Power Generation and Natural Gas Market in Venezuela

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Background

During the last 6 years, Venezuelan energy matrix has been dominated by oil and gas, with an average of 39.4% (607 Thousand Barrels of Oil Equivalent per Day - MBoed) and 34.4% (556 MBoed), respectively, of the total energy consumption [1]. In the third place, hydroenergy has had a mean of 21.7% (373 MBoed) [1] of the total energy, however, if only power generation is considering, hydropower overcomes all other energy sources.

Since the end of 2009, Venezuela has suffered several moments of electrical crisis due to an important increment in the electricity demand, the influence of “El Niño” phenomenon, and thermopower generation problems.

The electricity generation capacity in Venezuela is composed by hydro and thermopower. Hydroelectricity is generated mainly by dams located in southern Venezuela along the Caroni River, named Guri, Macagua II and III, and Caruachi, representing a power generation capacity close to 14,000 MW. Also, there are existent hydropower plants located in western and Andean regions along Uribante, Caparo, Masparro and Santo Domingo Rivers, with a power capacity over 600 MW (See table 1) [2].

There are some hydropower projects in development: Tocoma (2,160 MW) in the Caroni River, expected to be in operation by 2014, and La Vueltosa (771 MW) in the Caparo River, whose first two units are expected to be in operation by 2012, and a third turbine will be operating by 2013 [3].

Table 1. Hydropower Plants

Power Plant	Number of Units	Nominal Capacity (MW)	Location	Status
Guri	20	8852	Caroni River, South-eastern	Operating
Macagua	20	2930	Caroni River, South-eastern	Operating
Caruachi	12	2196	Caroni River, South-eastern	Operating
San Agaton	2	300	Uribante Rivers, Andean	Operating
Jose A Paez	4	240	Santo Domingo River, Andean	Operating
J A Rodriguez	2	80	Santo Domingo River, Andean	Operating
Masparro	2	25	Masparro River, Western	Operating
Tocoma	12	2160	Caroni River, South-eastern	In construction
La Vueltosa	3	771	Caparo River, Andean	In construction

Thermoelectricity is generated using three different types of drivers: steam turbines, gas turbines and engines. The steam turbines are used in three big plants: Centro, CGJJS (Tacoa) and Ramon Laguna, with a total of 4266 MW (see table 2). The majority of the boilers of these plants use fuel oil or natural gas as combustible, given priority to natural gas when it is available, as a state policy.

Table 2. Steam Turbine Plants

Power Plant	Number of Units	Nominal Capacity (MW)	Location
Centro	5	2000	Carabobo, North central
CGJJS (Tacoa)	9	1606	Vargas, North central
Ramon Laguna	5	660	Zulia, Western
Totals	**19**	**4266**	

The gas turbines can be used in two types of cycles: Simple and Combined. The simple cycle are used in 28 existent plants, with a total power of 3954 MW. The combined cycle is used in two plants: Termozulia I and II, located in Zulia state, western region of Venezuela, with a total of 940 MW, of which 600 MW are given by 4 gas turbines.

Finally, there are 53 plants (1,055 MW) that use diesel engines to generate electricity, called distributed generation plants. It worth be mentioned that all of these engines consume only diesel as combustible due to they were installed in locations without gas supply. These plants only will be generating when the supply from the grid is not enough to satisfy the electricity demand or they are located in places without Interconnected Electric System.

Aim

The aim of this work is to determine the impact of new power generation plants planned by the electrical sector on the Venezuelan natural gas market.

Methods

Statistical data about the historical behaviour of power generation capacity, electricity market and natural gas market were collected and analysed in order to establish the relationship between natural gas market and electrical sector in Venezuela. Capacity data per year of new power plants are obtained using information from the government and specific technical information, for determining future volumetric requirements of natural gas market. Finally, the impact on the Venezuelan natural gas market structure caused by the new gas volumes is determined, in order to establish new sources of gas and new infrastructure.

