

4.0 NATURAL GAS SUPPLY

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4.1 OVERVIEW

This section identifies and determines the available options for the supply of natural gas in Venezuela, with particular emphasis on those related to the projects under consideration. The information is contained in the following subsections:

- Overview
- Reserves and sources.
- Transportation pipelines.
- Infrastructure related issues.

The following Table 4-1 summarizes the natural gas supply issues for the GTL plant sites being considered:



Table 4-1 Natural Gas Supply Issues Summary

ISSUE	JOSE SITE	ANACO SITE	GÜIRIA SITE
Gas Reserves (Proven)	Not yet a Production Area.	Anaco District : 26 TCF Anzoategui State: 52 TCF Including Northern Monagas : 92 TCF	Future North of Paria and Orinoco Delta: 13 TCF
Fields	No current producing Fields.	Anaco District Fields (El Roble, Santa Rosa, San Joaquín, Guarío, Soto). Northern Monagas Fields (Jusepin, Santa Barbara, El Furrial, Musipan).	North of Paria (Rio Caribe, Mejillones, Dragon and Patao) Orinoco Delta (Loran, Cocuina and Tajali)
Location		Onshore	Offshore
Type	Associated gas from Anaco hub.	Associated Gas	Non-Associated Gas
Gas Production		Current around 900 MMSCFD. Handles Around 2,200 MMSCFD Including Northern Monagas production.	Expected over 1,000 MMSCFD
Facilities		Existing	Future
Transportation Pipelines	Existing system Supplied from Anaco Hub	Existing supply lines From local fields	Not available yet
Feedstock Availability	150 - 500 MMSCFD	Around 500 MMSCFD	Between 500 and 1,000 MMSCFD
Supply Pressure	400 psig	800 psig	Unknown Yet
Gas Pricing	0.60 US\$/MMBTU	0.50 US\$/MMBTU	Not yet known, but expected to be about 1.00 US\$/MMBTU
Comments	Can support both "short term" and "long term" projects.	Can support both "short term" and "long term" projects.	Vertically integrated Project is being considered. Future LNG plant will probably be located in the northern part of Paria.

4.2 RESERVES AND SOURCES

Until now, Venezuela's vast gas resources have only been used to cover the needs of the oil industry and the internal market. Although the bulk of the gas supply and reserves is associated with the oil production (with petroleum reserves in the order of 75 billion barrels), the country also has significant reserves of non-associated gas (See Figure 4-1). Eastern Venezuela in particular, is currently the country's main gas production source, with the highest potential for further development to cover the increasing internal demand and to enter new export markets.

The GTL projects being contemplated, together with the planned LNG plants and future gas pipeline interconnections to neighboring countries, are part of the new and ambitious plan to expand the gas industry in Venezuela, independent from the oil industry, and to serve as one of the main pillars of development.

Gas reserves, location, production, type and the development stage of the fields, will be addressed in terms of:

- Present situation.
- Future developments.

Fig. 4-1 Venezuela's Gas Reserves

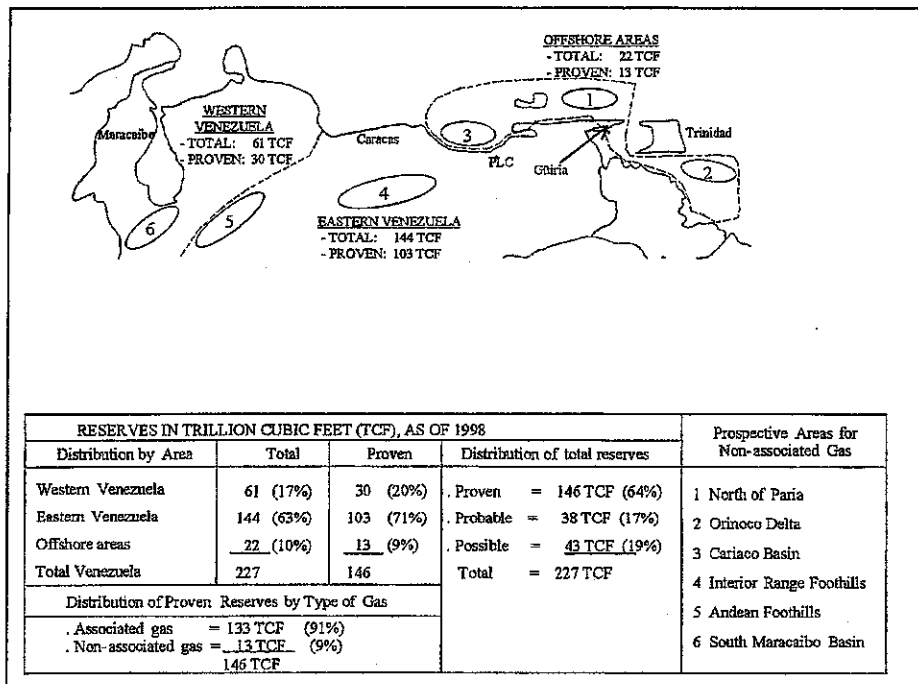
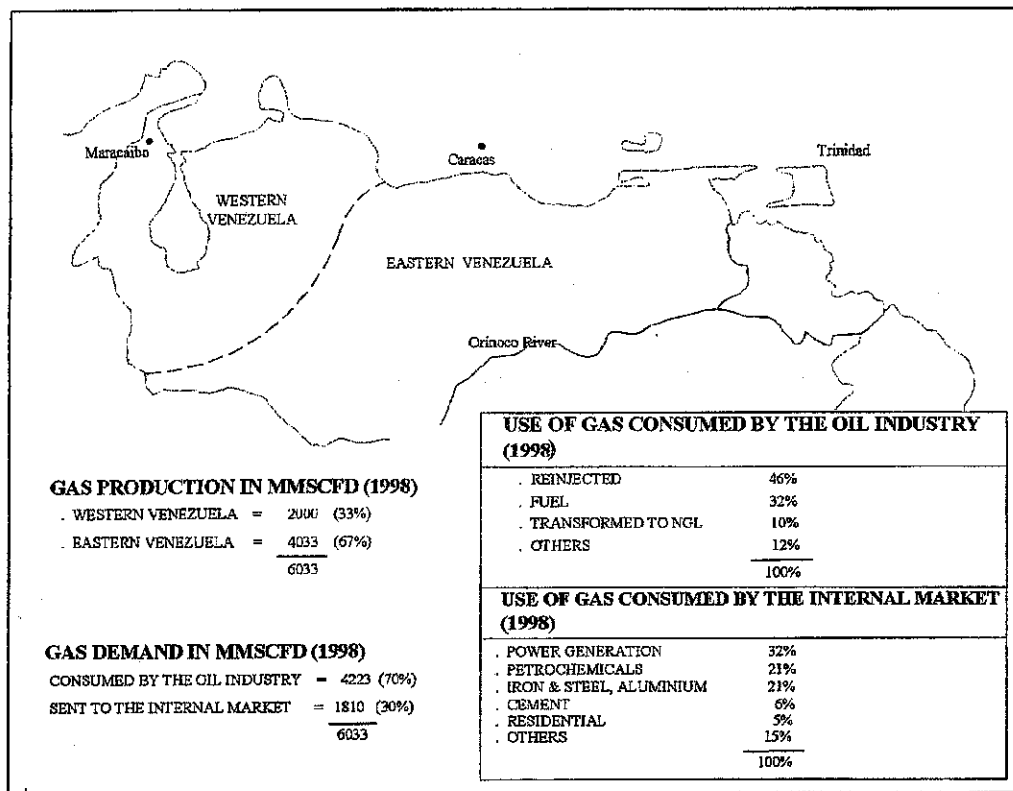


