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NATURAL GAS IN BRAZIL

TECHNICAL AND ECONOMIC ASPECTS

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I - BACKGROUND: BRAZIL'S NG EXPERIENCE

Historical use of NG in Brazil

The gas industry was born by the 1880's in the USA and Europe with the use of gas obtained by wood and coal distillation. The first gas company started in Baltimore in 1810 and it produced gas to illuminate the streets (public lightning).

The fast and huge increase of the oil industry and the industrialization observed during the second half of the XIX century contributed decisively to end the use of coal gas in almost all countries.

In 1897, with Thomas Edson's invention of the bulb lamp, the use of gas for lightning purposes was gradually replaced by electric lightning. However, gas use in domestic, commercial and small industries continued and, after the 2nd World War the gas industry experienced a constant improvement, changing its source from coal, to naphtha and, finally, to natural gas.

The Brazilian experience with gas started in 1854 when the "Barao de Maua," for public lightning installed the first gas-producing unit in Rio de Janeiro. It used coal distillation to produce the gas. The system was compared with huge European cities in terms of efficiency and intensity.

By the year 1872, King D. Pedro II authorized the installation of the "San Paulo Gas Company" in Sao Paulo/SP. Other important Brazilian cities adopted the coal gas system to illuminate their street (Salvador/BA, Recife/PE, Fortaleza/CE, and Belem/PA).

After a long period of use, coal gas became inadequate because of its low productivity, high cost and outdated technologies. By the early 1960's, gas pipeline systems operated only in Sao Paulo and Rio de Janeiro, which had successively changed their system to naphtha gas and natural gas - NG distribution.

By that time the Brazilian natural gas experience had begun. In fact it began in the 50's with the discoveries of oil and natural gas in the northeast state of Bahia. Despite the priority of re-injecting NG into wells in order to increase oil production at that time, NG began to be used in the textile and ceramic industries among others, in the "Reconcavo Bahiano."

In the 60's, two Natural Gas Processing Units (NGPU) were installed in Catu/BA and Candeias/BA to extract gasoline and LPG from NG. In 1971, NG began to be used as raw material in the fertilizer industry, in 1973, in the petrochemical industry.

In 1978, the "Polo Petroquimico do Nordeste," built by COPENE and others, was inaugurated and contributed decisively to the increase in NG consumption in Brazil.

In the 80's, a huge increase of NG production was observed in several states (Ceara, Rio Grande do Norte, Espirito Santo and Rio de Janeiro). It was necessary to stimulate the use of NG. To do so, the price was reduced to the same price as that fuel oil type Low Sulfur Fuel Oil - LSFO. The use of NG spread and several more industries started to use it.

Pipelines were constructed to supply distant markets. The two largest are the 755-km Rio/Sao Paulo line and the 480-km Nordeste, from Guamare/RN to Cabo/PE. They were constructed to supply the important markets of Recife and Cabo with NG produced in the Guamare fields, and to connect the Campos fields, located in Rio de Janeiro, to Sao Paulo.

According to Chapter III, Article 25, Paragraph 2nd, of the new Constitution of October 1988: "The states are responsible for exploring directly or by concessions to state-owned companies, the distribution and local services of pipeline NG." Before that time, there were only two companies in the NG distribution activity (CEG in Rio de Janeiro and COMGAS in Sao Paulo). After that, others states started to organize and administer NG use with the creation of NG state-owned distribution companies or by giving concessions to already existing state-owned companies. Now, there are sixteen companies, eleven fully operational and five under construction.

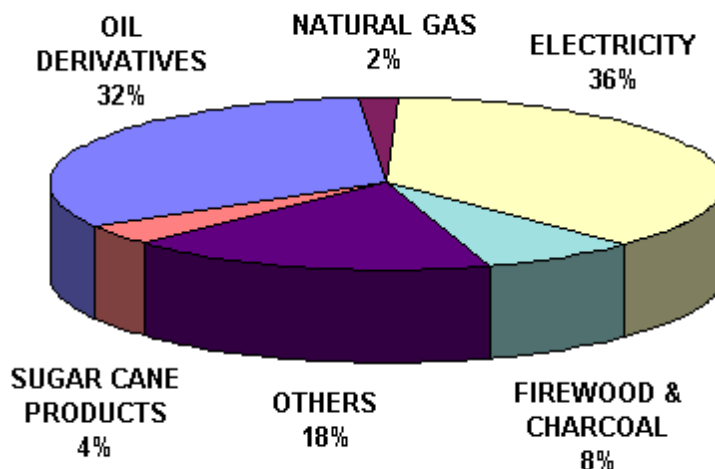
NG participation in the Energy Matrix

During the period 1950 - 1980, government energy policy consolidated the use of electrical and petroleum energy in the expanding industrial and infrastructure sectors. The energy sector became very important to Brazil because it was necessary to import oil despite the difficult balance of payment situation.

Indeed, after the two world oil crises of the 1970s, the consumption of oil derivatives decreased. Brazil started to stimulate domestic oil production to reduce consumption by adopting restrictive price policies and to use alternative sources of energy. So, electricity's share in the energy matrix increased, basically because of the long-run maturity of large hydroelectric investments and the incentives offered for its consumption. In the 80's Brazil launched the alcohol program, "Pro-alcool," that encouraged the substitution of alcohol for gasoline in the automotive sector.

These crises helped also the development of the NG industry in Brazil. Its share in the energy matrix increased from 0.2 % in 1970 to 2.0 % in 1990. Even though it was a huge increase, has a small share in energy matrix, especially when compared with other countries. The average NG share of the world energy matrix is about 23%. In some countries its participation reaches even higher levels, like Argentina (48%), Venezuela (41%), the Netherlands (40%) and the UK (30%).

ENERGY CONSUMPTION BY SOURCE - 1996



Source: MME

The Report of the "Comissao do Gas Natural" of march/92 estimated that NG share of Brazil's energy matrix would increase from 2.0% in 1990, to 9.8% in 2000, and to 11.9% in 2010. This increase would occur by using it to generate electrical energy and by displacing of oil derivatives (fuel oil, LPG, diesel oil and gasoline).

All of the latest information about NG indicates that Brazil has ample opportunity to reach such goals, but its success in doing so will depend on the government's energy policies, the regulatory framework, and the attractiveness of the Brazilian NG market to domestic and foreign investors.