Results

Power Generation Capacity

During the period 2005-2010, installed capacity of power generation in Venezuela has been increased from 21769 Mega Watts (MW) to 24838 MW, for satisfying an important raise in electricity demand [2].

The installed capacity and share by type of plant in Venezuela for 2005 and 2010 are shown in figure 1. The relevance of hydropower and steam turbines has been decreasing. Meanwhile, the gas turbine-based plants and distributed power plants have raised its share due basically to the needs to incorporate quickly new power generation capacity in order to minimise the electrical crisis mentioned above.

As it can be seen in figure 1, for 2010 hydropower plants represented a 59% of installed capacity, followed by fossil fuel powered plants: steam turbines, gas turbines, combined cycles and distributed generation with 17%, 16%, 4% and 4%, respectively [2]. The steam turbine plants can burn fuel oil or natural gas, meanwhile gas turbines of simple cycle or as part of a combined cycle plants can fire diesel or natural gas, and distributed generation plants only use diesel as fuel.

Mainly, increment in power capacity in last 6 years has been supplied by gas turbines and combined cycle plants (2057 MW) and distributed generation plants (983 MW), making evident the policy established by the Venezuelan government about to decrease the energy dependency from hydropower [2].

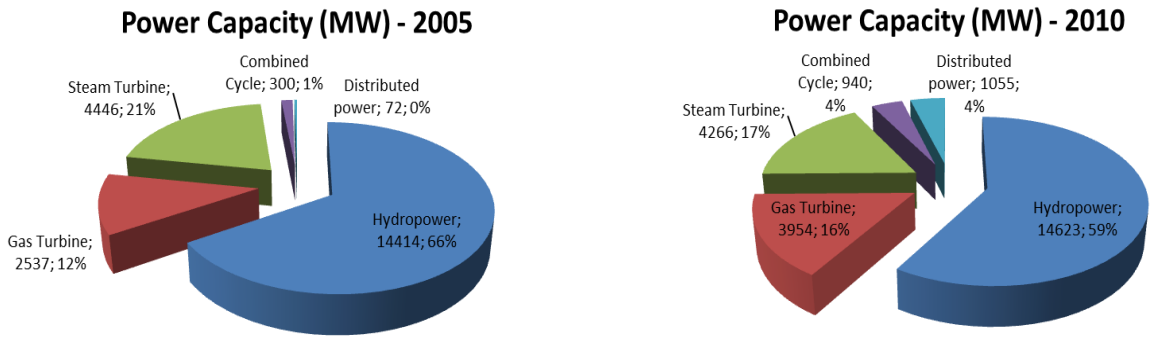

Figure 1. Capacity for type of plant

Gross Electricity Generation

The total gross power and by type of source generated in Venezuela during the period 2005 – 2010 are shown in figure 2. The energy produced has been increased at an average rate of 4.4% from 2005 to 2009, diminishing since 125 Tera Watts per hour (TWh) until 117 TWh in 2010, similar level than year 2007 [2]. This contraction is consequence of "El Niño" phenomenon that produced a net decrease in hydropower generation (86 TWh in 2009 to 77 TWh in 2010), and of equipment obsolescence in the thermopower plants that caused several electric power cuts.