Figure 4-2 gives an overview of the current gas production and demand in the country.

Fig. 4-2 Current Gas Production and Demand in Venezuela

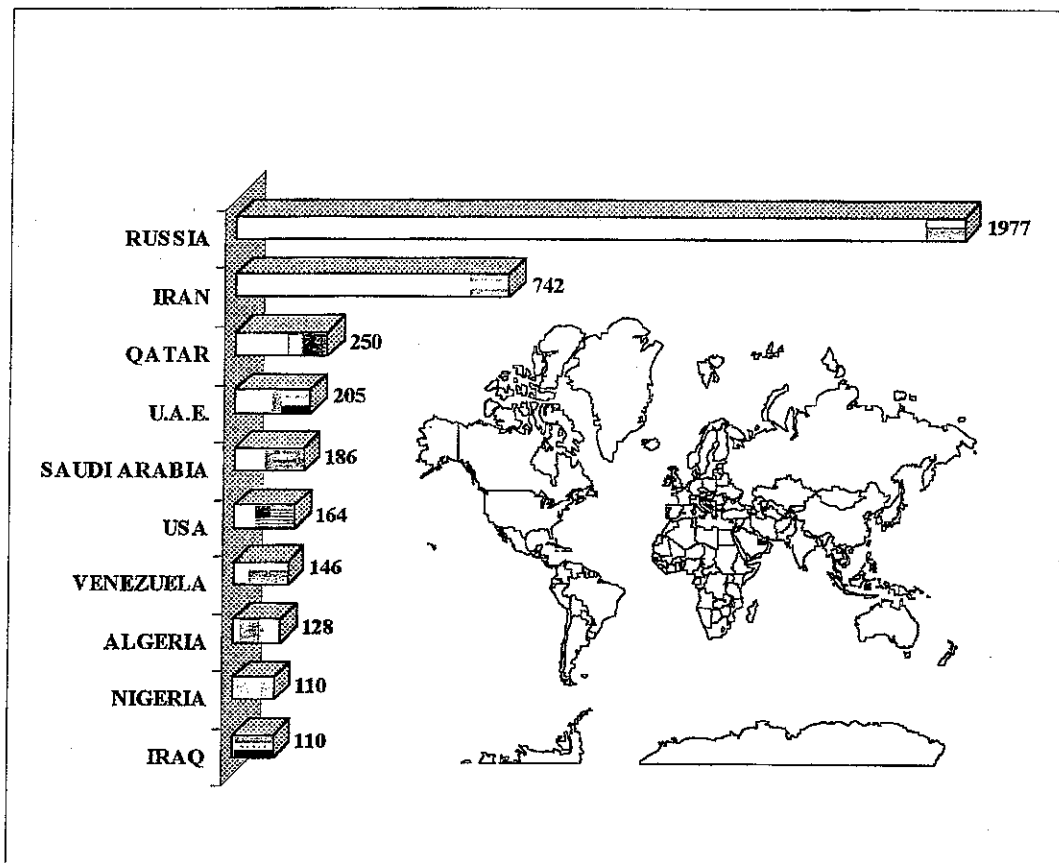


4.2.1 Gas Reserves and Production - Present

- Venezuela's current (1998) proven gas reserves of 146 Trillion Cubic Feet (TCF) rank as the seventh largest in the world and first in Latin America. In comparison, the US (ranked sixth) has proven reserves of 164 TCF and Algeria (ranked eighth), has proven reserves of 128 TCF (See Figure 4-3).
- The estimated total reserves (including proven, probable and possible) are in the order of 227 TCF, with the following geographical distribution (See Figure 4-4):