II - DESCRIPTION OF BRAZIL'S NG RESERVES AND PRODUCTION

One can say that Brazil's known NG reserves would be larger than if huge investments had been made in the past. But, according to the National Oil Policy of the Government, the target was to increase domestic oil production in order to reduce expenditures on oil imports.

So, Petroleo Brasileiro S.A. - PETROBRAS, created by law no. 2004/53 to run the government oil monopoly, focused its efforts in looking for oil reserves and not for NG reserves. But it is correct to say that the current Brazilian NG reserves were discovered due to petroleum exploration activities, as can be observed by the share of associated NG (70%) and non-associated NG (30%).

		NATURAL GAS RESERVES - billions m³		
		Associated	Non-associated	Total
	Brazil	111.1	46.6	157.7
	Amazonas	17.4	11.3	28.7
	Ceara	1.1	0	1.1
	Rio Grande do Norte	8.9	2.0	10.9
	Alagoas	1.7	10.2	11.9
	Sergipe			

		3.4	1.0	4.4
	Bahia	16.0	14.7	30.7
	Espirito Santo	1.1	2.4	3.5
	Rio de Janeiro	60.8	1.3	62.1
	Sao Paulo	0	3.2	3.2
	Parana	0.6	0.6	1.2

Source: DNC

The NG sector needs huge investments, especially in production and infrastructure (pipelines). In Brazil, the governments (Federal and states) were not able to obtain all the capital that the sector needed to improve NG use. Consequently, NG share has had and still has a small role in Brazil's energy scenario.

Despite these considerations, Brazilian NG proven reserves have increased year by year. From 1990 to 1996 it rose from 110 billion to roughly 157 billion m³. The reserves are divided into onshore (47%) and offshore (53%). The large onshore NG reserves are in fields in the states of Bahia, Alagoas and Amazonas. The Amazon basin has 28.7 billion m³ of NG proven reserves. All NG reserves, except Urucu and Jurua in Amazonas, are located in Atlantic Coast states, which suggests that Brazil's coasted basins probably contain the major NG reserves. As though to demonstrate this statement, the country's largest NG reserves are located offshore in the Basin of Campos/RJ, with 62 billion m³ (1996) representing about 40% of total NG proven reserves, and in the huge field of Merluza located in the state of Sao Paulo. The south and southeast regions (states of Rio de Janeiro, Sao Paulo and Parana) have the largest prospects of new discoveries, and basically in offshore fields.

Regarding the Brazilian Government efforts to open hydrocarbon exploration and production to domestic and foreign private enterprises (including joint venture with PETROBRAS), the resulting discoveries could add a further 150 billion m³ to known reserves.

According to the PETROBRAS Investment Plan - 1996/1999, about US\$ 5.1 billions will be invested in exploration and production activities in 1998 and 1999. This amount can be enlarged through joint ventures with others companies. In fact, according to PETROBRAS, there are more than 60 domestic and foreign companies interested in exploring Brazil's sedimentary basins in association with PETROBRAS. This company will continue to explore by itself 4.7% of the sedimentary basin area, it will explore 6.9% in joint ventures with the companies, and exploration rights to 88.4% will be auctioned off to domestic private and foreign companies by the new oil and NG regulatory agency.

		PETROBRAS INVESTMENT PLAN				
		1996	1997	1998	1999	TOTAL
	Exploration	483	363	785	843	2,474
	Production	1,063	727	1,575	1,933	5,298
	Refine	593	535	1,139	1,209	3,476
	Storage and Pipelines	307	582	496	377	1,762
	Offshore Transportation	56	5	42	27	130
	Others	335	294	166	174	969
	Total	2,837	2,506	4,203	4,563	14,109

Source: PETROBRAS S.A.

Brazil's NG production increased roughly 46% between 1990 and 1996, rising from 6.3 billion to about 9.2 billion m³, 64% of which was offshore. Major state producers in 1996 were Rio de Janeiro with 3.6 billion m³, Bahia with 1.7 billion m³, Rio Grande do Norte with 954 million m³ and Alagoas with 643 million m³.

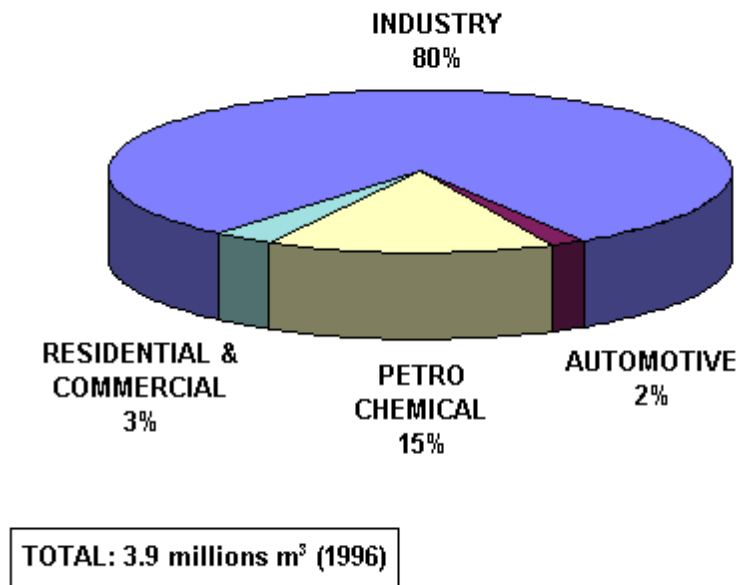
Almost US\$ 3.5 billion will be invested in production development during 1998 and 1999. It is expected that NG production will increase by about 65%, reaching 15 billion m³ per year, by the year 2000.

III - BRAZIL'S NG UTILIZATION, CURRENT AND FUTURE DEMAND

The total NG production in 1996 was about 9.2 billion m³, but only 3.9 billion were commercialized, 1.6 billion were re-injected in wells, 1.6 billion were lost or flared, and the rest was utilized in PETROBRAS' own power generation systems.

The 3.9 million m³ of NG commercialized was used as follows: 80% for industries, 15% for petrochemicals, 2% for the automotive sector, and 3% for residential and commercial sector.

