding the possible environmental impacts of hydraulic drilling. Although no study has proven the existence of causality between fracturing operations and several charges in millionaire disputes that have been arising since 2000, the ecological matter still persists. Additionally, massive fracturing operations require large volumes of water, which may represent an important restriction to the industry, given the need to preserve water resources in certain regions.

Tradeoff between environmental matter and possible economic benefits from shale gas makes countries and regions to get divided among those who forbid and those who seek to promote the E&P industry in unconventional reservoirs until today.

15. Source: America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy, IMS (2013)

Another great transforming factor in the geopolitical field is related to Liquefied Natural Gas (LNG) growing role, which represented almost 31.4% of gas transactions by the end of 2013. There are currently 17 exporting countries and 29 importing countries with production concentrated in Qatar, Malaysia, Australia¹⁶ and Indonesia. In addition to its role in safety and supply diversification, the LNG industry has been innovating in commercial and technological solutions as: floating liquefaction and regasification systems, use of LNG for land and sea transport and systems in reduced scale to meet remote and small markets (“Small LNG”).

How is Brazil positioning itself before the current international situation?

The Brazilian gas industry dates back to the 19th century and, already in the beginning of the 20th century, almost 10 cities had piped gas networks. However, with the advent of electricity, the distribution of piped gas stopped being developed and was restricted to Rio and São Paulo until the start of oil activities in Northeast Region in the late 50s.

Natural Gas production in Brazil was developed from the oil sector, initially from associated gas in the Northeast Region. With oil discoveries in Campos basin, especially in the 80s, the sector benefitted from the growth in offshore oil activities. Currently, most part of the gas produced in the country is gas associated to the oil produced offshore. Furthermore, the new pre-salt perspectives generate great expectations in relation to growth in associated gas production in the country. Today, proven gas reserves in Brazil are of 458,093 MMm³ (16.2 Tcf)¹⁷, located mainly in Campos and Santos basins.

Despite this, Brazil has been positioning itself as the main market importing gas in South America. In 2013, almost 50% of total gas offer to the market was imported - especially from Bolivia (through pipeline) or from Trinidad and Tobago (LNG) - and the increase in domestic production is expected to be low, at least within the next 5 years.

► Offer

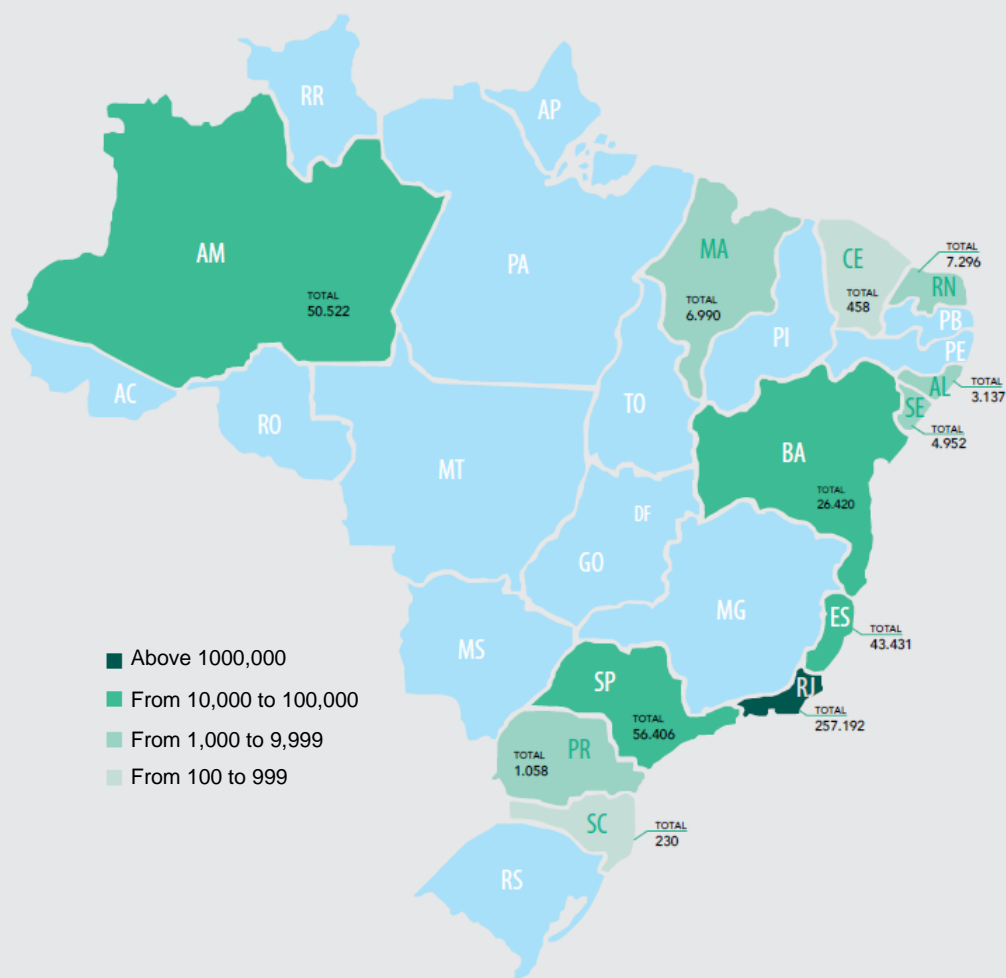
Ten companies produce Natural Gas nowadays in Brazil. Still, Petrobras is the main agent in the offer of Natural Gas in the country today. The company was responsible for approximately 81% of the national gas production in July, 2014. Since most part of Natural Gas reserves is offshore and is of associated gas, the national offer tends to remain directly related to investments in oil and oil production curve.

16. As of 2018, Australia starts to be the largest global producer of LNG [“The Future of Australian LNG Exports”, Oxford Institute for Energy Studies, (2014).

17. Boletim Mensal de Acompanhamento da Indústria de Gás Natural, MME (February/2014)

► FIGURE 8

Brazilian map of proven reserves

(in MMm³)

Region	States	Associated Gas	Nonassociated Gas	Total per region
Southeast	Rio de Janeiro	244,955	12,238	357,029
	São Paulo	16,608	39,798	
	Espírito Santo	34,011	9,420	
North	Amazônia	32,923	17,599	50,522
	Bahia	6,144	20,275	49,253
Northeast	Rio Grande do Norte	4,430	2,866	
	Maranhão	0	6,990	
	Sergipe	3,941	1,011	
	Alagoas	1,017	2,120	
	Ceará	458	0	
South	Alagoas	1,017	2,120	
	Ceará	458	0	
	Paraná	1,058	0	
	Santa Catarina	230	0	1,288

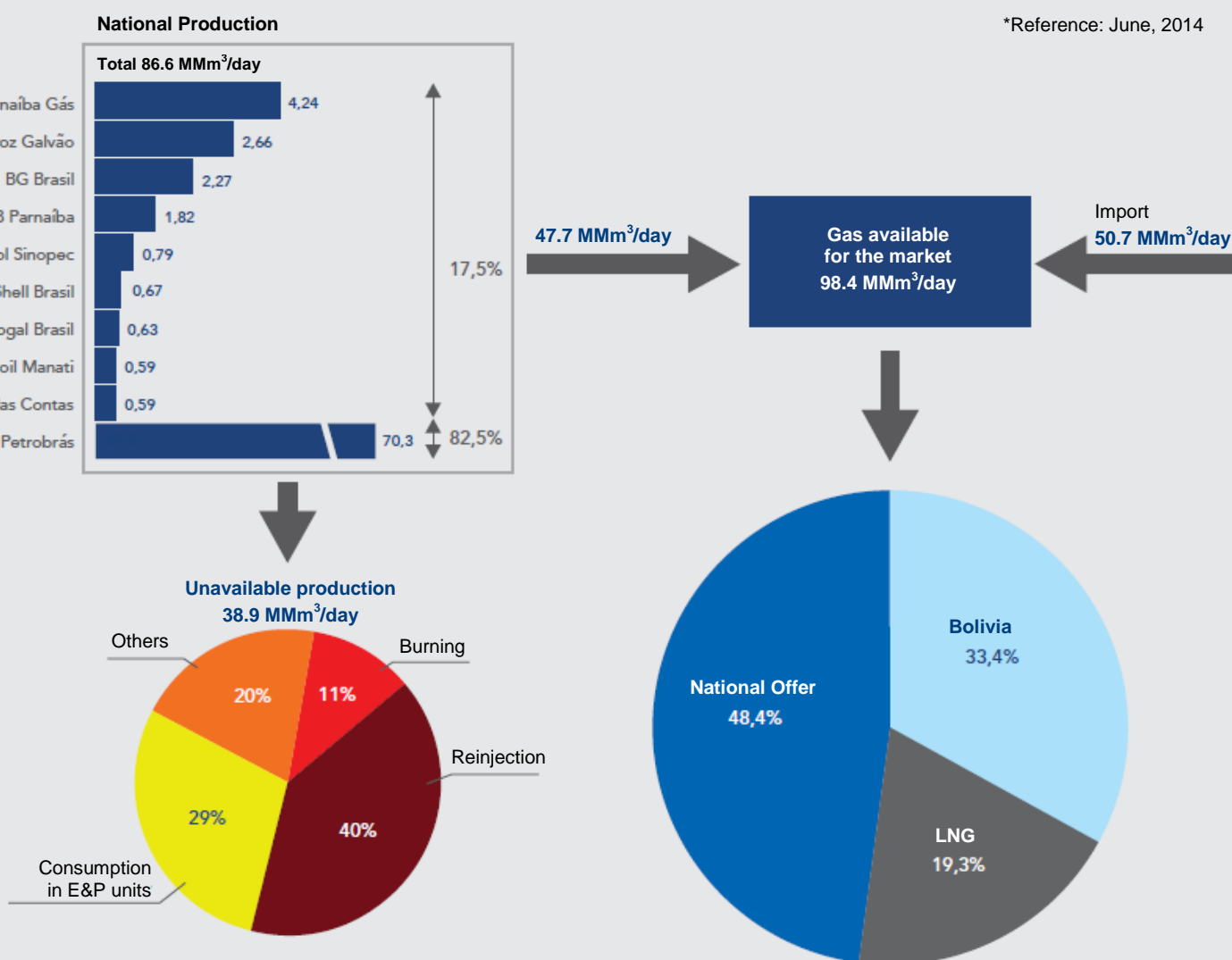
Source: Prepared by the author from MME data.

Petrobras expects to be one of the 5 largest oil producing companies in the world¹⁹ by 2030, and its Investments Plan 2014-2018 provides for investments of US\$ 153.9 billion in exploration and production, out of which US\$ 82 billion in pre-salt development [Chart 6]. Therefore, priority should continue to be oil production, and gas should remain as a secondary product associated to oil. Similarly, the company's investment capacity is targeted to oil production, which may hinder investments in drainage of the gas produced in pre-salt.