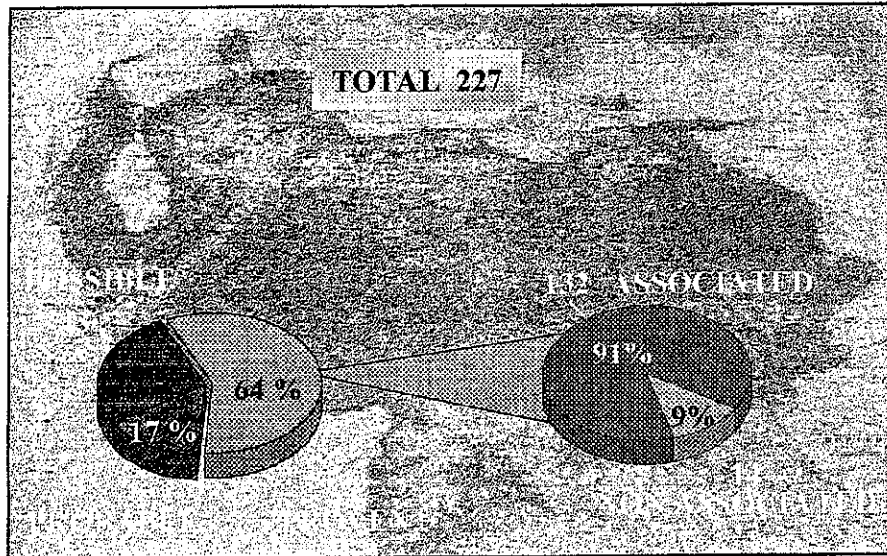
Western Venezuela	: 61 TCF
Eastern Venezuela (onshore)	: 144 TCF
Offshore	: 22 TCF
<hr/>	
Total Reserves	: 227 TCF

Fig. 4-3 Probable Reserves of Natural Gas in the World (TCF)



- Of the proven reserves (146 TCF), around 91% (132 TCF) correspond to gas associated with oil production, and 9% (13 TCF) to non-associated gas (See Figure 4-4).

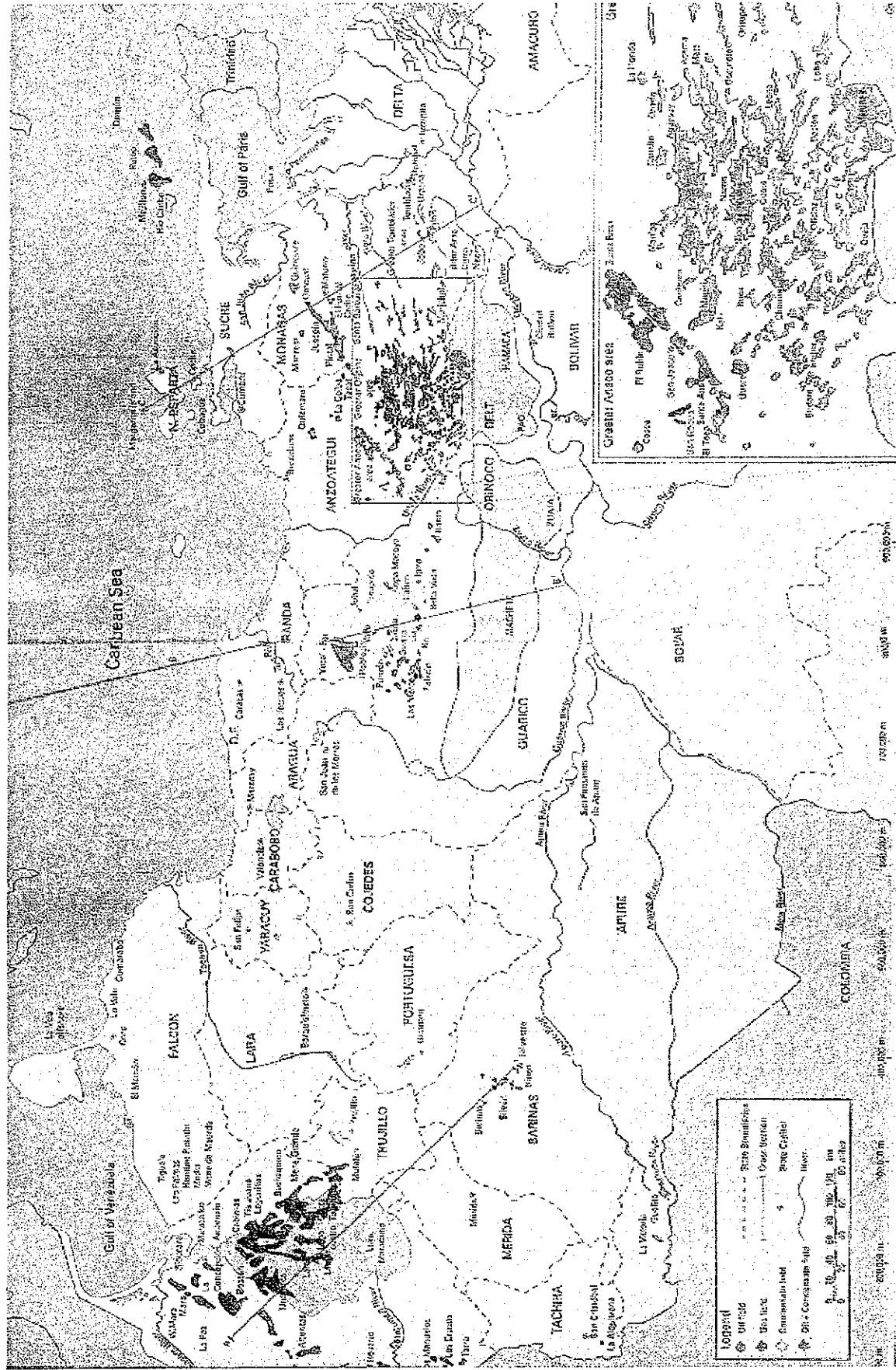
Fig. 4-4 Venezuela's Natural Gas Reserves (1998) TCF



- The reserves in Western Venezuela are mainly centered around the Lake Maracaibo basin, being mostly associated gas, with some gas condensate fields south of the Lake and the offshore La Vela area (both still being explored). The proven gas reserves are in the order of 30 TCF, and the produced gas is consumed in the surrounding area and the Paraguaná refineries, which are gas-deficient. Western Venezuela's gas infrastructure is not yet interconnected to the rest of the country (See Figure 4-5).
- The bulk of the onshore reserves in Eastern Venezuela are in the form of associated gas, and are located in the States of Anzoategui, Monagas and Guarico (See Figure 4-5).
- Presently, the only non-associated gas production in the country is from onshore fields in the State of Guarico (Copa Macoya), located in Eastern Venezuela (See Figure 4-5).