NG SALES - 1996



Source: MME

Due to the oil crisis and to the necessity of reducing outlays for imported oil, the government sought to maximize domestic oil production. Consequently, NG production and consumption was not stimulated but rather was developed only in association with oil production. This fact explains, in parts, why Brazil does not have a tradition of large NG consumption.

Projections of Brazil's future NG demand have to take into account the availability and price of competing energy sources. In the residential sector, NG competes with electricity and LPG. In the automotive sector, NG competes with diesel oil, gasoline and alcohol. In the industrial sector, the important competitor of NG is fuel oil used in furnaces and boilers. However, environmental pressures will discourage small and medium industries from using polluting high sulfur fuel oil - HSFO. For large industries and thermal power plants equipped with environmental equipment, high-efficiency combined cycles NG plants, which minimize environmental harm, will have some advantage.

NG Power Plant

ELETROBRAS' National Electric Energy Expansion Plan for 1996-2005 recognizes the risks of electricity shortage due to insufficient investments in the last 10 years, and the necessity of a new regulatory framework that could attract private investments. Over the next 10 years, it will be necessary for thermal power generation to account for a larger share of energy output as an alternative to hydroelectric generation.

In 1996, the installed capacity of Brazilian electric power generation was 58.2 GW, 91% of them produced by hydraulic energy and the rest by thermal. By the year 2006, it is projected that Brazil's installed electric power capacity will be of 89.3 GW. At that point, thermal energy will be responsible for 14.3 GW, an increase from 9 to 16% of its share in installed electric power capacity.

NG, currently not used to produce electricity in Brazil, will be responsible for the biggest part of the increased generating capacity in 2006. It is projected that NG thermal plants will account for 5,146 MW, with 890 MW in the northern region of the country, 800 MW in the northeast, and 3,456 MW in the south, southeast and central-midwest regions. Those plants will consume 50 million m³ of NG provided by domestic and foreign sources.

Automotive use

NG is being used as an automotive fuel worldwide. There are more than 1 million vehicles using NG as fuel in some 47 countries. In 1996, the USA had 30,000 vehicles using NG, Canada had 39,000, and Italy had almost 300,000. In Japan there were only 1,200 NG powered vehicles, but the government's goal is 200,000 NG powered vehicles by 2000. In all the countries named, the reasons for using NG are: adequate use of natural resources, environmental benefits, increase of NG share in the energy matrix, and economic advantages (competitive price of NG). One of the most successful program is that run by Argentina. There are about 390,000 NG powered vehicles and 500 NG stations scattered around Buenos Aires and other major cities.

The first Brazilian experience using NG dates from 1988, but the commercial use of NG started only in 1992. Nowadays, it is estimated that there are about 14,000 vehicles capable of using NG or other fuel (gasoline or alcohol). Most of them have an intensive use, like taxis and light commercial vehicles. However this fuel has a huge potential market and can be used in any vehicle. The NG vehicle's limited autonomy, the heavy NG storage cylinder tank, the small numbers of NG station (39), and the confusion with LPG (that is prohibited for use as an automotive fuel) have a negative affect.

The major objective of the Brazilian Government is to stimulate a change from diesel oil consumption to NG. The reasons are the deficit of domestic diesel oil production, requiring large imports, and the environmental problems faced in large, polluted cities. The city of Sao Paulo began a program that determine that will replace all diesel oil powered urban buses (11,000) by NG by 2007. It is an audacious program, but reflects both the viability of NG as a competitive fuel and the importance of environmental concerns.

Industrial use

Basically, NG will have to create its own market. In fact, there are some applications, as in the ceramics industry, where this energy will penetrate readily, especially given the environmental pressures. NG will do so by displacing fuel oil. Although NG is not expected to displace all fuel oil, it can represent more than half of the total industrial NG market. So, PETROBRAS will have to find a way to use the residual fuel oil. The main problem is the "bottom of the barrel," heavy oil that is commonly incorporated into the fuel oil pool. It has to find the best solution for using or transforming excess residual fuel oil into other high value-added products (diesel oil, gasoline and LPG), because fuel oil exports is not a good business. The solution may be the installation of high severe cracking conversion units, but that will take huge investments.

Urucu NG Project

The Urucu and Jurua regions are located about 700 km west of Manaus, Amazonas. There is a considerable oil reserve that produced 1,1 million m³ in 1996. But mainly, there are huge NG reserves (73,8 billion m³, including

proven, probable and possible).

The NG Solimoes basin project will supply the electric energy demand of the Amazon region. Basically, the NG produced by the Jurua reserves will be transported to the Caruari region (state of Amazonas) and will be used in power generation plants. The NG produced in the Urucu field will be transported by pipeline to Coari/AM. Then, NG will be liquefied and transported by barges and small ships to Manaus/AM, Porto Velho/RO, and Macapa/AP, where it will be turned back into gas and used in modern combined power generation plants.

The current electric energy generation capacity of the Amazon region is about 5,760 MW, of which 80% is hydroelectric and 20% is thermoelectric. The annual expenditures to generate this electricity are about US\$ 200 million. The ELETRONORTE NG demand forecast for the power plant in the northern region is 4.1 million m³ per day in 1999, 9.2 million m³ in 2005 and 15.7 million m³ in 2010. That company estimated also that it will be necessary to have 3,087 MW of thermal power generation plant by 2010.

This project will benefit more than 627,000 inhabitants of the northern region. It will have the following major benefits: development of NG exploration and production activities in the region, including infrastructure (ports, river navigation, etc.); modularity of the project that allows an increase of capacity according to electric energy demand; possibility of private enterprise participation; and environmental benefits by substituting diesel oil and fuel oil.

The investments needed for this project will reach US\$ 1.7 billion in NG processing and transportation, and US\$ 3.2 billion in power generation plant and other electrical infrastructure. The estimated cost for electricity supplied by using NG is US\$ 58/MWh, i.e., lower than the current price (above US\$ 100/MWh).

IV - THE NG TRANSPORTATION SYSTEM

The localization and the nature of the reserves are determining the structure of the NG infrastructure. Due to the high cost of compression and transport, the basic recommendation is to encourage NG use close to the production fields. Based on this principle, there are 69 NG pipelines in operation (59 onshore and 10 offshore) organized into 5 separate production and transport systems along the Atlantic coast: Ceara system, Rio Grande do Norte/Paraiba/Pernambuco system, Alagoas/Sergipe/Bahia system, Espirito Santo system, and Rio de Janeiro/Sao Paulo system.