► CHART 5

Overview of the Natural Gas Market

(in MMm³/day)



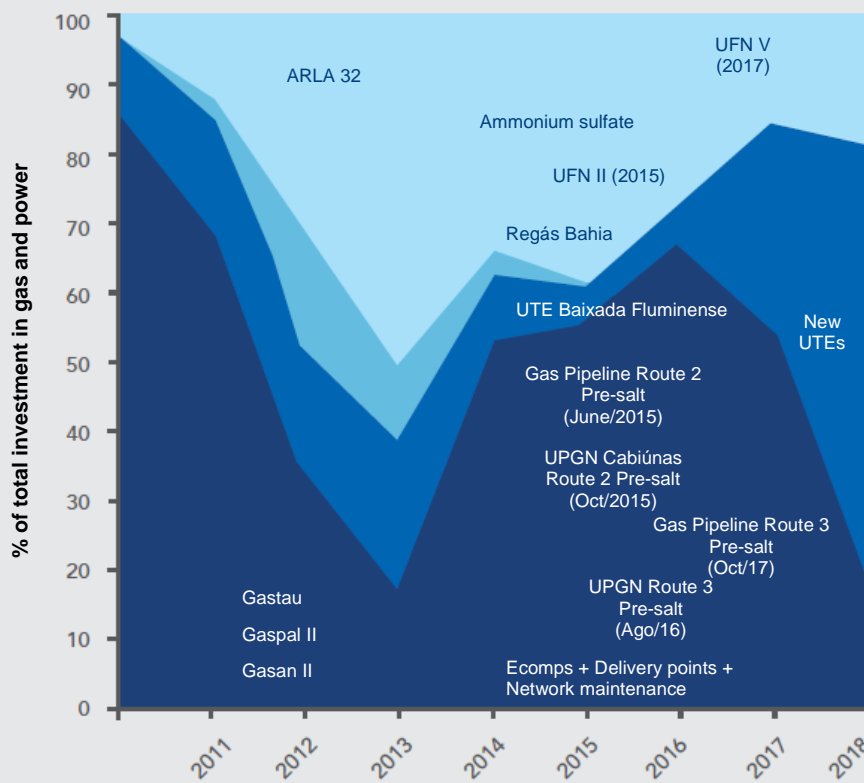
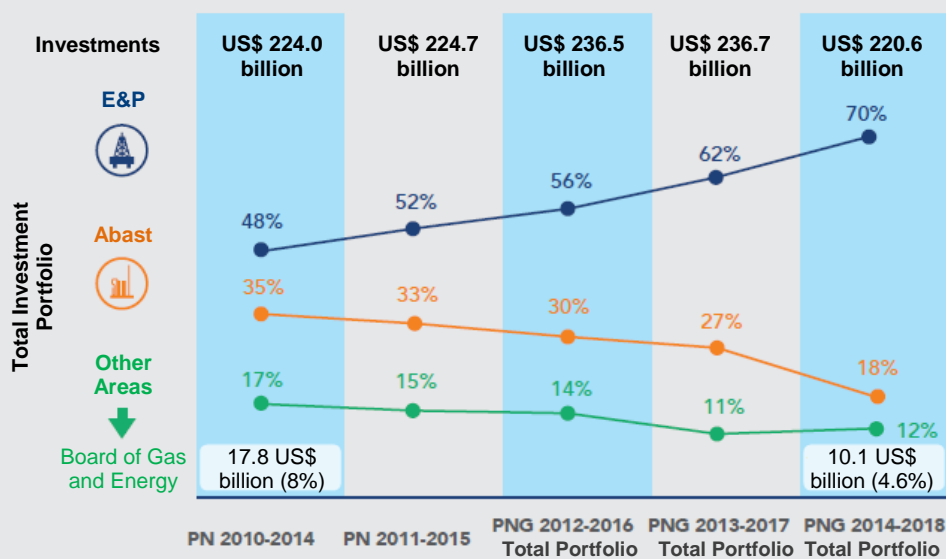
Source: Prepared by the author from MME data.

19. Petrobras website. www.petrobras.com.br/pt/quem-somos/estrategia (10/06/2014).

In particular, pre-salt fields are located almost 300 km away from the shore and massive investments will necessary to interconnect the several production clusters and transport gas to consuming centers. Petrobras' investments in gas and energy are being reduced from US\$ 17.8 billion in the Business Plan 2010-2014 (8% of the company's total investment) to US\$ 10.1 billion (4.6% of the total) in the Business Plan 2014-2018. Out of these, US\$ 6.1 billion will be destined to pipelines for

► CHART 6

Petrobras' Business and Management Plan



3rd Cycle of Investments - PNG 2014-2016

pre-salt drainage: the so-called Routes 2 (Cabiúnas) and 3 (Maricá), and respective UPGNs. Another relevant topic is that according to sector sources, pre-salt gas contains high percentages of carbon dioxide (CO₂) and its conditioning for market specifications may require the construction of enormous facilities to remove CO₂ in production platforms and reinject it in oil fields.

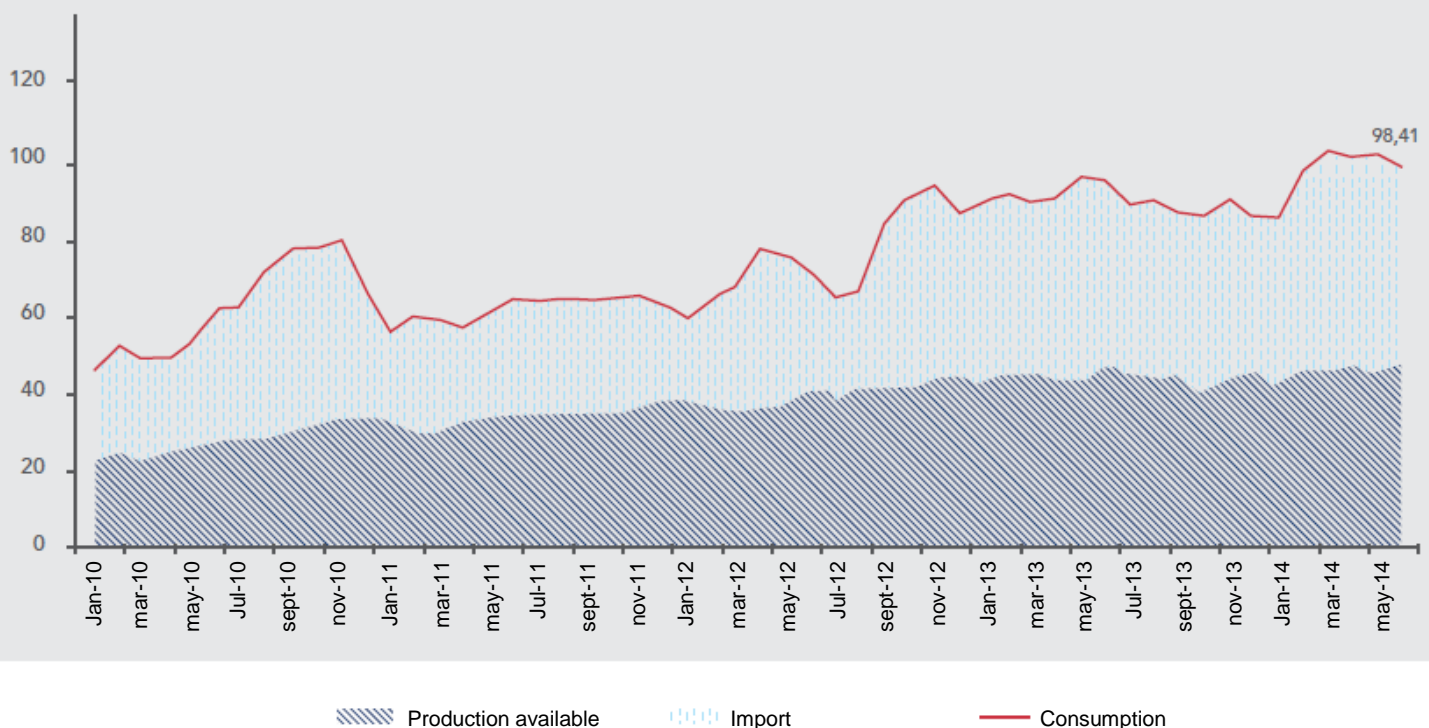
Natural Gas²⁰ exploration is still incipient in onshore basins and has not awakened the interest of national or international companies. ANP Round 12 was held in November, 2013, and only 72 of the 240 blocks offered were sold. Small and medium E&P companies, which could be better interested in specializing in research and production of nonassociated gas, are still facing difficulties to operate in onshore areas because of the high production drainage investments and market risks.

Thus, the domestic offer of Natural Gas is expected to remain highly dependent on oil production within the next 8 to 10 years once exploration blocks with chances of nonassociated gas, auctioned in 2013, shall not start commercial production before 2020/21. In addition, most part of pre-salt production should be

► CHART 7

Production, Import and Consumption of Natural Gas

(in Brazil (in MMm³/day))



Source: Prepared by the author from MME data.

20. In general, nonassociated gas.

available for the market between 2017 - 2018 once Routes 2 and 3 are still under the

bidding phase. That is, increased supply from national production should only occur in the medium/long-term once it depends on drainage pipeline construction in pre-salt blocks, granted before 2008, and from the beginning of the production in new bid Libra and Cessão Onerosa pre-salt blocks in exploratory rounds 11 and 12. Until then, the supply of Natural Gas should remain mostly imported, so that continued supply of gas from Bolivia and LNG offer and prices scenario, in the international market, will be extremely important for the country.

As the major investor in infrastructure in the Brazilian gas industry, Petrobras also holds full control of pipeline transport network, gas import assets operation and infrastructure, and LNG movement and regasification today. In addition, it also participates in the corporate structure of most state distribution companies. Petrobras controls 91% of the gas supplied downstream in the transport network and 100% of the access infrastructure to state utility companies when summing up imports made by its facilities and its own production.

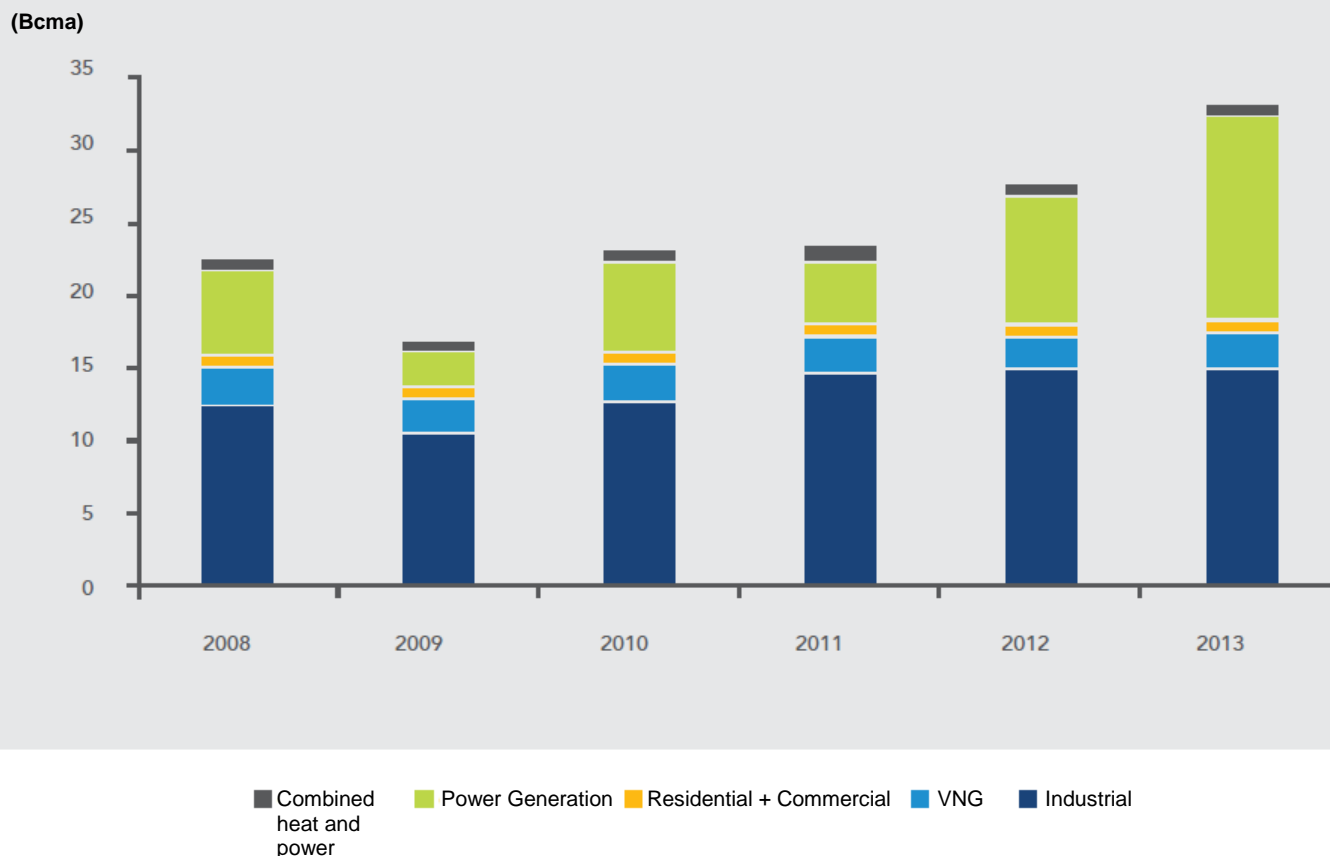
► Market

If the expansion in the domestic offer of Natural Gas is strongly linked to investments in the oil sector, Natural Gas consumption in Brazil is linked to state policies of piped gas distribution and policies of the power industry. Creation of the Thermoelectricity Priority Programme (PPT) enabled the power industry entry as a new consumer market as of 2000, which led to an important increase in demand. More recently, due to the long and unusual drought and reduced capacity of storage in power plants reservoirs, gas thermal plants started to be triggered more often. Consequently, PPT supply needed to count on Natural Gas imports from Bolivia, as well as imported LNG.

Gas consumption in thermal generation increased expressively, and represented 44% of total energy consumption in 2013. On the other hand, industrial consumption, which represents 45% of total consumption, depends on an offer at competitive prices. Uncertainties as to the demand in flexible thermal generation are reflected in gas prices that tend to rise with the import of LNG in spot market during low hydrology periods. Such volatility of offer and prices makes it hard for the industry to measure the benefits of using gas, which explains the stagnation of industrial demand for natural gas since 2011 [Chart 8]. Consumption remains stable and little expressive in residential and commercial, as well as vehicle segment.