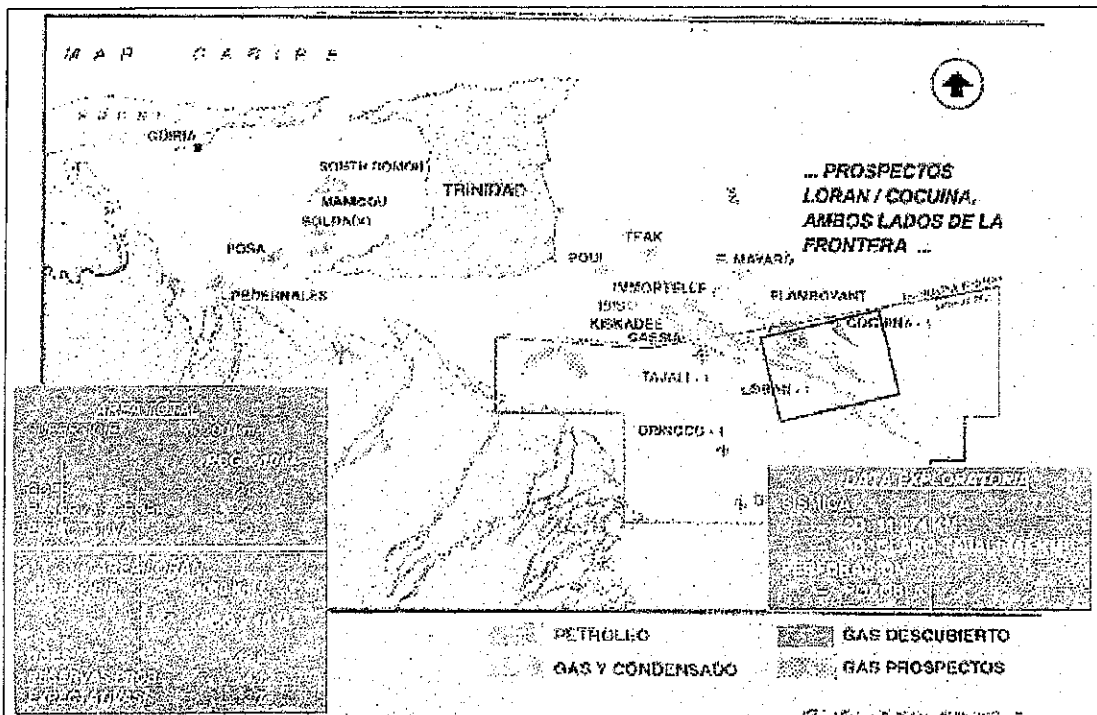


Fig. 4-5 Non-Associated Gas Production Onshore Fields



- Without counting Lake Maracaibo as an offshore region, all of the country's offshore reserves are of non-associated gas, which are also located in Eastern Venezuela (North of Paria Peninsula and Orinoco River Delta). They have been recently discovered and are still being evaluated (See Figure 4.6).

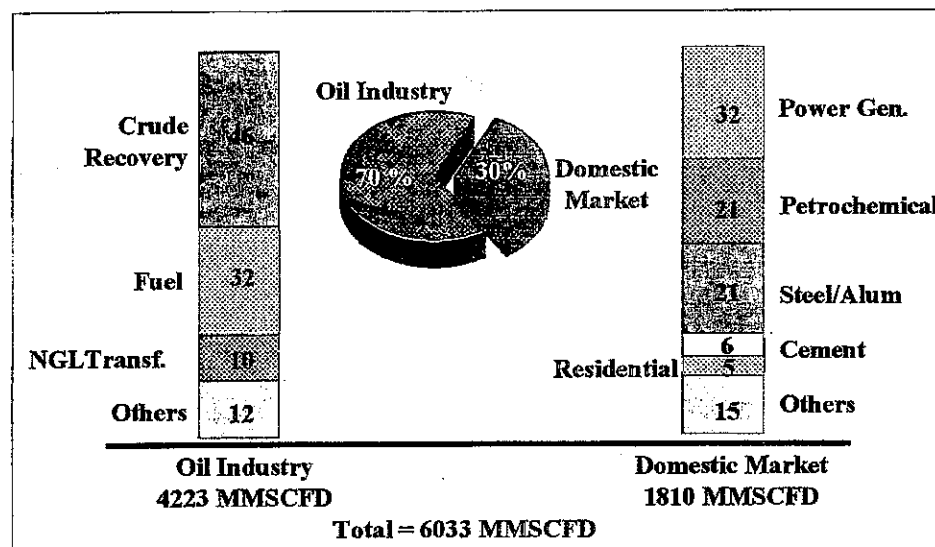
Fig. 4-6 Quantification of Resources in the "Plataforma Delta Costa Afuera" Area



- Eastern Venezuela, including the new offshore discoveries in the region, contains the bulk of the gas resources, with total reserves of around 166 TCF (73% of the country's) and proven reserves of around 117 TCF (80% of the country's), located in or near the area of the pre-selected sites.
- According to 1998 figures, of the country's total gas production of 6,033 MMSCFD, Western Venezuela produced around 2,000 MMSCFD (33% of total) and Eastern Venezuela produced a little over 4,000 MMSCFD (67% of it).

- A total of 4,223 MMSCFD (70% of production) was either consumed by the oil industry itself, reinjected for secondary recovery (46%), consumed as fuel (32%), transferred as NGL (10%) or put to other uses (12%) (See Figure 4-7).
- The remaining 1,810 MMSCFD (30% of production) was destined for the internal market, for power generation (32%), petrochemical use (21%), industrial use (42%) and residential use (5%). Eastern Venezuela provided over 90% of the supply to the internal market (See Figure 4-7).