The Rio de Janeiro/Sao Paulo system links the offshore fields of Campos/RJ and Santos/SP to Rio de Janeiro and Sao Paulo through a 945-km pipeline. There is also a connection to Belo Horizonte that is known as the Reduc/Belo Horizonte pipeline of 356 km. CEG in Rio de Janeiro, GASMIG in Belo Horizonte and COMGAS in Sao Paulo distribute the NG production of the Campos reserves. The Santos basin Merluza field was set up in 1993 to provide additional supplies to Sao Paulo.

The Espirito Santo system comprises 168 km of onshore pipeline that connects the Sao Mateus reserves to Vitoria. Perhaps its largest consumer is the Tubarao mining and steel industry.

The Alagoas/Sergipe/Bahia system begins in the state of Alagoas and delivers NG to Alagoas, Sergipe and Bahia through a 400-km pipeline. These three states are NG producers.

The Rio Grande do Norte/Paraiba/Pernambuco system is about 654 km long and transports NG from the offshore fields in the state of Rio Grande do Norte to Recife/PE.

The Ceara system has a 56-km onshore pipeline to transport NG in the Fortaleza area. This is a small pipeline with limited perspectives of expansion.

There is under construction the 194 km Pilar/Cabo pipeline that will connect the Alagoas/Sergipe/Bahia system with the Rio Grande do Norte/Paraiba/Pernambuco system, the 377 km Guamare/Fortaleza pipeline that will transport NG from the Rio Grande do Norte fields to Fortaleza/CE, and the Urucu and Jurua NG pipelines. Although these projects represent an important contribution to raising Brazil's NG consumption, the most

important one is the 3,400-km Bolivia/Brazil pipeline from Corumba/MS to Porto Alegre/RS, with a transport capacity of 30 million m³ per day. One must consider also the 580-km Uruguaiiana/Porto Alegre pipeline that will transport NG imported from Argentina. This system will supplement the NG provided by the Bolivia/Brazil NG pipeline.

V - EXTERNAL SUPPLY OF NG

Matching Brazil's NG future needs

The Brazilian studies of fuel demand indicate an increase in diesel oil, LPG and gasoline consumption. The consumption of fuel oil would also increase if NG were not available. In fact, the demand for fuel oil will be stable until 2000 because it takes time and investment to change industries' fuel requirements. However, increasing environmental concerns will depress the use of fuel oil, charcoal, firewood and coal in industries without gas exhaust treatment systems.

These studies included detailed programs of visits and estimates of conversion costs for industrial network expansions and the current costs of NG and competing fuels. Taking into account import price parity of competing fuels, industrial sector demand for NG by the year 2000 in the south and southeast regions will reach about 20 million m³ per day. This demand does not include an additional increase caused by industrial growth, expanded use of NG as feedstock, and more NG used in power generation.

Recent studies carried out by ELETROBRAS confirmed the economic viability of new gas-fired power generation in the south and southeast regions of Brazil. Due to delays in building hydropower plants, thermal generation is the only option, in the short run that could be implemented in time to avoid the risk of electric energy shortage.

There are large differences in various Brazilian projection of NG's share of the national energy profile. These differences reflect the fact that the NG penetration of individual sectors will depend on the price policies of competing fuels. This applies to the future co-generation market, which will be affected by the electricity price, and to the new market of NG as an automotive fuel, which is related to the price of gasoline, alcohol and diesel oil.

Regarding the southern and southeast forecast of energy demand, which encompasses the largest energy demand states, NG will be economically strategic because it can offer an energy supply for about the same price as one competing fuel (fuel oil) and lower than other alternatives. For this market, the importation of NG will be a viable and interesting alternative.

Importing from Bolivia, Argentina and Peru

Projections indicate that the domestic production of NG will not be sufficient to match future Brazilian demand. It will be necessary to exploit an external supply of NG. In the long run, additional NG could be obtained from the production of new discoveries, but currently, Bolivian NG imports seem to be one of the best available alternatives. Additional imports from Argentina, Peru and, as LNG, Venezuela or Africa would be feasible in the future.

In order to confirm Bolivian NG reserves for export to Brazil, an international consulting company performed an independent reserve certification study. The results are that, even taking into account Bolivia's own NG uses, the reserve volume could provide the 105 billion m³ needed to meet the contracted amount. The consulting company analyzed data from the 33 largest Bolivian fields that represent about 95% of known reserves (proven, probable and possible). There are great expectations about Bolivia's potential NG exportation capacity because less than 20% of the country has been explored.

Total Argentine NG reserves were estimated, in 1995, at 827 billion m³ (proven, probable and possible). Of these, 15% is located in the northwest basin, 53% in the Neuquina basin, and 32% in the Austral basin. The

northwest fields are well located to supply southern Brazil, leaving other regions to supply the domestic market. In fact, Brazil and Argentina have signed a 20 years contract to supply 2.5 million m³ in order to help satisfy southern Brazil's NG needs. The necessary pipeline will be 580 km long within Brazil, running from Uruguaiana/RS, through Alegrete/RS, Santa Maria/RS, Santa Cruz do Sul/RS to Porto Alegre/RS.

Concerning the potentially huge increase in NG demand, Brazil has started negotiations with Peru in order to import NG from the Camisea reserves. Peru's current proven reserve is about 300 billion m³. In the future, it may be feasible to construct a pipeline that would connect to the Bolivia/Brazil pipeline.

Importing LNG from other countries

LNG imports may become an attractive option in the medium and long run, even though the final price would be higher than that other options (domestic production and Bolivia and Argentine imports). They would be an important alternative to be used in some Brazilian markets along the coast, especially during in peak load periods.

VI - THE BOLIVIA-BRAZIL NG PIPELINE

The Project

After almost 30 years of negotiations, the Bolivian and Brazilian Governments signed in Cochabamba, Bolivia, on February 17, 1993, a contract for importation of Bolivian NG into Brazil.

According to the 20-year contract, the pipeline will supply the nation's central-west, southern and southeast NG markets. The contract specifies a volume of 8 million m³ per day initially, increasing progressively to 16 million after eight years of operation and remaining at that level for the rest of the agreement. In 1994, the two countries signed an addendum (Transport Capacity Option - TCO) to the contract authorizing the transport of an additional 6 million m³ per day.