▶ CHART 8

Average Consumption of Natural Gas in Brazil



Source: (MME, 2014) and reference [11]

Paradoxically, although Natural Gas is a strategic solution to generate power in Brazil, the Ten-Year Energy Expansion Plan 2022 provides for the inclusion of only 1,447 MW of natural gas thermoelectric capacity - versus a total of 35,073 MW additional capacity between 2014 and 2020.²¹ However, for the A-5 auction that will be held in November, 2014, there is approximately 20,000 MW gas thermal plants enrolled - although there is no sufficient offer of national gas to meet this additional demand within this deadline. Part of such projects should be enabled with the import of LNG. However, with auction ceiling price at R\$ 209/MWh, it will be hard to enable the prices and contractual conditions required by LNG suppliers. Today, the installed Natural Gas thermal capacity in the National Integrated System (SIN) is 10,366 MW, with the addition of 1,700 MW until April, 2016.

21. EPE, 2013

In general, there is still a lot of uncertainty regarding the real offer and demand of Natural Gas in Brazil. On the offer side, the sector continues depending highly on Petrobras, which will have its oil production commitments as a priority in pre-salt. On the demand side, priority is being given to thermal generation - a flexible consumption hard to predict - and planning does not point to the development of new consumer markets.

Additionally, the gas regulatory framework has not being able to solve some of its obstacles inhibiting the development of new projects in the sector yet. In this scenario, Petrobras will probably remain as the main player in the gas industry in Brazil for a while, acting throughout the value chain steps; however, with an increasingly reduced investment capacity in the sector.

► TABLE 1

Agents of Natural Gas Value Chain in Brazil			
Segment	Sector	Agents	Regulation
Upstream	E&P	Petrobras Queiroz Galvão Parnaíba Gás Natural (BPMB Parnaíba) Repsol/Sinopec Shell BG etc...	National Agency of Petroleum (ANP)
	Processing	Petrobras	
Midstream	Transport through gas pipeline	Petrobras	ANP
	Gas liquefaction	Petrobras & White Martins (Gemini project)	
	LNG transport	Petrobras (charters)	
	LNG regasification	Petrobras	
Downstream	Gas distribution	27 Companies Distributors of Piped Gas	State Regulatory Agencies
	Trade	Gáspetro (Petrobras) Natural Gas Traders	State Secretariats of Energy
	Consumption	Industries Thermal Plants Trade Residences VNG Stations	

Source: E&P Agents and Traders



Regulatory framework in Brazil

There is a significant structural separation in the gas regulatory framework in Brazil. While activities in upstream and midstream segments are regulated at the federal level, the piped gas distribution regulation is the responsibility of States.

At the federal level, the gas was traditionally object of Petrobras' activities, which since its foundation administered the State monopoly over hydrocarbons in Brazil. Petrobras' monopoly break occurred by constitutional amendment in 1995. Later, Law no. 9.478/1997 that became known later as the "Oil Law", disposed conditions for the operation of other companies in the oil and natural gas exploration and production sectors, and several of these measures rule the sector until nowadays. The Law also created the Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP) as the regulatory body of the oil and Natural Gas industry. Thus, the Oil Law made the end of Petrobras monopoly official, defined the principles for the concession of areas for E&P activities and established a sector regulation mechanism through independent regulatory agency, which in practice enabled the entry of other companies in the Brazilian E&P sector.

▶ TABLE 2

	Investors	Regulation
Upstream	<ul style="list-style-type: none"> ■ Petrobras ■ Brazilian and foreign companies 	<ul style="list-style-type: none"> ■ Guidelines are established by the Ministry for Mines and Energy (MME) ■ Federal Regulator: Brazilian National Agency of Petroleum, Natural Gas and Biofuels (ANP)
Midstream	<ul style="list-style-type: none"> ■ Petrobras exercises extensive control over the transport gas pipelines and LNG terminals ■ The private initiative may also invest in gas pipelines and LNG terminals 	<ul style="list-style-type: none"> ■ Concession scheme for national gas pipelines and authorization for international gas pipelines and LNG terminals ■ MME plans to expand the gas pipeline network (see PEMAT) ■ ANP regulates the free access and rates in existing gas pipelines ■ Rates of existing gas pipelines may also be negotiated and established by common agreement of the parties
Downstream	<ul style="list-style-type: none"> ■ 27 state concessionaires of Natural Gas distribution ■ Petrobras is a shareholder or partner of most local distribution companies 	<ul style="list-style-type: none"> ■ Concessions granted by state governments ■ Competent agencies or state secretariats approve prices and concession contracts ■ Local distribution companies have exclusive geographical franchise of 30 to 50 years.

Possibly because of the major production of associated gas in the country, the Oil Law addressed gas and oil matters together

- especially in upstream. Later, the gas sector development in Brazil and the growing demand of the electricity sector for Natural Gas exposed legal and regulatory disputes of the sector, mainly in the transport and infrastructure segments. After over 2 years of procedure, several sector agents met in 2009 to sign an agreement that enabled the approval of Law no. 11.909/2009 in the Senate, which became known as “Gas Law” - supplemented in 2010 by Decree no. 7.382 and also by ANP²² resolutions in subsequent years. These documents are now the essence of the gas regulatory framework at Federal level.

Regulations at Federal level are being developed ever since the end of the monopoly, in 1995, and the enactment of the Gas Law can be seen as a landmark for the Natural Gas sector in Brazil. Even with several gaps and regulatory obstacles, the existence of a specific regulatory framework for the sector increasingly adapted to the specificities of the Natural Gas industry represents an important step forward. However, there are still questions regarding the adequacy of such regulation to the Brazilian scenario, which counts on the presence of a dominant agent and less mature markets.

The current Federal regulation provides for the separation, in Natural Gas transport, of Loader (molecule owner) and Transporter (operator)

22. Resolutions: No. 44/2011; No. 50/2011; No. 51/2011; No. 52/201 1; No. 51/2013; No. 15/2014; among others.

of pipelines) agents. It was equally established that the grant of pipelines construction and operation will be obtained upon authorization, for international gas pipelines, and granting, for national gas pipelines. Now, the law ensures free access to transport pipelines and sea terminals, among other important measures.

ANP regulatory competence ends at the city gate. From this point on, the State sphere is responsible for piped Natural Gas regulation, including the establishment of rates, structure and methodology of the distribution rate review, in addition to decisions on the acquisition of gas by Free Consumer (FC), Self-importer (SI) and Self-producer (SP).

Loader/ Transporter

The current regulatory standards establish that the Loader (usually the gas producer) and the Transporter (usually the owner or partner of the contractor that built gas pipelines) need to be separated from each other. Most recently, in Resolution no. 51 of 2013, ANP established that in addition to loader and transporter being different companies they may not have any kind of corporate relationship. However, in practice, transport gas pipelines are mostly operated today by Transpetro, a Petrobras subsidiary, which in turn is also a Natural Gas loader.

Self-producer - SP Self-importer - SI Free Consumer - FC

Despite formally introduced by law, the relation between these new agents with the local distributor, holder of the gas distribution monopoly, was divided into Federal and State level generating a series of practical difficulties to develop such projects.

Free access to transport gas pipelines

MME is responsible for promoting the gas pipelines network expansion and annually indicates through PEMAT which sections will be object of public call for future concession.

Transport hiring is moderated by ANP and shall occur primarily in the available capacity, firm or extraordinary transport service, and further idle capacity contracted in interruptible service. Additionally, initial loaders, which make feasible or contribute to make the gas pipeline construction feasible, will have priority hiring in the available capacity.

Free access is not mandatory in treatment or processing facilities, in liquefaction and regasification terminals, as well as production flow gas pipelines (pipelines that connect the production unit to processing, treatment facilities or liquefaction units). This means, for example, that E&P companies operating offshore close to Petrobras Drainage Routes 1 and 2 (as well as Route 3, which will be ready in 2016-2018) will not have free access to pipelines guaranteed. For being drainage pipelines, this type of situation usually leads to the sale of such operators gas, still at the wellhead, for Petrobras at a usually low price.

In the case of FCs, SIs and SPs, while ANP is responsible for approving projects, the understanding about gas supply for installations depend of the State regulatory authority. Some practical difficulties faced by such agents are derived from this fact:

- Lack of clear and homogeneous State standards to acquire gas for Free Consumers;
- Non-recognition of some consumer facilities as SP or SI already registered at ANP along with State bodies;
- Establishment of additional restrictions for SPs and SIs by the State regulatory body; and
- Questioning about the determination of operation and maintenance rates (O&M), without the addition of distribution margins for SP or SI that installed their own pipelines.

Such difficulties are essentially linked to the agency or State regulatory body development level. The clearer and more isonomic are the State regulatory standards, fewer conflicts tend to occur.

There is a major disparity among State regulatory bodies today. Some States have more active and empowered bodies, which is translated into more transparent and consistent regulatory rules. Other States do not have rating methodology, and some States do not even have a regulatory agency. The State regulation then passes to offices of the State secretariat of energy that often do not have staff or technical training to address these topics properly.

Different corporate makeup of distribution concessionaires are summed to the heterogeneity among State agencies. In some States - as Rio de Janeiro and São Paulo - concessionaires have little or no participation in the Government. In others, as Espírito Santo, for example, piped Natural Gas is distributed by BR Distribuidora, a state company subsidiary of Petrobras. In general, the State regulation seems to be more developed in States where the gas distributor is in the hands of the private initiative.

The Natural Gas regulatory framework can be noted as recent and under preparation, and its suitability will be tested over the next few years. Convergence of rules from both (Federal and State) regulatory levels will be a gradual process, and any gaps will still be filled over time. However, the discussion on regulation is extremely important if the sector development is desired in the country, mainly due to its current structure that counts on a dominating agent present throughout the production chain.

PART

2



The Challenges for the **Natural Gas** Industry in **Brazil**



Specific questions were divided into major themes, in order to organize the discussion coordinated by FGV Energia in the next few months. Major themes allow us to structure and limit topics without restricting relations existing among them, once resolutions concerning a particular issue will inevitably influence discussions on other topics in many cases.

By deepening the topics listed below, it will be possible to understand what are the restrictions and possibilities of Natural Gas in Brazil and propose specific policies for the energy sector.

1

PLANNING

- Integrated energy planning
- Governance for integrated planning
- Planning from regional comparative advantages
- Signaling of the anchor demand for NG

2

EXPANSION OF THE OFFER

- Low predictability of the offshore offer
- Uncertainties related to the onshore potential
- Volatility and level of international prices for LNG
- Continuity of Bolivia's offer

3

DEMAND AND MARKETS CONSUMERS OF NATURAL GAS

- Relative prices between NG and its substitutes
- Level of Natural Gas prices in Brazil
- Development of markets in the medium-term

4

SHORT-TERM ACTIONS AND OTHER ISSUES NOT LESS IMPORTANT

- Feasibility of the operational swap
- Regulatory harmonization between State and Federal regulators
- Free access to infrastructure
- Market structure - dominating agent



Planning

Something almost unanimous for all sector agents is the need for a long-term plan that allows explaining several sectoral interactions and guiding the decision-making for long-term investments in Natural Gas value chain. Likewise, many respondents mentioned the lack of a specific plan for Natural Gas - today, it is considered that Natural Gas plan is prepared based on strategies for oil.

Under this theme, matters related to the integrated energy plan are included, as well as a reflection on the Natural Gas role in the regional context - does the gas need to be supplied throughout the national territory or only in regions with competitive advantage, both from the production and the offer side?

Below are presented the main topics addressed on planning.

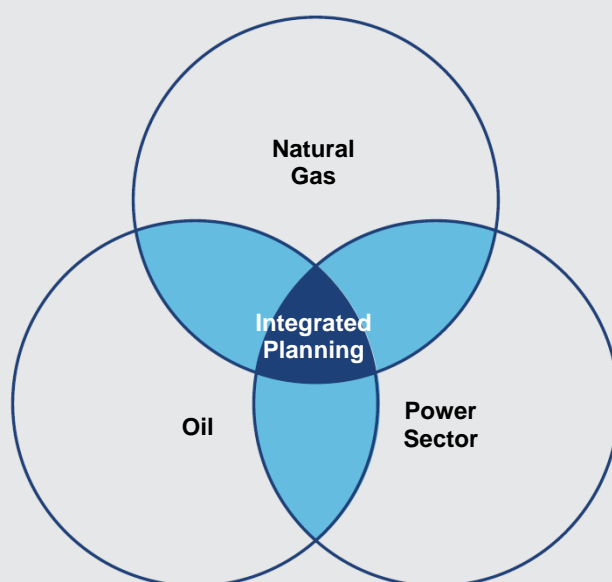
► Integrated energy planning

More than the lack of specific Government policy for Natural Gas, what seems more relevant for respondent agents is the need to improve the integrated planning of the energy sector countrywide where the availability of resources, the expected demand and regional comparative advantages of each energy source are taken into account. Within this context, the Government would be responsible for defining what is the expected role for Natural Gas in the Brazilian energy matrix, and what are the necessary actions to ensure the feasibility of this role.