Fig. 4-7 Venezuela's Gas Consumption - 1998 (MMSCFD)



- The Anaco district itself contains proven gas reserves of 26 TCF and produces around 900 MMSCFD, but being the central hub of the gas production in Eastern Venezuela (including the rest of the gas produced in the State of Anzoategui and most of Monagas), it handled over 2,200 MMSCFD (1998 data).
- The present gas supply comes from already developed oil fields in Anzoategui (El Roble, Santa Rosa, San Joaquin, Guario, Santa Ana, Soto,



Mata and others) and Northern Monagas (Jusepin, Santa Barbara-Piritai, El Furrial, Musipan, Orocuai and others), through existing gas gathering, compression and conditioning systems (dehydration and sweetening) tied to the Anaco hub. This system, and especially the gas compression infrastructure, is one of the most elaborate in the world, involving some 97 compressor plants of all kinds (gaslift, injection, transmission and boosting) in Eastern Venezuela alone, with some 150 plants in the country as a whole .

4.2.2 Gas Reserves and Production- Future Developments

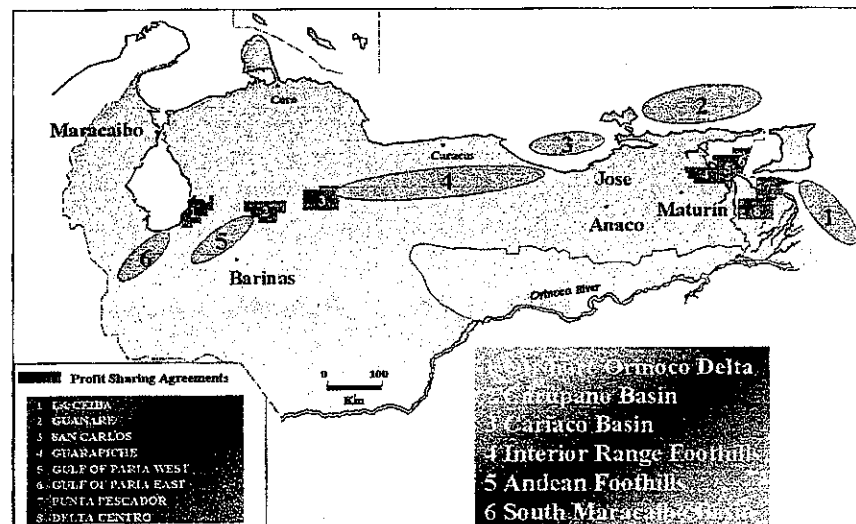
The related oilfield, gathering and conditioning infrastructure is being continually expanded to support the production plans, with the following developments:

- "Short term" plans (to be completed in the 2003-2006 time frame) are to increase the gas production in Eastern Venezuela (excluding the offshore fields) to levels between 7,000 and 8,500 MMSCFD. For the "long term" (beyond the year 2007), gas production could reach 11,770 MMSCFD, without counting the offshore contribution. All this is based on proven reserves being over 100 TCF.
- Anzoategui State has the greatest prospects for increased gas production. It has proven reserves of around 52 TCF, through the development of the new onshore exploratory fields located in the North (Piritu-Barcelona, Cajigal-Guaribe, Tala-Urica and Mundo Nuevo), and Center (Pato, La Florida, Maulpa, Casirito, Talara and Capacho).
- Northern Monagas, with proven gas reserves over 40 TCF, will contribute to these plans, through further developments in the existing onshore fields.
- In any case, Anaco will still be the main hub of the gas production from the onshore fields of Eastern Venezuela, due to its central location and configuration of the gathering and transmission infrastructure, which will only need to be supplemented. Jose could also become a gas hub itself, directly collecting the production coming from the new fields in Northern Anzoategui State and further developments in Northern Monagas.
- The North of Paria (Carupano Basin) offshore non-associated gas fields (Rio Caribe, Mejillones, Dragon and Patao) contain total reserves of 14 TCF, with

recoverable reserves estimated at over 10 TCF. Those fields are in shallow water (around 100 meters), with reservoirs occurring at an average depth of 2,300 meters. The Rio Caribe field contains condensate rich gas, while the other fields contain lean gas. They are slated to support the development of a potential LNG Project. There is a potential for additional discoveries in those fields.

- "Long term" plans consider Güiria as being the focal point for the development of both the North of Paria gas fields and Gulf of Paria/onshore Orinoco Delta prospects, since it is strategically located between those two areas and is also at a seashore location.
- The new Offshore Orinoco Delta non-associated gas fields (Loran, Cocuina and Tajali), which are still being evaluated, will also contribute to increase the gas reserves and production potential. Preliminary results indicate proven reserves of over 4 TCF, with further prospects of around 10 TCF.
- In Eastern Venezuela, there are also "long term" plans to develop new prospective areas of non-associated gas in the Interior Range Foothills (Northern Guarico State, located closer to Caracas and the main industrial center of the country), and in the offshore Cariaco Basin (located north of Jose). In Western Venezuela, the new prospective areas correspond to the Andean Foothills and the South Maracaibo Basin (See Figure 4-8).