This 3,150-km pipeline (557 km in Bolivia and 2,593 km in Brazil) has an estimated cost of US\$ 1.7 billion. It is projected to transport a maximum of 30 million m³ per day. Due to the huge investment needed, two transport companies were formed, with state and private share. PETROBRAS and its partners formed a transport company (Transportadora Brasileira Gasoduto Bolivia/Brasil S.A. - TBG) that will be responsible for construction and operation of the pipeline in Brazil. On Bolivian side, responsibility will fall to another transport company formed by ENRON, Shell, Transredes and the

TGB partners. The financial resources will be provided by financial institutions like the IDB, IBRD and BNDES, and by shareholders.

In order to guarantee the correct level of pressure during transportation, sixteen compression stations will be built along the pipeline, four in Bolivia (Izozog, Chiquitos, Robore, and Yacuses) and twelve in Brazil (Albuquerque, Guaicurus, Anastacio, Campo Grande, Mimoso, Rio Verde, Mirandopolis, Penapolis, Ibitinga, Sao Carlos, Araucaria and Biguacu). Four stations will be set up to measure the NG, two in Bolivia (Rio Grande and Mutum) and two in Brazil (Corumba and Paulinia). Thirty city gates will be installed spread throughout Mato Grosso do Sul, Sao Paulo, Parana, Santa Catarina and Rio Grande do Sul in order to measure and deliver NG to state distribution companies.

All pipeline operation and supervision activities will be managed by two control centers, one on the Bolivian side located in Santa Cruz de La Sierra, and one on the Brazilian side located in Rio de Janeiro. Using satellite communications, the entire system will be operated and monitored from these two points.

Connection with PETROBRAS' network

The pipeline route will be from Rio Grande in Bolivia to Campinas via Campo Grande in Brazil, and then to Curitiba, Florianopolis and Porto Alegre. This NG project includes a link to the Rio de Janeiro/Sao Paulo NG pipeline, thereby making it possible to supply both domestic (Campos and Santos basins) and imported NG.

The pipeline will cross the Rio Grande river in Bolivia and Brazil's Paraguay, Parana and Tiete rivers. Roughly 70 km will pass through the Mato Grosso do Sul flood plain. It will traverse about 4,000 properties spread over 122 counties.

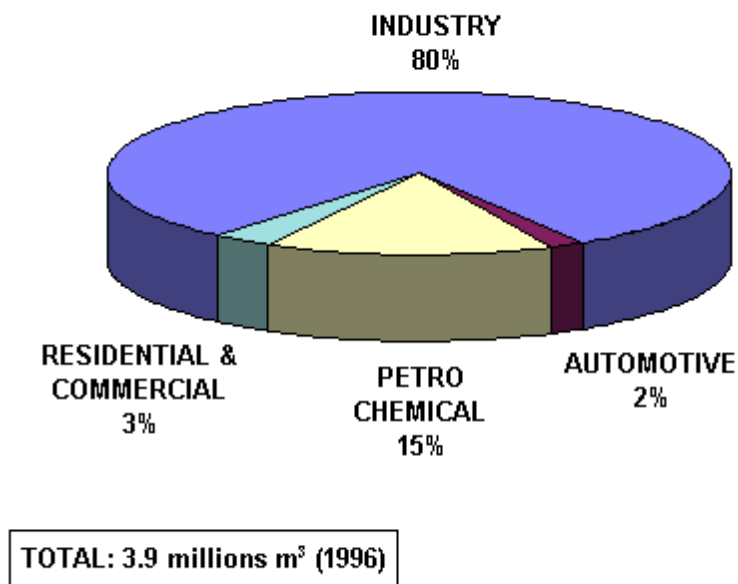
Impact in the States

Demand studies have focused on the regions that are going to be supplied by imports of Bolivia's NG, in particular Sao Paulo, Rio de Janeiro and Minas Gerais, but also Mato Grosso do Sul, Parana, Santa Catarina and Rio Grande do Sul.

Although the Bolivia/Brazil pipeline is scheduled to reach Porto Alegre only in July 1999, there are already NG companies in the southern states (COMPAGAS in Parana, SC GAS in Santa Catarina and SULGAS in Rio Grande do Sul). Contracts have already been made between them and PETROBRAS in order to guarantee their NG supply. There are also other alternatives for NG supply. According to some studies, the Coral, Estrela do Mar and Tubarao fields, located in the Santos basin, could provide commercial quantity of NG to Santa Catarina/SC and Curitiba/PR via pipeline.

The involved states carried these studies out, taking into account industrial, residential, commercial, transport, power generation and co-generation sectors demand. The studies showed a large future industrial NG demand. The potential NG demand is summarized in the next table. These data were based on macroeconomic growth expectations without considering low-value markets and consumers located far from the pipeline route. They show NG demand increasing from 18 million m³ per day in 1995 to about 44 million by 2000, and to 66 million by 2005.

NG SALES - 1996



Source: MME

According to information from ENERSUL, Mato Grosso do Sul's NG distribution company, NG imported from Bolivia will supply the industrial market of Corumba, Bodoquema, Campo Grande and Tres Lagoas. The distribution pipeline system will extend 156 km and is estimated to cost about US\$ 22 million. For the power

generation sector, it is planned the construction of at least two thermal units (one of 150 MW in Corumba and another of 300 MW in Campo Grande) that will consume about 2 million m³ per day of NG.

The state of Sao Paulo is the largest NG consumer in Brazil and, by the end of this century, it will reach 14.6 billion m³ per day (82% in the industrial sector). In fact, according to the recent law n^o 9477/97, all the polluting industries have 120 days either to modernize their gas exhaust treatment systems or to change the fuel for another with less polluting potential. This is considered a great push to increase the consumption of NG. In the automotive sector, there is a law that obliges the conversion of all diesel oil powered municipal buses to NG by 2007. The construction of 1297-km NG distribution pipeline, costing about US\$ 320 million is also planned.