Such a need to deepen the integrated planning greatly affects the gas sector, according to the characteristics of this energy. The gas is versatile and efficient, but also competes with oil in E&P activities and may be replaced for other energy sources in the demand side. The current official planning is targeted to: (i) the energy sector, through EPE, thus privileging the expansion of the electricity generation capacity; and (ii) to the oil sector, through Petrobras/CNPE, which directs investments for the expansion of oil production, specially offshore. Thus, the Natural Gas policy is intrinsically interdependent on these policies today.

“The Brazilian energy policy should show how much would be the participation of each source in the medium and long-term. A clear and predictable policy is missing today, thus the gas is “adrift”.”

► CHART 9



On the offer side, Petrobras “plans” the Natural Gas and today is responsible for basically the entire Natural Gas production in the country due to a particular characteristic of Brazil: our gas is mostly derived from production associated to oil nowadays. On the demand side, the gas dynamics is tied to the need of power generation at the expense of other segments that could use Natural Gas as input or energy, and also Natural Gas price policies compared to energy competitors, for example, fuel oil and LPG.

“The role of gas in the matrix should be discussed after an analysis of offer and demand scenarios. Defining the best use of Natural Gas *ex ante* is not possible.”

Given the sometimes different opinions on Natural Gas offer and demand scenarios in Brazil, we understand that integrated planning may facilitate a more explicit definition of the gas role in the power matrix. The matrix integrated analysis, considering the costs involved in the development of energy sources available in the country, as well as current tradeoffs in possible replacements on the demand side will enable a more efficient advantage of our energy resources.

In our view, it is also essential for the planner to define his/her priorities from an analysis of the possible offer, demand and investment scenarios in the power industry. This is why we consider the discussion on Natural Gas domestic and imported offer scenarios a priority, followed by a demand analysis due to possible replacements and relative costs in order to provide a basis for discussion on what is expected from Natural Gas.

► Governance for integrated planning

To address gas sector planning, the time horizon analyzed should be long exceeding the Government term. In a sector in which investments have long-term maturity, short-term means 5-8 years and long-term is estimated based on projections for the next 20-30 years. State policy is mentioned instead of Government policy in this scale.

In the power industry, the next decades are planned generally by two institutions: the Energy Research Company (EPE) with a technical bias, and MME representing the view of the current Government.

“Petrobras must always solve the Brazilian market problem. This is wrong. The Government must have a long-term policy.”

Gas planning “in fact” is prepared by Petrobras. Direction of the gas industry is essentially defined in Petrobras investments plan because of the priorities set by the company. For being dominant in gas (and oil) production countrywide, Petrobras ends up occupying a gap left by institutions in charge of the planning - in particular, EPE, which expends greater effort planning the electricity sector.

This model in which planning functions of the gas sector are in practice undertaken by Petrobras may have advantages and disadvantages that may be discussed and deepened. However, even if Petrobras is controlled by the Union it is a mixed corporation whose role should not include long-term planner. Additionally, even if Petrobras’ interests are considered perfectly aligned with the Government’s interests, its controller, the lack of transparency this scheme imposes to the gas sector planning is perhaps its most damaging aspect.

The technical framework supporting decision-making for Natural Gas ends up defined by Petrobras - and not explicitly by the planner. Furthermore, this model creates a strong information asymmetry environment with other agents, thus jeopardizing not only integrated planning, but also investments of other agents in the sector.

How is it possible to improve transparency and reduce information asymmetry when preparing gas policies? How and why a more transparent plan may contribute for the gas sector development? These questions regarding transparency and sector governance emerged during interviews and must be object of analysis within the planning context.

“What it wants to achieve and roles are not clear, and you end up leading the gas sector with a set of punctual interventions. Because of this, market agents start to play this game and each one defend a list of individual claims.”

► Planning from regional comparative advantages

Integrated planning does not necessarily imply unique national planning. Unlike the power industry that operates more robustly nationally, balancing hydrological cycles from North to South through SIN, Natural Gas may have regional comparative advantages.

Depending on the country's thermal plant, gas demand could become national if the need for gas thermal plants installation distributed throughout Brazil was pointed. However, PDE estimates a modest increase in Natural Gas thermal plants concentrated in South and Southeast regions. In parallel, gas production is currently regional, being 50%²³ of its national share concentrated in Rio de Janeiro and Espírito Santo.

Questions about offer, demand and infrastructure available may lead to different consensus in case they are addressed regionally or nationally. Likewise, the discussion about regional comparative advantages may enable important projects in regions where gas is further available - as in the case of cogeneration projects in the Southeast region.

In a country of continental dimensions as Brazil, thinking about comparative advantages each region has offering resources is important once energy resources are not distributed evenly throughout the country. A regionalized view of the power matrix could be embedded in the integrated planning idea and would help to build a more efficient power matrix.

Likewise, planning should consider the country's comparative advantages in relation to the several energies available. In particular, this matter is relevant in the country's gas sector because of the national production characteristics - especially gas associated with oil.

“We have a great energy diversity; in addition to energy diversity, we have a wide regional spread, too.”

23. Average 2013. Source Abegás & ANP.

It should be questioned whether the Natural Gas market should grow in all Brazilian regions or only in regions with comparative advantages, for example, regions with high industrialization and concentrated energy demand, or even regions with significant gas resources.

From Brazilian offshore oil producing companies viewpoint, the availability of associated gas for the market may represent an opportunity cost, especially in pre-salt. With legal burning restrictions, it is common to have large volumes of Natural Gas reinjected in reservoirs to maximize oil production, or to have them consumed internally in E&P facilities. In 2013, almost 13.7% of the national production was reinjected and 14.0% was consumed in E&P units. Summed to other losses, only 57.4% of Natural Gas national production was made available in the market. With the advent of pre-salt, the share of reinjection is estimated to increase. Thus, defining a strategy to optimize the production of Natural Gas that harmonizes both with oil production imperatives and also the industrial and environmental policy for Brazil is important.

Notwithstanding, possible interests in conflict concerning oil and gas may be addressed based on energy integrated planning. Given the power industry needs and global trajectory towards cleaner energies, what is the opportunity cost for Brazil for not developing the supply of associated gas for the domestic market? These matters should be addressed in an integrated manner seeking to analyze comparative advantages and relative costs to direct investments for one source or another.

Economic Theory Vision: Comparative advantage

AS MUCH AS REGION X is able to produce everything more efficiently than others in a certain country, the economic theory shows that it may be more worthwhile for X to produce only a few goods and have greater advantage compared to others, and let other regions produce the rest (even if they are more inefficient). This happens because even though X is more productive, if it expends efforts producing goods that do not have the greatest advantage; it will incur an opportunity cost.

Unlike the concept of competitive advantage, the comparative advantage concept takes the scarcity of production inputs (capital, work, earth) into account. That is, by directing all efforts to that more advantageous production, it would use its resources more efficiently and generate even more value than if it distributed such efforts among all activities.

► Signaling of anchor demand for Natural Gas

Where can gas have a greater impact for the economic development? Is there any consumption strategic segment in which Natural Gas must be a priority on commercial bases? The economic value generated in the industry, with the emergence of shale gas in the United States was an important consequence of unconventional gas revolution since the drop in natural gas prices in the American market led to the renaissance of the petrochemical industry in the country. The analysis and definition of a priority consumer segment depends on the strategic interests of the country, which should be defined in the planning. However, they should not be object of crossed subsidies, a practice observed in Brazil during the 80s and 90s.

In Brazil, consumption of large volumes in thermal generation could be an anchor demand for gas and enable several investments to expand the offer. However, the flexible and unpredictable regime of thermal plants flow controlled by ONS, associated with low gas prices in current PPT contracts, hinders this policy once it is difficult to supply gas in a flexible and inexpensive way simultaneously.

Another option for gas is to act in the electro-intensive industrial sector, which usually has important spillovers in the economy. But the industrial market needs a proper sign of prices given the global competition, stability and continued offer, in addition to time for development. In current conditions, in case there is an entry of large gas volumes, what would be this market's absorption limit for the new offer available? For the next few years, in the Natural Gas offer uncertainty scenario, entrepreneurs will find it difficult to decide on investments in an industrial facility in need for Natural Gas as energy or input.

Gas is an extremely versatile energy, but it still depends on a strategic plan to enable projects that usually take many years to be amortized. Enable investments in Natural Gas implies defining, regionally or nationally, which segments will be anchor for its development and promote a proper indication of volumes and offer prices.

“We should think about planning the matrix per subsystem, making gas develop first where it could contribute more.”



Expansion of the offer

“I don't see any drastic change to the gas offer scenario until 2025.”

Given the weightings relative to integrated planning of the power industry, which forms the larger interests of the country, the expansion of Natural Gas supply is a priority to start preparing coherent policies for the industry in Brazil.

To meet the gas demand countrywide, Brazil now imports almost half of the gas consumed (whether as LNG or from Bolivia). National gas offer is expected

to remain (at maximum) stable within the next 4 to 5 years²⁴ due to: (i) uncertainties related to the pre-salt gas volume that will be provided for the market; (ii) limited investments in Natural Gas exploration onshore in the last few years; and (iii) the transport and production drainage gas pipelines construction deadlines. That is, on this horizon, most of the country's demand for Natural Gas will remain being met by imported gas.

Regarding import, Bolivia gas supply contract will be expired in 2019. In addition to the need of renegotiating the agreement terms by the Governments involved, the political scenario in Bolivia does not seem to have favored investments in exploration recently, and there are doubts about the continuity of production in current volumes. In the case of LNG, which should supply part of the country's demand at least until 2020, the international prices scenario is uncertain and hard to predict.

“I think gas needs to have a role in the Brazilian power matrix depending on the gas offer I have inside the country.”

Uncertainty in the country's gas offer is very important for agents throughout the chain and directly affects their investment perspectives. In the current offer and demand scenario, we understand that the “gas role” in the country's future may vary significantly depending on short and long-term offer projections. Deepened and realistic discussion on the offer expansion potential then becomes a priority to prepare policies for the sector.

Thus, we start our detailed analysis in the offer scenario from a deepening in matters related to each of its components, namely: (a) pre-salt gas; (b) onshore gas in Brazil; (c) gas imported from Bolivia; and (d) LNG import.

► Low predictability of the offshore offer

With increased oil production in pre-salt, a significant production of Natural Gas in these areas is expected. However, there are still great uncertainties related to (i) when this gas will come; (ii) what will be the gas volume produced, and especially, how much will be provided for the market; and (iii) how will this gas be drained.

Uncertainties regarding the volume produced and, to a certain extent, the time it will take to reach production are part of the risks in oil and gas exploration and production activities. Therefore, it can be assumed that this uncertainty will be revealed over time as geological reservoirs assessment advances. Still, it is believed that such uncertainty is already mapped in a satisfactory manner and that it is possible to work with production curves from current data.

24. PNG - Petrobras 2014-2018

“Perhaps we even know how much there is, Petrobras knows. Now, there is no sign for entrepreneurs. Nothing. Zero. Huge uncertainty.”

On the other hand, the gas share that will be provided for the market and planning to drain such gas can and should be object of study and disclosure of objectives by the planner. That is, there is no way to escape from uncertainties inherent to E&P activity; however, a better definition of what should be made with the gas that is eventually produced from pre-salt would help to improve offer predictability for the sector. For example, with the entry into production of Lula and Sapinhoá pre-salt fields, an average increase in gas burning rejection of almost 5 MMm³/day was noted in 2014. Such gas could be consumed in the domestic market if there was proper flow infrastructure.

The main difficulty in defining the volume that will be provided to the market is related to the possibility of reinjecting large gas volumes to increase oil extraction from the reservoir. It is also summed the own consumption of E&P facilities that work essentially fed by Natural Gas and in oil refineries. Thus, also important is the matter related to the need of using gas in oil production and refining process.

Gas flow to the coast, as well as gas movement between offshore production units may also represent an important restriction on domestic gas supply. Difficulties to enable the movement of offshore gas are probably harmful to increased volumes provided and inhibit production competition. This is a matter that affects both pre-salt and post-salt offshore production.

The current legislation provides for free access to transport pipelines.²⁵ However, there is no guarantee of free access to flow pipelines used to move the gas offshore, where it was still not processed.²⁶ Large production fields enable offshore flow when producing sufficient volumes of gas to amortize the high investment in infrastructure. However, smaller fields, or with low Gas-Oil Ratio (GOR), are not able to monetize the produced gas and end up being forced to burn or sell gas to Petrobras, which has the largest production scale in Brazil. Given situation, we understand that offshore gas flow needs to be discussed as it favors the offer centralization into a single agent, in addition to encourage increased burning by hindering the monetization of the gas produced. Consequently, it also restricts the promotion of expanded Natural Gas offer.