Fig. 4-8 Prospective Areas for Non-Associated Gas



4.3 TRANSPORTATION PIPELINES

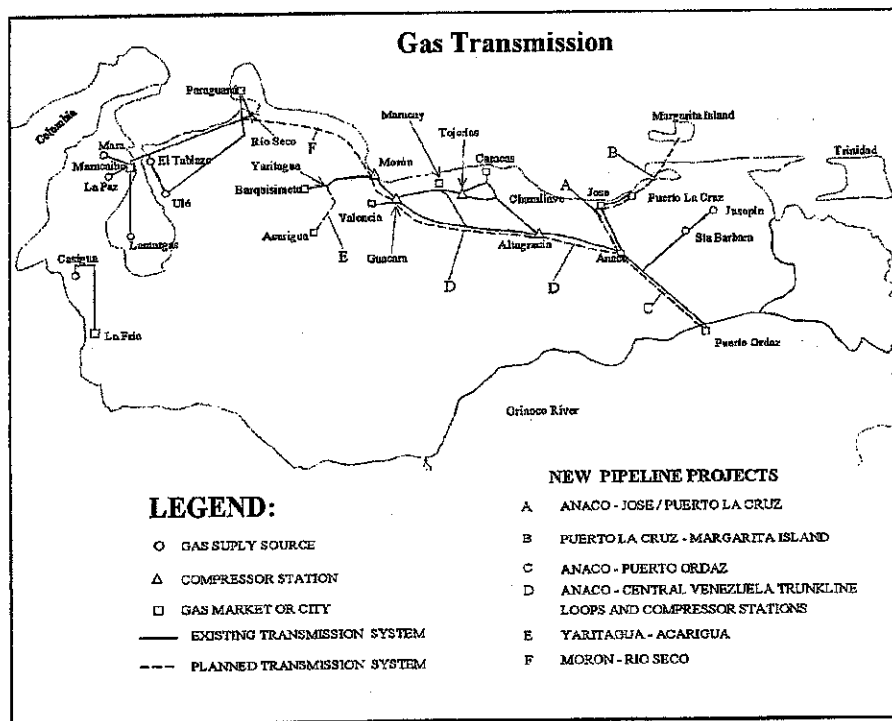
In the past, an extensive gas transmission infrastructure was built, linking the main producing areas in Eastern Venezuela with consumers (mostly industrial) in Caracas and other cities in the center of the country. The Western Venezuelan supply and distribution system is still independent. This transportation system was built and is currently operated by PDVSA, but it is an area to be opened to private investors under the new gas development policy.

Venezuelan gas pipelines will be discussed under the following headings:

- Present system.
- New and future developments.

Figure 4-9 shows an overview of the Venezuelan Gas Transmission system.

Fig. 4-9 Overview of the Venezuelan Gas Transmission System



4.3.1 Present System

Typically, the associated gas produced in the existing oilfields of Venezuela, in excess of that being reinjected or used internally for operations, is gathered and sent first to NGL extraction plants to remove liquids. After this, the lean gas (already compressed and conditioned) is introduced to the transmission systems.

Except for some low pressure gas produced in the onshore fields on the Eastern side of Lake Maracaibo, there is practically no wasted or flared gas.

The current gas transmission system is comprised of around 5,000 Km of pipelines, handling some 2,600 MMSCFD and serving roughly 1,300 industrial and 460,000 residential clients. The only main cities in Venezuela that are currently served by a gas distribution network are Caracas, Maracaibo, Barcelona and Puerto La Cruz

The Western Venezuela gas system, which is outside the scope of this Feasibility Study, has its own extraction (Lama, Lamarliquidido, Tia Juana 1/2/3, and El Tablazo) and fractionation (Bajo Grande, Uié and El Tablazo) plants, located in and around Lake Maracaibo. It supplies the El Tablazo petrochemical complex, power generation plants, industrial and residential consumers (mostly in the city of Maracaibo, and lately, some other cities on the Eastern side of the Lake), and the Paraguaná refineries (Cardon and Amuay). As mentioned before, this system has a gas deficit and is not yet connected to the rest of the country.

The Eastern Venezuela gas system, with the bulk of the reserves and production capacity, transports the excess supply to markets in the Jose-Puerto La Cruz area, Puerto Ordaz (Guayana region) and North-Central Venezuela. This system will provide the required gas supply to GTL plants located in Jose or Anaco, and is described in the following text.

- One of the two main sources of lean gas comes from the NGL extraction plants located in Anzoategui State, around the city of Anaco. These extraction plants have the following rich gas processing capacities:



- San Joaquín : 1,000 MMSCFD
- Santa Rosa : 250 MMSCFD
- Guara Oeste : 42 MMSCFD

Total : 1,292 MMSCFD

- The second main source of lean gas, sent to the Anaco hub via a 36" and 26" diameter pipelines, comes from the NGL extraction plants located in Northern Monagas State, which has the following rich gas processing capacities:

- Santa Barbara : 800 MMSCFD
- Jusepin : 350 MMSCFD

Total : 1,150 MMSCFD

- A small supply of non-associated gas is received from the Copa Macoya field, and is introduced along the main line from Anaco to Caracas.

'PDVSA Gas' main transmission system originates in Anaco, with gas pipelines radiating North to Jose, Southeast to Puerto Ordaz and Northwest to Caracas and Central Venezuela (up to the city of Barquisimeto). Out of a total of 5000 Km of existing gas pipelines in the country, the main gas transmission system, centered in Anaco and located in Eastern Venezuela, involves around 3500 Km of lines already in-place.

- The Anaco to Jose system includes both 26"-diam. and 16"-diam. gas pipelines, without intermediate boosting. It serves the Jose Industrial Complex, the Puerto La Cruz and El Chaure refineries, the urban gas distribution networks of Barcelona/Puerto La Cruz, and a few other industrial users in the area including a cement plant at Pertigalete.
- The Anaco to Puerto Ordaz system includes both 26"-diam. and 20"-diam. gas pipelines, together with a partial 36"-diam. loop in its final leg, without

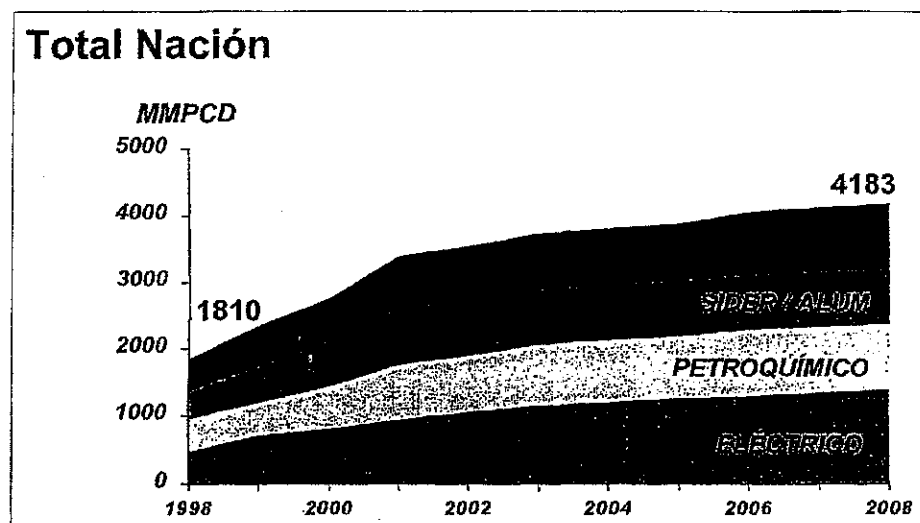
intermediate boosting. It serves the iron and steel, aluminum, and other metallurgical industries of Guayana.