According to studies carried out by CEG and RIOGAS, the two Rio de Janeiro NG distribution companies, the industrial sector will continue to be the largest consumer. These studies foresee the possible displacement of competing fuels (50% of current fuel oil customers, 100% of the cement industry and 40% of firewood users in the ceramic industry). In the Resende and Porto Real areas, industrial NG consumption is expected to reach some 150 thousand m³ per day. Nowadays there are two small power plants in Rio de Janeiro (Santa Cruz and Roberto Silveira). It is expected that two 400 MW NG power plants, with a consumption of 2 million m³ per day each, will be installed.

The Minas Gerais NG distribution company, GASMIG, will increase its sales from today's 850 million m³ per day to about 3.5 million m³ by 2002. This is a projection that will cost about US\$ 100 million. The majority of this increase will be due new consumers. In fact GASMIG has 29 existing consumers and 22 contracted, but is waiting for a connection with GASMIG's pipeline network. GASMIG's studies project a NG pipeline network expansion of 360-km (Itauna, Vale do Aco and Tronco Norte), that will cost about US\$ 97 million and represent a potential demand of 1.1 million m³ per day by 2000. This demand could grow to 1.5 million m³ per day if the local cement industries were induced to use NG.

Parana has a potential demand of 3,5 million m³ per day (without considering power generation), of which 2.3 million will be in the area served by the Bolivia/Brazil Pipeline (Curitiba and Ponta Grossa). It is estimated that the 300-km NG pipeline distribution network in these two cities will cost US\$ 70 million. Two power generation plants are expected to be built, one of 300 to 380 MW in Curitiba region and another one of 500 MW that will use Argentine NG.

It is expected that 2.3 million m³ per day of NG will be consumed by about 100 industries located in the Santa Catarina's coast by 2005. It represents almost 50% of total potential demand of Santa Catarina. To supply this market, a 300 km pipeline network will be constructed at a cost of about US\$ 70 millions. The major consumption sector in the state of Santa Catarina will be the ceramic industry, responsible for 1.2 million m³ per day. The western region of the state is considered to be a very attractive market as there are huge cold cuts companies like Perdigao and Sadia with a potential market of 1.5 million m³ per day of NG. Beyond that, the state distribution company SC GAS and the state electric company CELESC are evaluating a 250 MW power generation plant to be constructed in Joinville.

The state of Rio Grande do Sul NG distribution company SULGAS commercializes about 70 thousand m³ per day of residual gas to four companies located in Canoas, Sapucaí do Sul and Esteio. However, there are almost 100 enterprises spread throughout 35 counties of Serra Gaucha and Porto Alegre, representing a potential NG demand of 5 million m³ per day. In the southern and eastern regions of the state, a new 350 MW Power Plant is anticipated between Porto Alegre and Caxias and a 450 MW Power Plant in Uruguaiana that will absorb 5 million m³ per day of NG. Gerdau Industries is studying the installation of a 700 thousand m³ per day NG steel industry in Uruguaiana.

VII - OTHER COUNTRIES' EXPERIENCES

Argentina

The Argentine NG industry is divided into production, transportation and distribution. A company cannot own more than one NG company. The prices are not controlled. The regulatory agency, Ente Regulador del Gas - ENARGAS has the duty of protecting consumers, promoting competition, guaranteeing open access, and ensuring non-discriminatory tariffs. Cross subsidies are forbidden and tariffs are adjusted in accordance with the US producer price index. There are several producers (YPF, Total Austral, Brides, etc.) and the price between them and distribution companies is uncontrolled. The transportation industry is divided into two companies that are not allowed to buy or sell NG, the government regulates their tariffs, and uninhibited access to them is guaranteed. There are 8 distribution companies that are partially controlled by ENARGAS (tariffs). Although they hold a regional monopoly, large consumers are permitted to buy NG directly from producers.

United Kingdom

About 30 companies are authorized to supply NG in the UK with prices uncontrolled. The NG transport activity is a natural monopoly and is held by BG, which was privatized in 1986. Trasnco (a BP subsidiary) owns the distribution network. Apart from BG, there are customers who own and operate pipeline systems in a defined area and independent NG suppliers that use BG pipelines (open access) at partially controlled tariffs. The regulatory agency, Office of Gas Supply - Ofgas, was created by the Gas act of 1986. In 1995, amendments (Gas Bill) were published in order to introduce competition into the domestic market, especially in the residential sector. The UK NG industry can be characterized by strong competition in the industrial sector and an increase in the small consumer market, with a small bureaucracy (small regulatory body).

United States

At the production level, there are thousands of producers, but five companies supply about 50% of total NG production. NG is transported through 23 major and 55 minor interstate pipeline systems. The NG distribution industry has about 1600 local distribution companies organized by region. At the federal level, there is the Federal Energy Regulatory Agency - FERC that controls the prices and tariffs of producers and

transporters, the price setting rules for consumers, and the construction of inter-state pipelines. It sets maximum and minimum transportation rates on open-access pipelines. The state regulatory agencies, Public Utility Commissions, control the local distributors' activities and the construction of state pipelines.

In recent years, anti-trust policies were introduced to improve competition in the transport sector and to guarantee open access. However, there have been difficulties in defining whether it is economically feasible to duplicate facilities (pipeline) and whether open access is feasible.

France

The mixed ownership company Elf carries out the NG production activity. However, most of the supply is imported, under a legal monopoly, by the state-owned enterprise Gas de France - GdF. This company and Societe Nationale des Gaz du Su-Ouest - SNGSO have the right to transport NG. The distribution is carried out by municipalities or under state or local authority concessions to public or private entities. For the most part, GdF carries out NG transportation and distribution. The body responsible for supervision of supply conditions and prices is the Ministry of Economy, Finance and the Budget, but the Ministry of Industry carries out the supervision of the NG industry. For non-household consumers, the contract may require the continuous provision of NG or it may permit an interruption.

Italy

Agip and Societa Petrolifera Italiana provide domestic NG supply. But the most of the supply is imported. There is no NG import restriction (no monopoly), but SNAM has the exclusive right to construct and operate pipelines for the transportation of hydrocarbons produced in Italy. All these companies are subsidiaries of Ente Nazionale Idrocarbon - ENI. The distribution activity is carried out by Italgas Societa (subsidiary of SNAM), Italiana Perial Gas (mixed ownership), and local distribution companies. The pricing of NG by SNAM for distributors is subject to government intervention through the Comitato Interministeriale della Programmazione Economica -

CIPE and the price control function is delegated to Comitato Interministeriale Prezzi - CIP. Law no. 9 introduced wider access to the existing network, though new entrants will have to build their own pipelines.