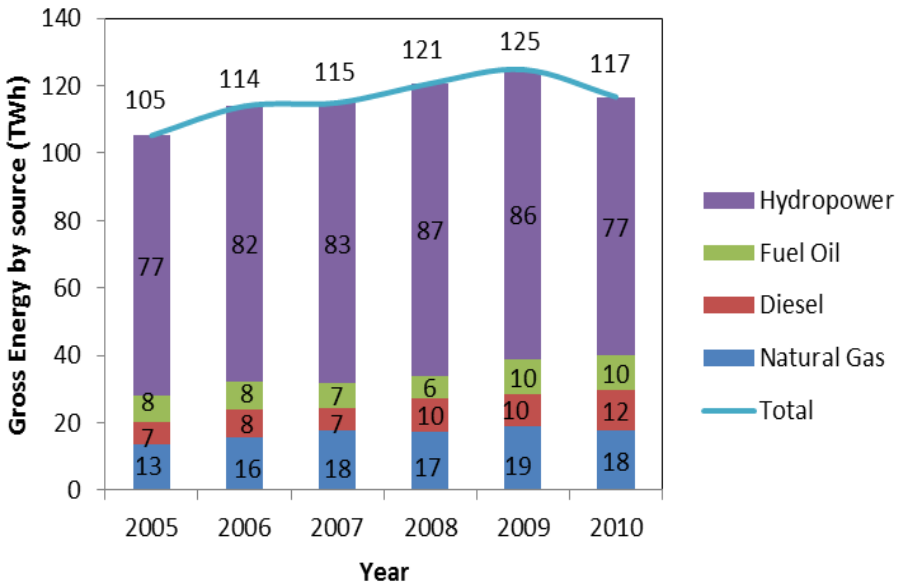

Figure 2. Gross Electricity Generation. Total and by Energy Source. Period 2005 – 2010

It is evident that dependency of the Venezuelan energy supply from hydropower has been decreased, although still is so important. However, in spite of hydropower represented the 59% of capacity installed for 2010 generated the 66% of the total energy

The supply of natural gas increased in 5 TWh during the period 2005 to 2007, staying around 18 TWh during the following 3 years; meanwhile the power generation from liquid fuels was augmented from 16 TWh to 22 TWh, overcoming natural gas power generation in 2009 and 2010 [2].

From figure 2, it can be obtained that the share of energy from natural gas has had a quasi-constant behaviour, around 15%. Also, the irregular behaviour of the segment belonging to liquid fuels (diesel and fuel oil) is evident, changing from a minimum of 12% in 2007 until a maximum of 19% in 2010.

This behaviour is derived from the increment in the use of diesel in distributed generation plants, which only can use diesel, and in gas turbine–based plants and steam turbine plants, that have suffered gas shortages due to lack of gas supply facilities, having to burn liquid fuels to accomplish energy demand.

Fuel Consumption for Electricity Generation

Considering only thermopower generation, during the period 2005-2010, the consumption of fossil fuels has risen from 149 MBoed to 211 MBoed (see figure 3). The fuel dominant has been natural gas, whose demand in the electric sector has been raised at an almost constant rate of 8%. However, in 2010 this tendency changed diminishing to 2008 volume level. If liquid fuels are added, already for 2010 the consumption of liquid fuels was higher than the gas.