Pre-salt brought a new horizon for the domestic oil industry. However, signals about production future in these areas are still missing. There are still uncertainties about production curves and volumes to be reinjected, which does not allow a proper signal of the market offer. Planners

“Gas is the main energy moving oil production, and pre-salt is mainly oil. Then, pre-salt gas lives far away and perhaps need it a lot to bring oil.”

25. Today, treated and processed Natural Gas movement pipelines are primarily pipelines installed onshore.

26. UPGNs receive Natural Gas on the coast and only then deliver treated and processed gas for movement through transport pipelines.

may guarantee that signals will come in time, so that the Brazilian Natural Gas industry is capable to absorb the offer variation from pre-salt. In their favor, planners still control a last variable of such movement: Union gas part, ensured by the share scheme to the State in pre-salt blocks. Where will this gas go? What are the Union plans for it? How will it be drained? These are some of the questions persisting.

► **Uncertainties related to the onshore potential**

There are doubts regarding the existence and commercial feasibility of onshore gas offer in Brazil. The main indicator mentioned is lack of investors' interest in the 12th bidding round, mainly comprised by onshore gas areas.

It may also be argued that conditions laid down to invest in onshore Natural Gas production and exploration areas are not attractive. Onshore nonassociated gas E&P activity has technical characteristics that usually lead to lower return margins and require greater control of operating costs, making them more interesting for smaller investors.

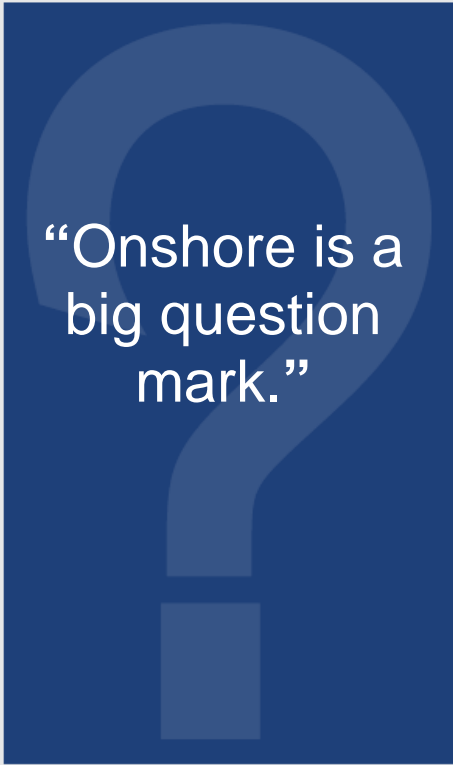
However, such investors are not prepared to cope with the several risks associated with onshore exploration in Brazil, namely:

- i. geological risk, with elevated exploratory cost due to large extensions of areas with little or no geological information available at the time of bidding, and hampered by the lack of supporting infrastructure to operate;²⁷
- ii. limited network of pipelines for onshore production transport;
- iii. market risk due to prices uncertainty and product liquidity in the domestic market;
- iv. projects financing difficulties in a still not so mature scenario with little national private initiatives, in addition to overly burdensome and complex taxation; and
- v. unappealing tax regime which does not provide commensurate incentives with the risk and return on investment.

Within this context, the first question that needs response is: what is the real onshore gas potential? Maybe it is too soon to obtain a reliable response for this question. Lack of onshore exploratory activity turns this question into a true black box for the sector.

“In the last onshore bidding, part of it went for Petrobras and most part nobody wanted. This is a prove that the balance among incentives and costs is wrong.”

²⁷. Many Brazilian sedimentary basins are located in remote areas where the operation cost is higher for being distant from E&P support bases.



“Onshore is a big question mark.”

“Yes, there is gas onshore. But having gas for trade is a huge difference.”

“I don’t see a lot of potential in onshore areas, investments are hard and have long maturation. Also, there is no onshore infrastructure to transport this gas to the demand.”

“First: there needs to have auction every year, onshore, offshore auction, there needs to have a calendar. Second, if we would like to increase the gas offer in Brazil, it would be necessary to have a different regulation for land and sea.”

Only land exploratory activities intensification may begin to outline the real potential of onshore gas. For this, agents show that defining consistent strategies is necessary to reduce the geological and financial risk of the onshore exploration activity. Having greater predictability on the bidding calendar, adjusting the regulation to make it simpler and manageable for small and medium investors, offering incentive conditions (royalties and low bonuses, different taxation) are some of the suggestions we hear to make onshore exploration more attractive in Brazil.

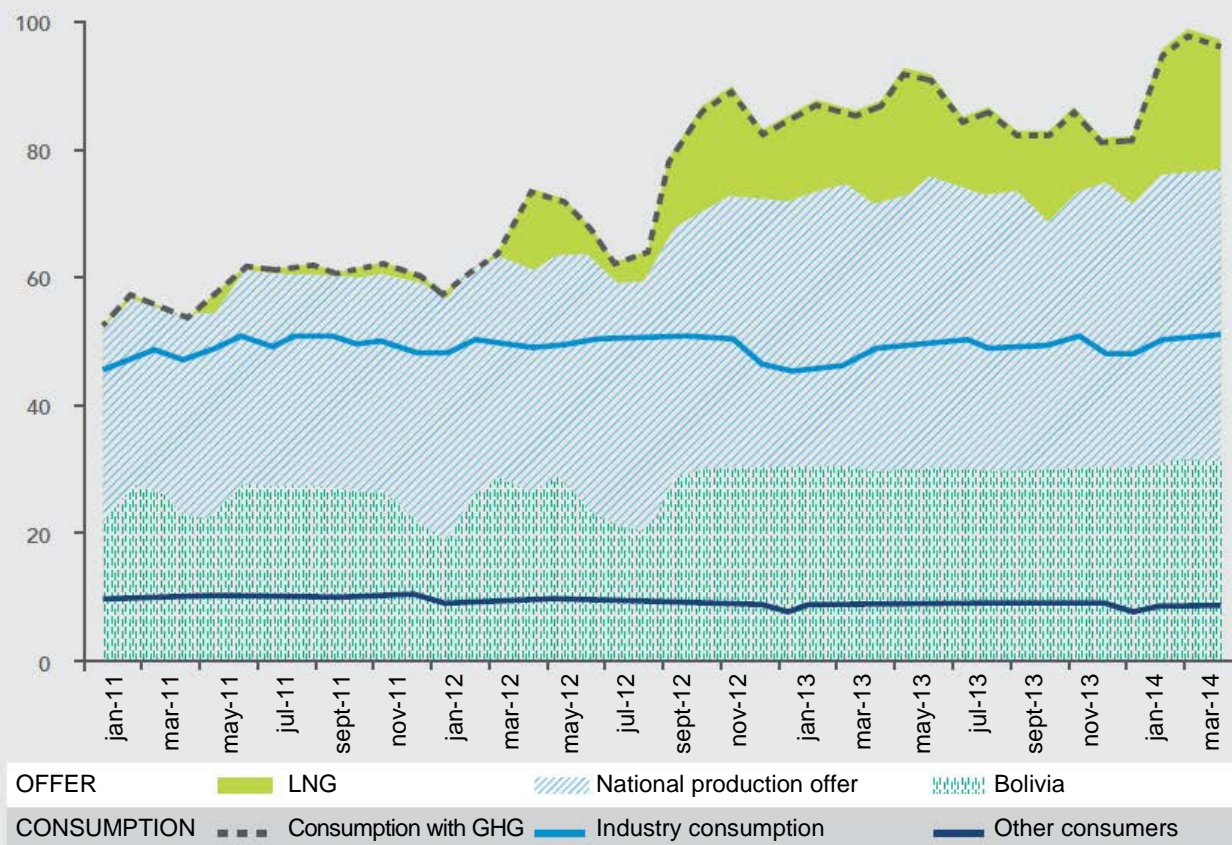
Given the current scenario, greater onshore domestic offer could be made provided that the policy adopted would be able to attract investors. If the country is interested in encouraging onshore E&P activities, Brazil would need to adopt measures to put its exploratory borders in national and international agents’ agenda so it may then outline a perspective of increased offer in the medium and long-terms.

► **Volatility and level of international prices for LNG**

With increases thermal dispatch due to low hydrology, the gas demand increased significantly in the past two years in Brazil. Such a demand from thermal plants for Natural Gas has been met mainly through LNG import by Petrobras in the short-term international market.

▶ CHART 10

Components of NG offer and consumption

(in MMm³/day)

Source: Prepared by the author from MME data.

In this scenario, Petrobras is subject to the volatility and high LNG market cash prices in the order of 16 US\$/MMBTU FOB, in 2014.²⁸ Once the gas sale price for part of PPT thermal plants was set in contract, transferring LNG import costs for these thermal plants, mostly controlled by Petrobras, that pay US\$ 4,60/ MMBTU²⁹ for gas consumed is impossible.

Given the difficulty to increase Natural Gas offer in the short-term countrywide, any additional demand for Natural Gas in this period will be met by importing LNG. In this context, the Natural Gas domestic scenario may suffer from major exposure to the international price of LNG, which faces a great uncertainty in the medium and long-terms. Such uncertainties are mainly related to sharp changes

“The flexibility needed by the power industry today is only achieved with LNG. Except that LNG is too expensive.”

28. Boletim Mensal de Acompanhamento da Indústria do Gás Natural, MME (August/2014)

29. Average gas price for PPT thermal plants until July, 2014 (Source: MME).

in gas geopolitics with a difference in regional prices and perspectives of changes in large global export and import markets.

A further complication arises from the fact that the demand for Natural Gas for thermal plants is flexible due to characteristics of our system - where thermal generation acts supplementary to seasonality and intermittence of water cycles. Additionally, we do not have capacity to store gas to act as balance buffer between the continuous supply flow and the intermittence of thermal consumption. These points make it difficult to sign long-term contracts to supply LNG, which could provide more favorable price conditions when compared to prices in the “spot” market.

Thus, increased consumption in gas thermal generation without increased national offer needs to be assessed in relation to LNG volumes that should be imported in order to meet the flow indicated by ONS, as well as in relation to the variation of such flow, which makes it extremely hard to sign long-term agreements by independent producers that do not have a portfolio of several gas supplies, as in the case of Petrobras. Understanding the LNG prices scenario is essential, both in the short-term market and in the long-term contracts, in addition to identifying possibilities to mitigate risks associated to the uncertainties of the international market.

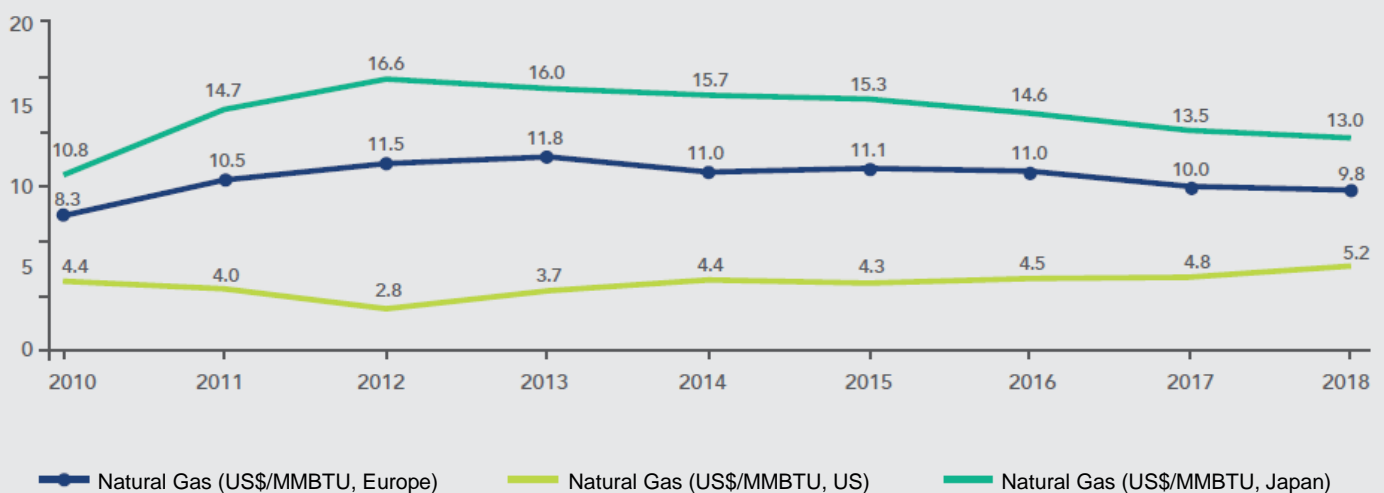
LNG price projections point to a mild price drop in the Asian spot market between 2015 and 2018, which mark out the prices currently paid by Brazil. However, if regasification and transport costs are summed, regasified LNG price should exceed US\$ 16/MMBTU in the medium-term.