VIII - BRAZIL'S NG REGULATION AND LEGAL ASPECTS

Constitutional Aspects and Amendments

Brazil's Federal Constitution of 1988, in Article 177, granted to the federal government the monopoly of the following activities: exploration and production of oil, NG, and other fluid hydrocarbons; refining of domestic and imported oil; import and export of derivatives of the activities listed above; and maritime and pipeline transport of oil, its derivatives and NG. This monopoly was first instituted by Law

no. 2004/53, which also granted to PETROBRAS the exclusivity of execution of the oil and NG monopoly activities. Constitutional Amendment no. 9, enacted on November 09, 1995, kept the oil and NG monopoly, but permitted that Federal Government to contract state-owned and private companies to handle the activities subject to this monopoly. Related to this issue, Law no. 8987 of February 13, 1995 - Concession for Public Services - established that all concessions for public services must be granted through a bidding process.

According to Article 25, Constitution 1988, local services of NG distribution are a monopoly of the states, which might perform them directly or might concede them to a state company. Constitutional Amendment no. 5 of August 15, 1995, kept the competence of the states, but now allows them to concede the NG distribution activity to state-owned and private companies.

Law 9478/97

On August 6, 1997, the new Law of Hydrocarbons no. 9478 was enacted. It deals with national energy policy, treats activities related to the petroleum and NG monopoly, and creates the Conselho Nacional de Politica Energetica - CNPE and the Agencia Nacional de Petroleo - ANP.

The first Chapter, discusses Brazil's policies regarding the rational utilization of energy sources, which includes the protection of consumer interests and, the environment; the guarantee of oil products and NG throughout the country; and the promotion of NG use on an economical and freely competitive basis.

The CNPE, linked to the Presidency of the Republic, was created with the responsibility of proposing national policies and specific measures destined to: promote the rational utilization of energy resources; assure the supply of energy inputs to remote areas of the country; submit to the National Congress special measures that imply subsidies; review the energy matrix; set directives for specific programs, such as the use of NG; establish directives for importation and exportation; and assure the adequate functioning of the National System of Fuel Stocks and compliance with Annual Plan of Strategic Fuel (Law no. 8176/91).

Chapter IV created ANP as an autonomous federal regulatory body for the fuel sector. Its purpose will be to promote the regulation, contracting and surveillance of the oil and NG industry, but also for such other fuels as alcohol.

ANP will manage the bidding process for the concession of exploration, development and production contracts in Brazil's sedimentary basins. PETROBRAS will transfer to ANP information and data on Brazil's sedimentary basins and on oil and NG exploration and production activities carried out under its prior monopoly. It will authorize any enterprise constituted under Brazilian law that meets the technical, legal and economic requirements established by ANP to construct, operate and expand refining, processing and transportation plants and to import and export oil, its derivatives and NG. ANP will take over the responsibilities of the Departamento Nacional de Combustiveis - DNC, related to the activities of distribution and retail sale of oil derivatives and alcohol. It will guarantee the open access to transportation pipelines and maritime facilities, existent or to be constructed, in return for adequate remuneration.

During a 3-year transition period, according to Law no. 9478/97, Ministers of Finance and Mines and Energy will accomplish price adjustments for oil products and NG. During this period, Brazil's government is going to implement the following measures: the oil derivative prices will be set at parity with international market prices; the LPG subsidy will decrease gradually; the fuel oil freight tariff will reflect distances from refineries to distributions bases; the price of anhydrous alcohol will stay uncontrolled and the price of hydrated alcohol will be free by the transition period dead-line; the NG price to distribution companies will have to be based on acquisition cost plus transport tariff; and by the end of transition period, prices of all fuels will be regulated only by market forces.

IX - PRICE ANALYSIS OF NG AND COMPETING FUELS

The price policy of NG is proposed by DNC and determined by an legal act of the Ministry of Finance. Bulk supply price from PETROBRAS to the distribution companies have been fixed by this system. In order to make NG competitive in Brazil's market, there is a DNC Act no. 24, edited in June 1994, determining that the domestic NG price, from PETROBRAS to distribution companies, has to obey the parity of 75% of the HSFO price. Until 1996, this price remained at about US\$ 2.5/MMBTU. State authorities (Article 25 of Constitution) have set the retail prices from distribution companies to consumers. But, since beginning of the "Real" Plan in 1994, the price is under control of Federal Government.

The fixed price of NG must take into account all the costs of the NG industry. It seems that the best way to deal with the issue is to separate it into three basic levels: exploration and production, transportation and distribution. At each level, the tariffs or prices need to be defined and should cover the fuel cost of each activity.

At the first level, the prices of imported NG and domestic NG have to reflect all the cost of acquisition, exploration and production. To guarantee the viability of supply and a return on invested capital in the long run, which means forward provisions, they shall have some adjustment parameters as a protection to the sellers (international prices of a basket of fuels) and a take or pay obligation to the buyers.

Brazil's domestic NG production will have to compete with imports from Bolivia and Argentina, according to Constitutional Amendment no. 9 and Law no. 9478/97. The entrance of new producers and importers will create conditions for gas-to-gas competition in a free price market.

At the second level, the price of NG should include both transportation and the bulk price for distributors. The transport activity has the characteristics of a natural monopoly and, therefore, transportation tariffs, which are linked to fixed and high cost investments in infrastructure, should be regulated by an independent agency. This agency should have to guarantee open access to third parties.

The pipeline transport tariffs should have two components: 1) capacity charge that covers the fixed costs in pipeline investment and operation, and reflects long run marginal cost; 2) a variable charge that is linked to the volume of NG transported and represents short run marginal cost. This formula encompasses fuel consumption losses and part of the operating costs.

The domestic NG transport tariff is lower than the cost of Bolivian NG since the distances from the source to the market are much smaller. In fact, the geographic distance is a major component of transport cost. Brazil's Federal Government decided to set a uniform city gate price to all the states along the Bolivia/Brazil pipeline. Considering the cost of acquisition and transportation, NG from Bolivia will cost about US\$ 2.2 MMBTU (US\$ 1.0 acquisition plus US\$ 1.1 transport) along the main trunk line. At this price, NG from Bolivia will be competitive in markets such as Sao Paulo, where the LSFO price is about US\$ 3.8 MMBTU. When compared with HSFO the advantage is not so clear, especially because environmental costs of HSFO are not internalized in its price.