- The first leg of the Anaco to Central Venezuela system, up to the Altagracia booster compression plant, includes four gas pipelines (two 26"-diam., one 30"-diam., and another 36"-diam.). From there, other main lines branch and transport the gas to Caracas, Maracay, Valencia, Moron and Barquisimeto. The system includes booster compression plants located at Guacara and Moron. It serves the Caracas gas distribution network, industrial users in Central Venezuela (including Barquisimeto), power generating plants (Tacoa and other gas turbine plants around Caracas), together with the El Palito refinery and the Moron petrochemical complex.

4.3.2 Future Developments

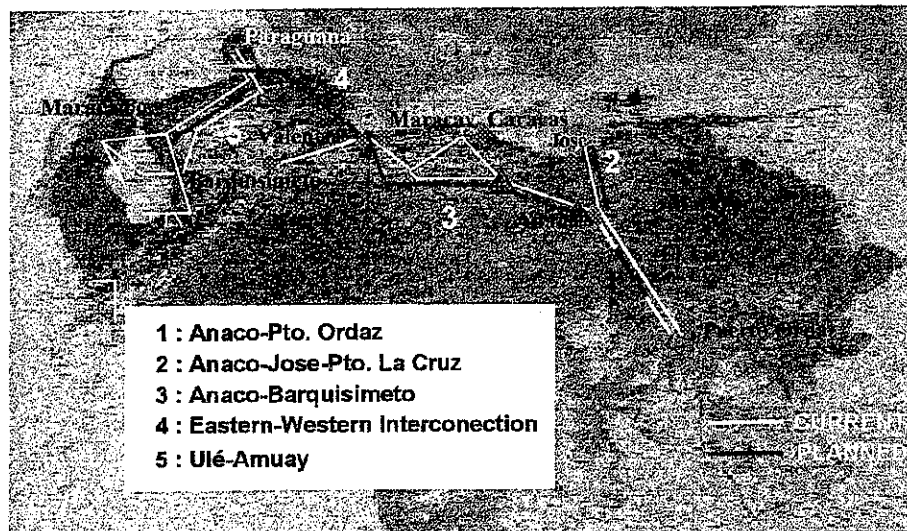
Natural gas currently accounts for 47% of the country's primary energy consumption matrix and is expected to account for 60% of the matrix, by the year 2006. To cover the increased demand for power generation, industrial and residential use contemplated for the country, the gas transmission system will need to be expanded. The current internal market demand of 1,810 MMSCFD is expected to reach 4,183 MMSCFD by the year 2008 (See Figure 4-10).

Fig. 4-10 Expected Growth of Internal Natural Gas Market



For this, the following developments are planned (See Figure 4-11):

Fig. 4-11 Planned Expansions to Venezuela's Natural Gas Network



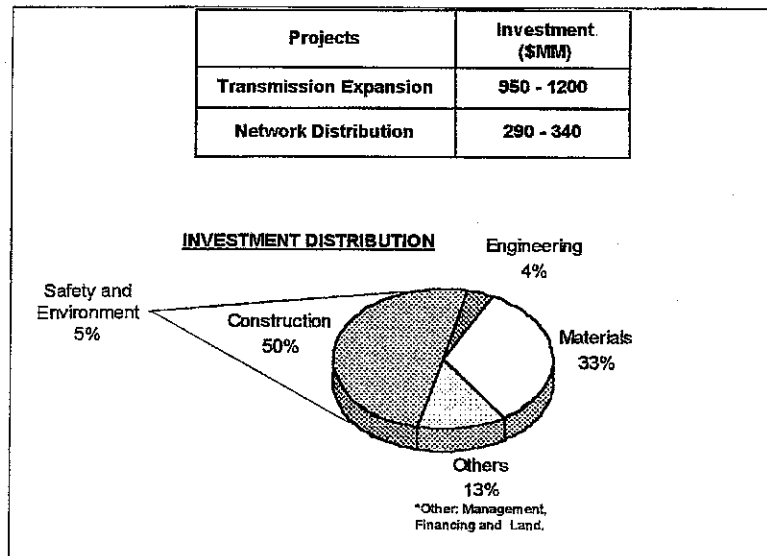
- Capacity expansion of the San Joaquin and Santa Barbara NGL Extraction Plants, as part of the on-going ACCRO Phase III/IV Project, being developed as a Build, Own and Operate (BOO) contract by the ACCROVEN SRL Consortium. The consortium has been formed by Enron, ACCRO Barbados, a subsidiary of Transcanada Pipelines, and Technoconsult. The following increases in the capacity to process rich gas, will be in operation by the beginning of the year 2001:
 - San Joaquín: one new 400 MMSCFD train, to reach a total capacity of 1,400 MMSCFD.
 - Santa Barbara: one new 400 MMSCFD train, to reach a total capacity of 1,200 MMSCFD.
- A new gas pipeline from Anaco to Jose and Puerto La Cruz (146 Km), to cover the increased demand contemplated in the Jose Industrial Complex and Puerto La Cruz area. This will be the first line to be built, and is estimated to be in operation by the year 2001.