“Interaction between gas and power industry is inevitable. And the answer is not easy. Neither the gas or the power (industry) have the answer.”

► CHART 11

Estimates of international prices for Natural Gas

(US\$/MMBTU)



Source: EIU Economic and Commodity Forecast, June 2014

With an indicated maintenance of current import volumes within the next years, analyzing the possibility to import LNG in medium and long-term contracts with less volatile prices than those practices on the spot market, which currently depend on climatic conditions and geopolitical disruptions becomes important. Therefore, it becomes vital to consider alternatives to enable a longer contract, such as the development of storage infrastructure, payment of capacity that takes into account fixed supply costs (for example, contractual “take or pay”), or development of secondary market for Natural Gas in order to meet the flexibility of thermal consumption.

“How to reconcile the power industry consumption? Thermal plants are an option. Storage strategy development and secondary market are also options. It may also be thought about creating a pool of gas agents, as in the power industry.”

► Continuity of Bolivia’s offer

Supplying the country with almost 31 MMm³/day, the gas imported from Bolivia is an offer mattress that allowed Brazil to anchor several projects related to Natural Gas since 1999. PPT, as well as Vehicle Natural Gas (VNG) market expansion projects are two examples of programs enabled by gas in Bolivia. Today, after 15 years from the beginning of supply, we see the end of contract getting closer, due in 2019, in a context very different from the beginning.

With the development of the Natural Gas consumer market throughout years, Bolivian gas is entirely consumed and prices are frequently below the domestic gas price. However, gas demand in Brazil increased so much that renovating the contract in 2019 is key to ensure the national supply of Natural Gas in the market. Petrobras and YPFB should renegotiate.³⁰ Since both companies are controlled by their respective Governments, negotiations should also be based on mutual international cooperation and political interests.

It is understood that negotiations should take into account Brazilian needs to renovate the contract, thus ensuring the highest possible volume of gas in the coming decades at competitive prices. However, since the oil and gas industry nationalization in Bolivia, in 2006, little investment has been made in E&P in the country. A new question related to Bolivia’s capacity to continue supplying the current amount for a long-term in a new contract arises because of the lack in the development of new fields.

“Bolivia does not have a problem with reserves, but with little investment.”

Possibly, in order to mitigate the risk of supply shortage from Bolivia, Petrobras already shows a resumption of investment in that country: despite the losses during 2006’s nationalization, Petrobras joined the consortium responsible for Itaú field in 2010.³¹

30. Yacimientos Petrolíferos Fiscales Bolivianos (YPFB).

31. Consortium comprised by: Petrobras (30% operator), Total (41%), BG Bolivia (25%), YPFB- Chaco (4%)

More recently, in April 2014, Petrobras also declared it will invest over US\$ 2 billion dollars in San Telmo, Astillero and Sunchal areas with a potential of approximately 6 TCF.³³

“From the political viewpoint, Bolivia cannot lose Brazil as a market.”

In addition to the commitment with Brazil, Bolivia also has a gas export contract with Argentina with a minimum basis of 12 MMm³/day, which may hinder the renegotiation of terms in the Brazilian contract in 2019. However, part of the agents believe Brazil is an essential market for Bolivia.

“There is a major concern with Bolivia gas offer. If it does not come from Bolivia, it will come by LNG.”

In the current situation, estimating the future of Bolivia' gas import contract is not possible. However, without Bolivia's volume as of 2019, it would be necessary to enable a significant increase in domestic gas or LNG import offer capable of compensating the current 31 MMm³/day imported from Bolivia. Thus, the end of Bolivia supply contract today is translated into uncertainty about the volume supplied in the future, as well as increased uncertainty about general prices. The better the indication that the planner is able to supply, whether in relation to contingencies for Bolivia supply shortage or the future of the supply contract, the greater the capacity of incorporating Natural Gas into projects with life beyond 2019.



Demand and Markets

Consumers of Natural Gas

Natural Gas can be used as energy or input for the industry to produce a few goods and services. In both cases, however, its use can be replaced by another product - such as LPG to cook food or fuel oil in power production or in the industry. Therefore, Natural Gas demand analysis in several consumption segments should consider this possibility of replacing its use for other energies.

The decision to Natural Gas or a possible substitute will depend on the advantages and disadvantages of each one. Depending on the consumption segment, factors as offer predictability and stability are important. Particularly in the industrial sector, the benefits for using Natural Gas may also include improved quality of its final product. However, as it should be, relative prices between Natural Gas and its possible substitutes play a central role in that decision.

Price at which Natural Gas will be available for several consumer segments depends

on its production or import cost, and also the cost of drainage, transport and gas distribution to the point of consumption. Production, transport and distribution costs, in turn, are related to the amount of gas produced and consumed, once there are important savings in the value chain scale. Finally, the balance price will depend on the total amount offered and Natural Gas demand.

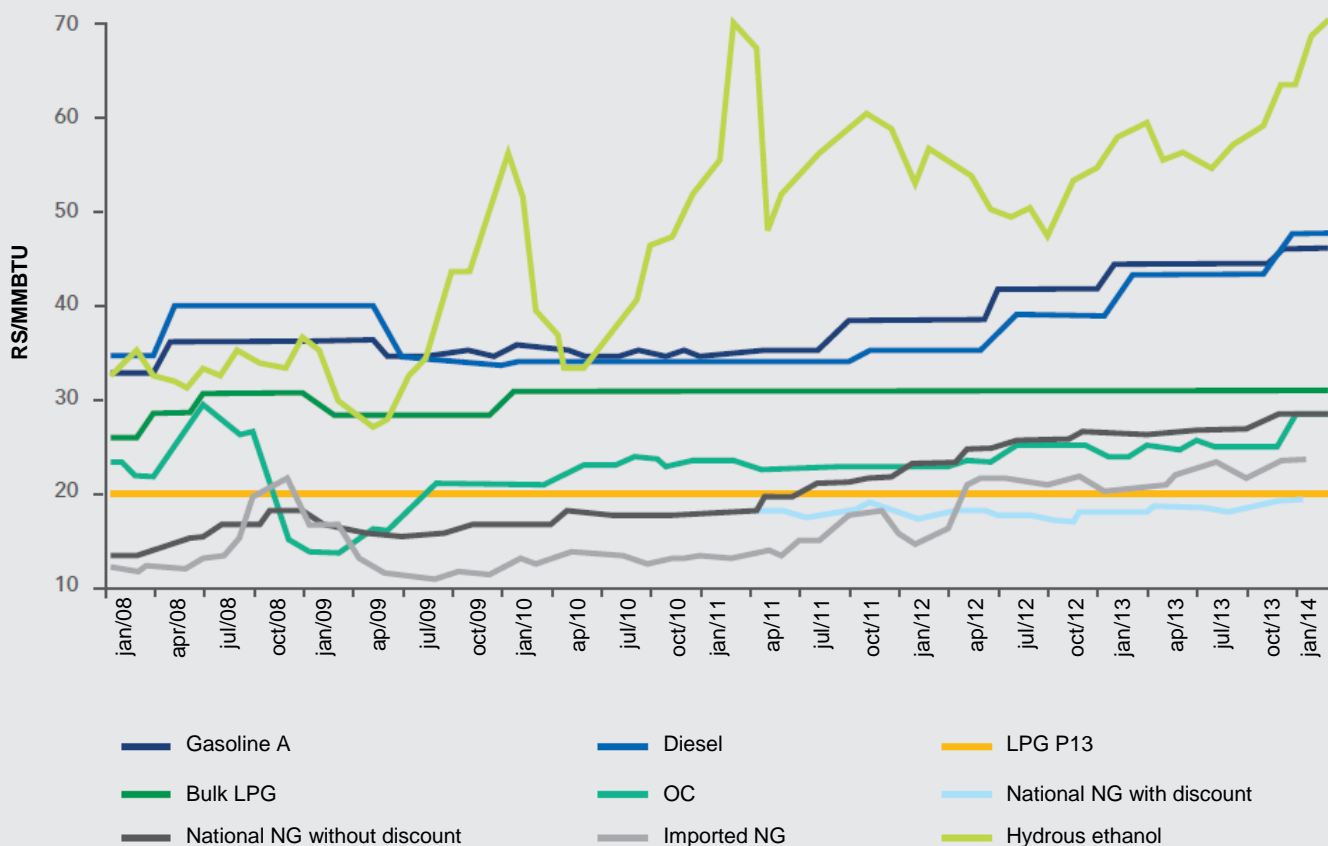
This way, we address Natural Gas demand from the perspective of the decision of end consumers, considering relevant factors in consumer's decision by other energy. In this scenario, the central discussion should be around relative prices addressing other considerations depending on the consumption segment analyzed.

► Relative prices between Natural Gas and its substitutes

Nowadays, the domestic Natural Gas price for utility companies receives a discount from Petrobras of approximately 30% on a provisional basis, which is passed on to the end consumer. Thus, domestic gas price is comparable to the price of Bolivian gas. In the short-term, the discount in gas price

► CHART 12

Prices of Fuel in Brazil



Source: Abegás

is an advantage for consumers. However, even with the provisional discount, the gas final price cannot be competitive for large industrial consumers, which have to compete with products imported from China or United States where the production cost is lower than in Brazil.

Natural Gas also competes with energies whose prices are subsidized. LPG price, for example, is not altered since 2004, whether in P13 (cooking gas cylinder) or supply in bulk. Diesel and gasoline prices are also controlled, essentially as inflation control mechanisms. Gas price for PPT plants is lower than gas price in the city gate, which may be a cross-subsidy, where other market segments pay a higher price to keep prices low in power generation. How is it possible to compare the relative prices of fuels in this scenario?

Subsidy or price control and lack of clear predictability increase uncertainty about the price of energy. For investors whose choices represent a long-term investment commitment, the risk assessment to choose one or other energy has an even greater weight. The greater the uncertainties on relative prices to choose the fuel, the more this choice will be based on aversion of the consumer risk.

Prices policy discussion is a matter that comprises all energies, not only Natural Gas. However, a deeper discussion on the Natural Gas molecule pricing policy fits this context, especially due to the current market structure with the offer still highly concentrated in only one agent.

As it happens with several other products in general, Natural Gas prices should respond to variations in offer and demand. On the side offer, variations in productions, in import volumes and storage levels are the main factors affecting prices. On the demand side, the level of economic activity and climatic factors are some of the elements influencing gas price.

Another essential aspect for pricing is related to the substitutability of demand for natural gas in the various consumer segments. This fact is closely related to the elasticity of Natural Gas substitution for other energies. That is, gas pricing should consider its energy replacements - in particular, oil and its derivatives.

Obviously, the effect of oil prices in Natural Gas depends on each country or region, consumption segments served and possibility to replace gas in the short-term. In Brazil, the market structure and pricing, yet not quite transparent, make it difficult to analyze how these factors may affect the price of Natural Gas.

In this context, the discussion on prices policy related to Natural Gas and other energies is essential to decrease uncertainties for agents and attract investors.

“The reference of relative power prices was lost due to subsidies for several energies.”

“Gas pricing should be made by energy replacements.”

“We need to give an economic signal for agents.”

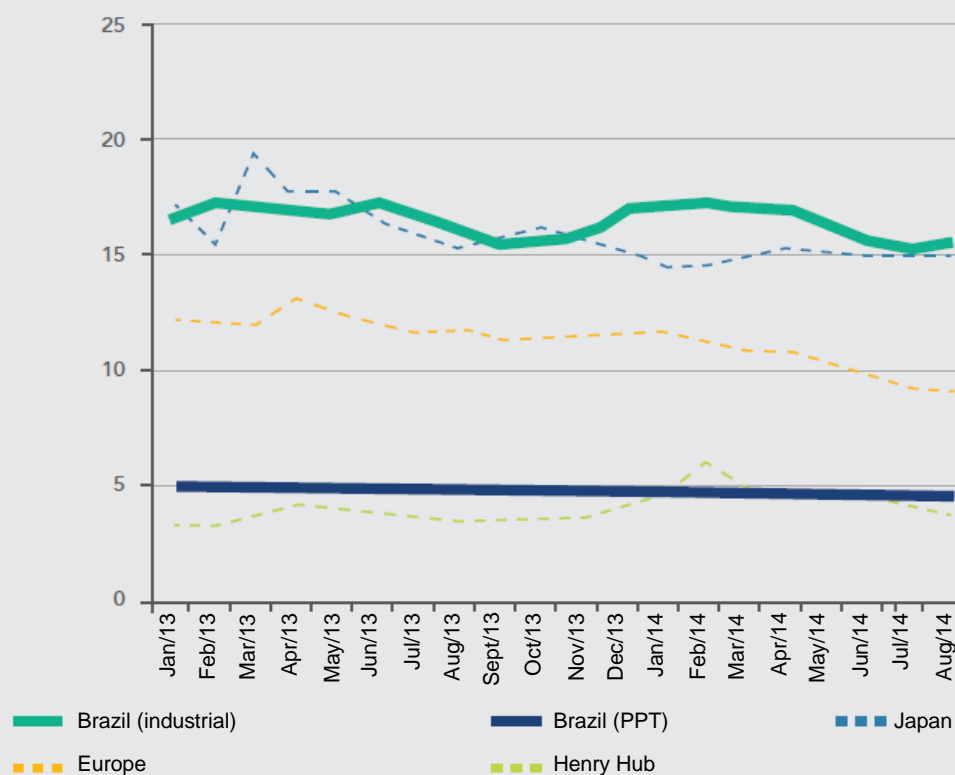
“Prices are high and future offer has a broad forecast. This takes competitiveness off our country, off our production.”