In the industrial sector, NG use is advantageous when compared with diesel oil, LPG, charcoal and firewood due to the high economic cost of those fuels. But when compared with fuel oil, the advantages are not so evident because of fuel oil's low economic cost. The use of NG in furnaces and boilers instead of fuel oil, represents an economy of about 5 to 15% (HSFO), which is not enough to encourage consumers to change their existing fuel

oil supply system. But in large cities, like Sao Paulo and Cubatao, where controlled atmosphere furnaces are required, the economy is greater, which means that environmental constraints will play a decisive role in NG's substitution for fuel oil.

The electric power generation expansion will take a period of time and a larger amount of investment. For these reasons, NG will remain competitive in the long run. The economic value of NG in co-generation is related to electricity costs and to the alternative fuel (fuel oil). Considering the economic cost of electric power expansion above US\$ 40 per MWh, as estimated by ELETROBRAS, co-generation plants will become attractive.

The NG transport tariff and the acquisition cost of NG should be separated. The distributors and larger consumers should pay the full costs of acquisition. Transportation costs should be separated, as transporting companies should not have any participation in the producing companies. This principle has advantages, particularly for large consumers with the option to change to alternative fuels depending on the cost of acquisition and the cost of transportation. Separation of the two components establishes better transparency in terms of identifying price changes, and leads to improved economic efficiency. The NG purchase contracts should contain provisions for protecting the transporting and producing companies, but also the distribution companies. There should be contract duration, volumes, take or pay clauses, and a price revision index.

At the third level, the cost of displacement of competing fuels, as LPG, electricity, diesel oil, gasoline and alcohol, should be considered. But the price of NG at this level should reflect all the costs involved (production, transport and distribution).

NG used for cooking and water heating is competitive with LPG and electricity due to the high value of those fuels. In the residential sector, the cost of distribution is very high due to its small consumption per unit, but even so NG will have a huge penetration considering the high cost of electricity and gradual elimination of the cross-subsidy for LPG. In the commercial sector, NG competes with LPG and electricity for cooking. For water heating the main competitor is electricity. For boilers and furnaces, diesel oil is preferred. Comparing NG with all these competing fuels, it is clear that NG will be able to displace a considerable amount of these fuels.

Although the automotive sector represents only 2% of Brazil's total NG consumption it is a high value for NG when it replaces gasoline and alcohol. But when used as fuel in buses in substitution for diesel oil, the netback cost is low due to the lower price of this fuel. Nevertheless, the expected environmental constraints will increase the attractiveness of NG.

The economic benefit of NG, compared to competing fuels, becomes evident when one considers environmental constraints imposed on industry and vehicle emissions. In order to compute environmental benefits of NG in its comparative price, a tax could be imposed on all fuels according to their polluting potential. This action would impose a penalty on dirty fuels like fuel oil and diesel oil, and would promote the use of

NG. There are several countries that imposed an environmental tax on fuels, which includes carbon dioxide and sulfur taxes on oil. But, as matter of fact, it also can be imposed on gasoline and diesel oil.

X - CONCLUSION

Brazil's experience with gas started in the XIX century, but its use has not been widespread, maybe due to the Brazilian Federal Government policy that always stimulated crude oil production. The fact that there are not huge NG reserves in Brazil also contributed because consumers were not confident of a regular supply of NG. The NG distributors were not motivated to improve their market share by displacing other fuels. The producer, PETROBRAS, was not stimulated to produce more NG as its production was enough (and still is) to match the Brazil's small NG demand.

Now, Brazil is in a hurry to develop more sources of energy as its demand forecast points to an energy deficit. In fact, some energy supply problems have already happened, such as the black-out that occurred in many cities on April 24, 1997.

NG seems to be an attractive alternative option as it suffers a minimum loss in transport (compared with electricity), is low cost compared with competing fuels, and has environmental benefits. Particularly in the case of electric energy, NG has a competitive cost advantage over on hydraulic alternative. Power plants can be readily

installed, consequently their generating capacity can be increased as the energy demand rises.

Besides the competition with others fuels, Brazil is generating the necessary conditions to develop gas-to-gas competition by opening exploration to independent producers to compete with PETROBRAS and by assuring open access to the NG transport pipeline system.

The Government is implementing a new era in Brazil's oil industry. Although the Federal Government monopoly was ratified by the 1988 Constitution, new laws were enacted to allow private sector participation in activities related to the oil industry. Constitutional Amendment no. 9 enabled private sector participation in oil and NG activities. Law no. 8987/95 established that a bidding process must grant all concessions for public services. The new hydrocarbon Law no. 9478/97 was enacted in order to promote competition and to attract private investments in oil industry activities. This law created also the Conselho Nacional de Politica Energetica - CNPE and Agencia Nacional de Petroleo - ANP that will constitute the regulatory body.

This new agency, ANP, to be set up in January 1998, will have to define regulations for the NG sector, including the natural monopoly activities. So ANP will be responsible for promoting competition in the NG supply system. It must enforce the third party access guarantees to port facilities and to pipeline transport systems through adequate tariff payments to the owner of the installation and through the implementation of restrictions on cross-ownership of exploration, production, importation, transportation and distribution activities to avoid hegemony or collusion by one or more companies.

NG has a huge potential market in Brazil, especially if large gas fired power generation and environmental constrains are considered. A power plant is considered to be an important anchor market for NG because it represents a large consumption. This fact is important in giving confidence to the NG market and on attracting new consumers as they realize the benefits of using NG. Another consideration is that a power plant represents a new market, but does not have to displace of competing fuel. Environmental pressures will play a meaningful role in NG penetration of Brazil's energy market, displacing polluting fuels like fuel oil, diesel oil and gasoline.

The elimination of inter-fuel and transport subsidies, but also the restoration of competing fuels prices in international parity is fundamental to the broader consumption of NG. In fact, economic benefits are one of the most attractive factors for potential entrepreneurs.

Brazil's government is now implementing a liberalization program for oil derivatives that compete with NG, eliminating inter-fuel cross subsidies and transport subsidies. This Program represents the Government's effort to consolidate NG as an important fuel in the energy matrix.

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