- A new gas pipeline, from Puerto La Cruz to Margarita Island (84 Km), to serve an increased demand from power generation, tourism and residential consumers in the island. A feasibility study is underway for this project.
- A new loop in the Anaco to Puerto Ordaz line (126 Km), supplementing the transmission capacity to the Guayana region.
- New loops and increased boosting capacity in the main Anaco to Central Venezuela trunklines, to cover the increased demand.
- A branch line from Yaritagua (near Barquisimeto) to Acarigua (95 Km), to serve the needs of this growing agro-industrial city.
- A new gas pipeline from Moron to Rio Seco (264 Km), to interconnect the Eastern and Western gas transmission systems.

All these new gas transmission projects will require investments ranging from 950 to 1,200 MMUS\$. These are expected to come mostly from private investors, who will take advantage of the legal framework, which has opened the gas industry.

Eventually, the national interconnected gas transmission system will have around 6,200 Km of pipelines, handling 5,600 MMSCFD (See Figure 4-12).

Fig. 4-12 Opportunities for Investment in Natural Gas



All these facilities will allow for a stable "long term" supply of gas to any new GTL plant to be located in the region. Since most of them are either already in place or are planned, the investment required to bring the feedstock (natural gas) to the plant battery-limits for the Jose and Anaco sites, is not going to be charged to the GTL Project.

The gas supply pipelines to the Jose and Anaco sites are already in-place, since they serve existing users. For the "long term", they would need to be supplemented with planned loop lines.

The gas supply to the Güiria site will be provided, in the "long term", by the future development of the offshore gas fields located near the area (North of both Paria and the Orinoco Delta). Offshore gas development will be considered together with LNG or GTL production as vertically integrated projects.

4.4 INFRASTRUCTURE RELATED ISSUES

This subsection addresses the following infrastructure related issues, dealing particularly with the gas supply for the GTL projects:

- Plant feedstock.
- Gas Pricing.

4.4.1 Plant Feedstock

- "Short term" gas availability (between the years 2003 and 2006) would be around 150 MMSCFD (range between 100-200 MMSCFD), capable of being delivered to Jose, through the existing production and pipeline system.
- 500 MMSCFD of gas is currently available at the Anaco site. There are plans to increase the transmission capacity from Anaco to Jose, so it has been assumed that this supply could also be available at the Jose site for a "long term" (beyond the year 2007) project.
- "Long term" gas availability at the Güiria site is still undefined, because it is to originate from the future production of the offshore non-associated gas fields

north of Paria. Those reserves could not only support the requirements of an LNG Project, but also those of a world scale GTL Plant requiring 500 to 1,000 MMSCFD of gas. However, the production and use of offshore gas could be part of vertically integrated projects.

- Feedstock to the GTL plant, at all the pre-selected sites, would be dry, low sulfur natural gas that has already been through conditioning and extraction processes for recovery of NGL. Therefore, those process blocks are to be excluded from the feasibility study.
- Gas composition and quality to be used, for both "short and long term" projects is shown below. This composition is typical for the deliveries made from the general gas transmission system and not from a particular field.

Table 4-2 Gas Composition for Normal Operation

Component	Volume or Mole %
C ₁	80.95
C ₂	8.00
C ₃	1.50
C ₄	0.55
C ₅ +	0.30
N ₂	0.20
CO ₂	8.50
Total	100.00
H ₂ S	10 ppm
Water (max.)	10 Lbs/MMSCF

- Gas supply pressure at plant battery limits to be 800 psig at Anaco and 400 psig at Jose. Delivery temperature will be around 110 °F (for all sites).

4.4.2 Gas Pricing

The "short term" supply will basically come from associated gas, having a relatively low cost, being co-produced with oil. However, gathering, processing

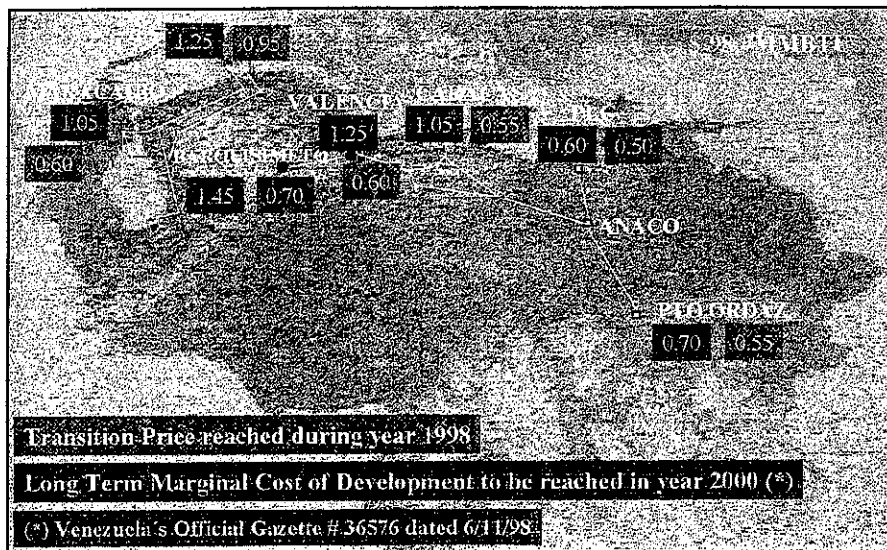


and especially transportation have a significant impact on the total cost structure. An initial transition price (reached during the year 1998), will cover operating and maintenance costs of the gas transmission system. A "long term" marginal cost of development price, to be reached in the year 2000, will account for the opportunity value of the gas in the different regional areas, involving both transportation distance and demand (See Fig. 4-13).

For the Anaco and Jose sites, the following costs have been provided:

- Cost of gas supply at Anaco is currently at 0.50 US\$/MMBTU and is expected to stay at that level.
- Cost of gas supply at Jose is currently at 0.60 US\$/MMBTU and is expected to stay at that level.

Fig. 4-13 Natural Gas Pricing Policy



The cost of gas for the "long term" Güiria site has not yet been determined, but probably will be about 1.00 US\$/MMBTU, depending on the configuration of the offshore non-associated gas fields and synergy opportunities with the future LNG project.