► Level of Natural Gas prices in Brazil

In addition to relative prices, the current absolute levels of Natural Gas prices in Brazil are also a source for concern among agents. Due to the mix of offer and direction of Natural Gas supply for the power industry, the industrial segment has been indicating that prices faced by the industry in Brazil, almost US\$ 14-17/MM BTU,³³ strongly impact competitiveness, especially in industries that use the Natural Gas as input. Additionally, the migration of producers to the United States in the search for cheaper gas has been affecting the Brazilian industry.

► CHART 13

Prices of Brazilian Natural Gas vs. International prices (in US\$/MMBTU)



Source: Prepared by the author from MME data | Deflators: IPCA, USA CPI; Germany CPI; Japan CPI

What type of policy could be implemented to make gas price more competitive? From the economic viewpoint, the price of a product reflects market conditions. That is, the price is a symptom of market operation, a variable resulting from the balance. In the case of Natural Gas in Brazil, the high price can be derived from limited offer of Natural Gas and the current market structure, which counts on only one bidder.

33. Boletim Mensal de Acompanhamento do Gás Natural, MME, September, 2014.

This is one of the most relevant themes, but that does not reach a consensus. Producing agents understand that the gas price should reflect its scarcity and; therefore, pricing would be based on opportunity cost, while consumer agents understand that prices should be regulated by the Government while the supply monopoly persists. Tax burden, which represents from 20 to 30% of the gas price for end consumers, is also added.

“Brazil would need a single price while Petrobras is the supplier.”

In general, increased offer of a product tends to reduce its price. In the case of Natural Gas, expanded offer arises again as a desirable policy - this time, with the perspective of making Natural Gas prices more competitive. Regarding market structure, the gradual entry of new agents from expanded offer should introduce more competition in the upstream. None of these results, however, should be noticed in the short-term once offer expansion policies, if implemented today, should begin to take effect only from the medium to the long-term.

Immediately, more transparency and isonomy in pricing Natural Gas can be sought with clear separation of molecule prices and transport rates. In the case of transport, with the strong operation of regulators to define rates and assess the idle capacity of gas pipelines.

This could be the first measure to provide more confidence and predictability in the short-term.

“The idle capacity should be on the spot. Given this idle capacity, agents interested in placing gas in the gas pipeline tease: ‘I have gas to put here. ANP will set the rate with all the transparency. You need to enforce the law.’”

► Development of markets in the medium-term

Given the high investments in infrastructure, the gas demand development needs, in addition to proper indication of prices, a stable volume of offer for a certain period. In addition, consumer markets take time to develop. In Brazil, industrial consumption stopped growing over three years ago and most part of the new gas offer was incorporated by the growing demand of the thermal industry, which already responds for 44% of the total demand.

Today, we live in a moment in which the greatest question is about the future offer of gas in Brazil. However, we have been through opposite situations in which good offer opportunities were difficult to establish because of lack in demand. Sharp contributions of new volumes to the market can become unfeasible because they are difficult to absorb in consumer centers, and at the same time insufficient to enable export investments. This was the case of gas imported from Bolivia.

Initially, there was no private interest in moving gas from Bolivia to the Brazilian market once the Brazilian market demand, at the time, did not justify the high GASBOL initial investment cost, which was enabled by Petrobras leadership and investment. Similarly, onshore gas fields do not seem attractive once, among

“There must be a steady gas consumer market, otherwise the well is unfeasible.”

other factors, there is a great uncertainty regarding demand. Companies prefer to invest in prospects with high probability of oil production, with faster monetization and international market prices.

“If we have a lot more gas in pre-salt, are we going to be able to export this gas? Maybe not. So, we need to start having policies...”

To avoid situations like this, offer and demand should always evolve in a coordinated way. However, its evolution naturally tends to occur at different paces. Offer expansion is more uncertain³⁴ in general, usually resulting in sharp increases due to the discoveries of new reservoirs. Consumer markets usually develop slowly and progressively because of a proper indication of volumes and prices,³⁵ and economic situations favorable to the business as logistics facilities, qualified and cheap workforce, competitive taxation etc. Thus, when preparing policies to promote expansion of the offer, it is essential to estimate the development strategy of new consumer markets as soon as possible.

As soon as the new offer is indicated, the integrated planning should identify an eventual need for anchor demand to enable this offer, as well as markets with greater potential to be developed according to the country's strategic interests. This aspect is extremely important in the Natural Gas sector due to the need of drainage and production transport to the consumer market.

This particularity of the gas sector becomes even more relevant today, given the debate of pre-salt gas offer.

“What is the Brazilian policy for pre-salt gas? What policy will we have to use gas in thermal market and non-thermal market? No one knows.”

- How much gas will come from pre-salt and other reservoirs?
- When? At what prices?
- To where will it come? What will we do with the gas that will come?
- Can we enable a better use of pre-salt gas by developing new gas consumer markets?
- What markets could bear potentially elevate prices of pre-salt gas?

Efforts expend to respond these questions are essential to create an environment that favors infrastructure investment and expansion of the Natural Gas market in Brazil.

34. As it results from exploratory activity that may or may not succeed in its endeavor.

35. UTEs are an exception to the rule, but face more difficult conditions of supply contract in Brazil.



Short-term actions and other issues not less important

Offer, demand and integrated planning are key weighing elements for policies from the Natural Gas industry. However, there are other issues not less important that reference the operation of the sector. They are like engines that need to be correctly adjusted for the sector to be able to respond and move according to the objectives signed in the energy policy for gas.

Some of these issues are listed and are briefly discussed below. They are “friction points” between agents, which sometimes generate impasses capable of paralyzing the debate on the future of the industry.

► Feasibility of the operational swap

Implementation of regulatory standards for swap operation is among the short-term actions that may help streamline the development of Natural Gas in Brazil mentioned during interviews.

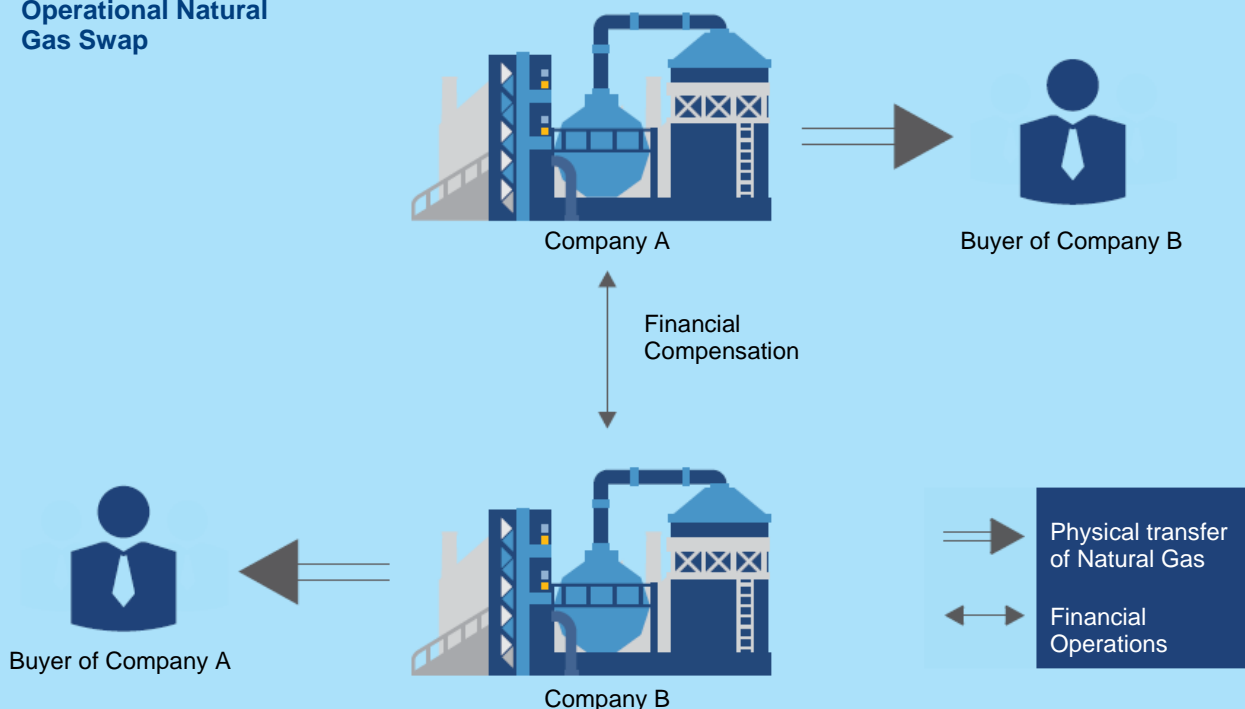
“I think swap is the most important. We need to address it.”

Operational swap

SWAP IS OPERATIONAL GAS EXCHANGE, so that it can be transferred between companies, in different States or regions, via financial compensation without the need to physically move the gas. For example, the company A has gas in the Southeast region and is able to have an operational exchange with company B,

which has gas in the Northeast region. In this arrangement, company A may sell gas for a consumer in the Northeast region and the physical delivery would be ensured by company B - while company B would do the same in the Southeast. This way, companies' gas offer scope is extended without adding costs of transport.

Operational Natural Gas Swap



Waiver of gas physical movement, thanks to the operational swap, also allows companies to provide gas for consumers that may not be interconnected by the transport network. This reduces the reliance on a transport network entirely interconnected and approximates producer and consumer markets.

Despite the several benefits provided by the swap, it still cannot be practiced for lack of explicit regulation. Even already being provided for in the current legislation, there are several technical matters and especially tax matters that still need to be defined to enable the operation, including ICMS payment in the origin or destination. ANP already recognizes the operational swap in its regulation, but does not set clear terms for its execution. Swap regulation could encourage the investment in nonassociated gas fields.

One of the difficulties to discuss swap is the fact that it needs to involve other bodies - as Treasury - for example. With this, the articulation among different Government entities and the convergence of goals is essential to enable swap.

“First, I have the operational swap: will gas be taxed here or there? We will have to discuss it at Confaz.”

► Regulatory harmonization between State and Federal regulators

As we discussed previously in this Booklet, the State regulation of Natural Gas piped distribution still causes some impasses in relation to understandings of agents at the time of signing supply contracts. Especially in what regards self-producers and self-importers.

“Self-producers, self-importers and free consumers are important and need to have regulatory harmonization to be consolidated.”

It is also noted a strong imbalance in the development of State regulators. The lack of regulatory institutionalization, which can occur in some States, ends up compromising the understanding between distributor and entrepreneur so that it prevents or hinders the execution of projects related to Natural Gas.

Given the different development stages of State regulatory agencies, it will be necessary to enable the structuring and qualification of State regulatory agencies in order to make the regulation more homogeneous and transparent countrywide. Thus, good articulation capacity is necessary from the planner and Federal regulator so as to obtain commitment from States to implement these processes - that can be costly at first for State Governments, but that will enable them to have more control over their local Natural Gas consumption policies.

“State regulators have strong heterogeneity and major disparity of rules.”

Not least, given the great interaction among gas and power sectors, Aneel and ANP must have convergent regulation. In theory, such convergence between two federal regulators in sectors sharing the same planner (MME) should be facilitated. However, part of difficulties being faced by the Natural Gas sector, as already mentioned, is linked to the high and volatile consumption of the power industry.

“ANP - Aneel interface is more complicated than ANP - State agencies interface.”

Integrated planning of the power not only energy industry - with the definition of clear energy policy targets and goals, and means to achieve such goals would certainly contribute for a better understanding between the federal regulators. Likewise, it would be possible to define a strategy to enable State regulation entities, especially in regions where the matrix had great participation in Natural Gas. In any case, the understanding between ANEEL and ANP and the reduction of disparities between state regulators is a goal that can and must be sought within the current structure of the sector.

► Free access to infrastructure

Access to transport and drainage infrastructure was already presented when we addressed the Natural Gas offer. However, due to its importance, we are back to this point here.

In Brazil, investments in the creation of a pipeline network were led by Petrobras that today operates the entire Natural Gas transport, transfer and drainage infrastructure. Despite the legal separation between transporter and loader, Petrobras monopoly over the gas pipeline network and large volumes it produces made it the main loader and transporter, being now the only provider of Natural Gas to markets, except the State of Maranhão.

“Other producers (in addition to Petrobras) have no alternative for drainage.”

Thanks to its broad Natural Gas production and import portfolio, Petrobras is capable of ensuring the deliveries of gas hired by supplying Brazil and creating safety for its buyers. On the other hand, consumers will have little bargaining power given the lack of real supply alternatives. In Brazil, as previously seen, there are some alternatives in the national production of gas in which other companies as BG, Queiroz Galvão and Parnaíba Gás Natural produce significant quantities of Natural Gas. However, diversity arising in production does not appear in the offer for consumers. This phenomenon typically stems from access problems and development of transport and drainage infrastructure.

How is it possible to increase the participation of new producers in the offer for consumers? Part of the response can be on the guarantee of access to potential offering companies to the transport network - where the offshore gas drainage should also be analyzed.

“Gas drainage and cleaning are infrastructure barriers to induce independent gas production.”

Some stronger measures on the separation of loader and transporter agents try to strengthen the free access to transport pipelines. The gas law established the separation between loader and transporter, thus restricting Petrobras participation in new transport projects. In a recent public notice, in order to hire the capacity for a new transport gas pipeline Itaboraí - Guapimirim, Petrobras announced its intention to not participate as transporter in the project without, however, indicating if this will remain the company's position in future projects.

On the other hand, only Petrobras was interested in hiring the capacity - which is not a big surprise, once the gas pipeline, with only 11 km, will transport gas between Comperj and Gasduc III UPGNs, both from Petrobras.³⁶

36. Gas pipeline that connects the production area of Cabiúnas, in Macaé, to Reduc refinery, in Duque de Caxias, both in Rio de Janeiro.

Regarding existing gas pipelines, the practical implementation of such separation is more complex. Petrobras made structuring investments, owns existing transport facilities and will remain being the largest producer - hence, loader - of gas in the country for some time. A possible divestment of Petrobras in transport companies would imply a broad discussion, which certainly should take into account the best interests of the company and its shareholders.

This way, despite the corporate separation between loader and transporter established in Natural Gas regulatory framework, Petrobras is expected to continue acting simultaneously in both functions for some time, unless its shareholders decide differently. Ensuring transparent and reasonable access of other agents to Petrobras transport gas pipelines is important, and start a discussion on how to ensure that other producers have access to the processing infrastructure and production drainage gas pipelines for which the current legislation does not ensure free access.

Drainage difficulties will be evidenced with the need of pre-salt gas drainage - in particular in Libra field, where the Union will own part of the gas production and will need to define what will be done with its part in the production. Any definition will be closely related to the definition of the pre-salt gas amount, which will be provided to the market in fact as we discussed in the offer section.

“At some point, the infrastructure sharing, treatment, drainage and gas processing facilities matters will have to be addressed.”

► Market Structure

Currently, the Natural Gas sector in Brazil has Petrobras as protagonist in all stages of the Natural Gas value chain from E&P to consumption - both in distribution, in which it is shareholder of most distributors and in power generation, in which it already became the 8th generator of the country in terms of installed power.³⁷ From the company's viewpoint, the operation is not necessarily advantageous in financial terms, since it ends up assuming several commitments to execute projects of public interest. From the society's viewpoint, its vertical and dominant position inhibits the entry of new agents and represents a major barrier to competition in the sector with all the negative effects arising from such situation widely known in economic theory.

37. Source: Petrobras (June/2014)

“We have to rethink Petrobras’ role. What is Petrobras’ role in the gas sector?”

Petrobras dominance in the gas sector today arises from its participation in structuring investments for the sector, in projects defined as interesting, whether company or Government projects without an apparent interest of private agents at the time. Thus, a question about the capacity or interest of other agents to meet consumer markets’ demands still exists, thus ensuring expanded gas movement infrastructure and promoting the expansion of Natural Gas exploratory borders in case of progressive disinvestment by Petrobras.

Economic Theory Vision: consequences of an imperfect competition

THE THEORY OF OLIGOPOLIES is capable of showing that situations where competition is not ensured bring negative consequences for the society.

Monopoly is an extreme case of this situation. It is set when a single bidder is capable of providing a certain good to the society. When the monopolist makes the decision on how much and how to produce, he/she knows he/she is alone in that market and that such decision will impact the price that will be effective. As a consequence, the monopolist production will be way beyond the competition because the lower production the higher will be the price of the product. This reduction in production will be made to the point when

gain with increased price equals the loss with reduction in products sold.

If, on one hand, the monopoly situation provides the monopolist with extraordinary gains, on the other, it provides consumers with even greater costs than the extra gain of the monopolist. Therefore, the society as a whole loses. This reasoning can also be extended to cases where there are few (but influential) producers. As much as they are not able to coordinate actions, they know that they can influence (at least in part) the price that will be practiced. Soon, a monopoly situation is not socially desirable and seeing Governments constantly seeking to increase the competition of their products.

However, this would be a reasonable progression for an industry initially developed by the public initiative, seeking to increase the share of new agents, promoting competition in markets, and leading to an economic balance of the sector. However, given the need to meet the power industry demand in short term and with a high level of reliability, and with regulatory and fiscal conditions that do not efficiently attract the private interest, the gas sector remains very dependent on the actions of a dominant agent.

“... There needs to have a disinvestment policy, but a planned policy.”

To emancipate the sector of State incentives, and alleviate public and Petrobras commitments, it is necessary to find a plan that allows to attract new investors for the Natural Gas sector. But, how is it possible to encourage the entry of new agents in the Natural Gas sector? What is the proper “timing” to reduce initial structuring interventions and start promoting the broad development of competitive markets in the Brazilian Natural Gas sector? The future of the Natural Gas industry in the medium and long-term also depends on the policy maker response to the sector’s questions about market structure.



Prospects for 2020



In case Petrobras plans become a reality, Brazil will start to produce from 3.7 to 4.2 million barrels of oil per day in 2020, and will be able to offer 140 MMm³/day of national gas for the market. According to EPE projections, the demand for steady Natural Gas should reach 127 MMm³/day plus a total flexible demand of 45 MMm³/day, which should be partially met by LNG imports, the lack of other domestic flexible supplies. Until Brazil develops massive onshore and shallow water natural gas resources, the production cost and consequently Natural Gas prices should remain high over the next decade.

Due to the delay to implement Petrobras refining plan, in addition to the growing Natural Gas imports, Brazil will continue to import LPG, gasoline and diesel.

According to EPE projections, the Brazilian transformation industry will lose share due to a more moderate relative expansion compared to other segments and the exposure to external competition.

The power sector should see growth in wind power supply, which may add another 9000 MW to the existing wind park. On the other hand, increased storage capacity at SIN will be only 7000 MW by 2022 against an additional offer of 48000 MW in the same period, thus making the country more vulnerable to climatic factors and wind intermittency. The increasing reliance on thermal energy for backup becomes an extremely important factor for the energy sector planning in Brazil.

In the international plan, the Natural Gas industry undergoes important inflection points that will certainly cause an impact on investments, availability and prices of imported natural gas in 2020.

Abundance of oil and gas extracted from shale deposits in the US are impacting not only prices of Natural Gas in North American market but also the international oil prices. On October 22, 2014, Brent oil was quoted at \$ 86/barrel while the Henry Hub (HH) was \$ 3.87/MMBTU.³⁸ If oil prices keep this downward bias in the medium term, this may put into question the feasibility of both shale projects, and other complex projects that require large investments, such as the pre-salt, and new Natural Gas liquefaction projects.

Low Henry Hub prices, on the other hand, place the USA as the most competitive LNG exporter at the end of this decade when compared to new LNG projects in Australia and the East Coast of Africa. However, it can't be stated that Brazil will benefit from

38. Source: Market Watch

more advantageous LNG prices in the US once export projects from the country require high credit rating buyers, anchored in 20 to 25 years purchase contracts, which is hard to be passed on to consumers in the Brazilian power sector.

In Europe, natural gas has been losing space for renewable energies and, more recently, for the cheaper and more pollutant coal. Natural gas thermal plants are being shut down in Spain and Germany, and the gas sector has been trying to reinvent itself, looking for markets in the land and sea transport sector. Given the lack of demand in Europe, new LNG projects are being delayed since everyone looks for buyers in Asian markets. Several uncertainties surround the global Natural Gas market until 2020, notably:

- The size of demand and type of prices indexation of Asian markets, in particular China, since Japan and South Korea markets are almost saturated;
- Deadlines to make a decision to invest in LNG export projects in the US and other regions, notably East Africa, Australia and Russia;
- Evolution in shale gas production in other global regions;
- Evolution or stagnation in the European Natural Gas market.

Given these factors, the discussion about the Natural Gas role in the energy matrix and Government actions encouraging domestic gas production are extremely important to guide the public and private investment over the next 6-8 years.

► Next steps

Identifying relevant themes is a first step to guide **FGV Energia** work in relation to the discussion of proposals for the gas sector in Brazil over the next 12 months.

In this Booklet, we addressed some of the principles guiding the gas industry in Brazil today, introduced the gas value chain, characterized its context in the national and international market and raised some relevant topics of the regulatory framework ruling the sector nowadays. Next, we deepened the central proposal of the Booklet, bringing to discussion the main themes affecting the Natural Gas industry in Brazil. In this sense, we understand that:

1. Given the lack of clear policies for the sector, expanding the dialogue among agents is paramount in order to define guidelines that help to develop the offer and demand in a coordinated way, guided by an integrated plan capable of clearing interactions between the gas, power and oil industries;

2. Offer expansion policies will be related to (i) increased domestic production, whether promoting the offshore offer or exploring the still little known onshore borders; (ii) enable the import of gas in the medium and long terms, in order to balance the flexibility needs and low demand prices;
3. Proper development of demand depends on offer expansion indication and predictability, especially regarding the projection of relative prices and gas volumes; and
4. There are also operating pending matters, especially due to friction between industry players, which, if resolved, can quickly cause major positive impact.

After launching the Natural Gas Booklet in November, 2014, **FGV Energia** will organize meetings and debates in order to define proposals and initiatives for all major challenges identified in this first study. These debates will be held throughout 2015 with the involvement and contributions of sector agents and investors in order to contribute to define a long-term policy for Natural Gas in Brazil and identify solutions to remove barriers and obstacles for the sector's development.

Glossary

SI	Self-importer	IOC	International Oil Company
ANEEL	Brazilian Electricity Regulatory Agency	LNG	Liquefied Natural Gas
ANP	Brazilian National Agency of Petroleum, Natural Gas and Biofuels	MMBTU	Millions of BTU
SP	Self-producer	MME	Ministry for Mines and Energy
BTU	British Thermal Unit	MMm³/day	Million cubic meters per day
FC	Free Consumer	NOC	National Oil Company
CNPE	National Council for Energy Policy	O&M	Operation and Maintenance
CVU	Unit Variable Cost	OECD	Organization for Economic Cooperation and Development
E&P	Exploration and Production	ONIP	National Oil Industry Organization
EIA	U.S. Energy Information Administration	ONS	National Electric System Operator
EPE	Energy Research Company	PDE	Ten-year Energy Plan
FGV	Getúlio Vargas Foundation	PEMAT	Ten-Year Expansion Plan of the Pipeline Transport Network
FOB	Free on board	Petrobras	Petróleo Brasileiro S.A.
G&G	Geology and Geophysics	PLANGAS	Natural Gas National Plan
Gasbol	Bolivia-Brazil Gas Pipeline	PNE	National Energy Plan
LPG	Liquefied Petroleum Gas	PPT	Priority Thermoelectric Program
NG	Natural Gas	SIN	National Interconnected System
CNG	Compressed Natural Gas	TBG	Transportadora Brasileira Gasoduto Brasil-Bolívia S.A.
LNG	Liquefied Natural Gas	Tcf	Trillions of cubic feet
NGV	Natural Gas Vehicle	Tm³	Trillions of cubic meters
GOR	Gas to Oil Ratio	UPGN	Natural Gas Processing Units
IBP	Brazilian Institute of Oil, Gas and Biofuels	YPFB	Yacimientos Petrolíferos Fiscales Bolivianos
BCR	Benefit-Cost Ratio		
IGU	International Gas Union		

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