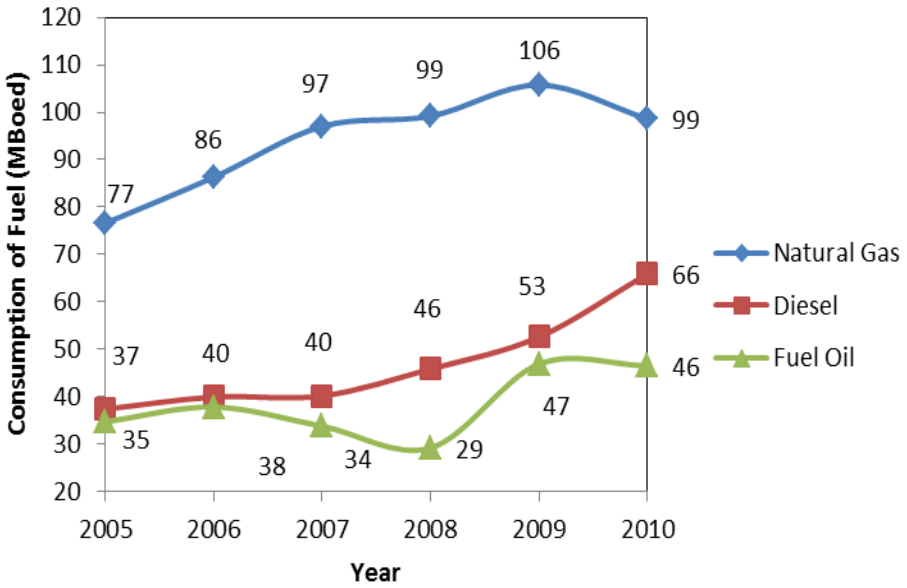

Figure 3. Fuel Consumption by Fuel. Period 2005 – 2010

By 2010, 7040 MW (69%) of 10215 MW of thermopower capacity installed can burn natural gas as fuel. The details of these values for each type of cycle are shown in table 3. Considering respective efficiency of each cycle, a load factor of 70%, gas pipelines systems and volumes available to supply these plants, the gas demand by 2010 would have been 1414 MMSCFD, overcoming the actual gas supply (572 MMSCFD) by 842 MMSCFD.

Power Generation Expansion

In order to satisfy electricity demand and solve the current electrical crisis, it is known that the Venezuelan government has expansion plans for power generation capacity using natural gas as fuel, according to the Venezuelan energy policies.

Table 3. Fossil Fuel Powered Plants. Year 2010

Cycle	Power Capacity 2010 (MW)		Potential Demand of Gas (MMSCFD)
	Installed	Fuel: Gas or Dual	
Gas Turbine	3.954	3954	810
Steam Turbine	4.266	2486	455
Combined Cycle	940	600	149
Distributed power	1.055	0	0
Total	**10.215**	**7.040**	**1.414**

The plans include the installation in the short term of 5997 MW and the rehabilitation of existent plants for 4123 MW [4]. Based on these plans and technical considerations about the type of driver that can use natural gas as fuel, in table 4, the forecast of new gas powered capacity to be installed in the period 2011 – 2015 is shown.

Table 4. Forecast of New Thermopower Capacity (MW) – Fuel: Gas or Dual

Year					Total 5 years
2011	2012	2013	2014	2015	
1109	1155	1230	1230	1125	5849

It is worth to note that the new hydropower projects (2931 MW) represent only an increment of 20% (see table 1), confirming the energy policy related to diminish the hydroenergy dependence of electric system.

Size of Natural Gas Market

In Figure 4, natural gas production and its utilization in Venezuela during the period 1996–2010 are presented. This figure indicates that total production has been raised from 5275 Millions of Standard Cubic Feet per Day (MMSCFD) in 1996 to 7000 MMSCFD during the years 2005 to 2010, meaning an increment of 32% and an inter-annual variation of 1.85%. Historically, this production has been used in oil production activities, such as injection for oil enhanced recovery, fuel for compression activities and pumping units, vent and transformed to liquid.

The gas utilization in oil production activities has been increased from 3478 MMSCFD (65.9% of total production) in 1996 to 5349 MMSCFD (76.8%) in 2010, making evident the priority of oil sector for utilization of gas production.

The gas supply to internal market has been almost constant in a value of 1800 MMSCFD, representing an average of 30% referenced to gas production. This internal market is composed by different economy sectors: electric, petrochemical, steel and aluminium, domestic and industrial, being the electric sector the main natural gas consumers (535 MMSCFD in 2010). The 70% of fossil fuel plants in Venezuela can use natural gas as fuel, which would imply that gas demand will grow.

As above mentioned, the gas demand would grow in 842 MMSCFD, reaching a total of 1414 MMSCFD (see table 3) versus 572 MMSCFD of gas that were delivered to electric sector. Actually, this sector instead of using natural gas as fuel in new and existent plants, they are burning diesel or fuel oil due to shortage in natural gas supply.

This situation has been caused by several factors: 1) incremental needs of gas volumes for oil activities; 2) gas production is concentrated in the eastern region, whereas in the central and western regions there are a gas shortage, 3) gas market structure is not impelling the search of new gas reservoirs and the construction of infrastructure required for handling gas production towards the market.

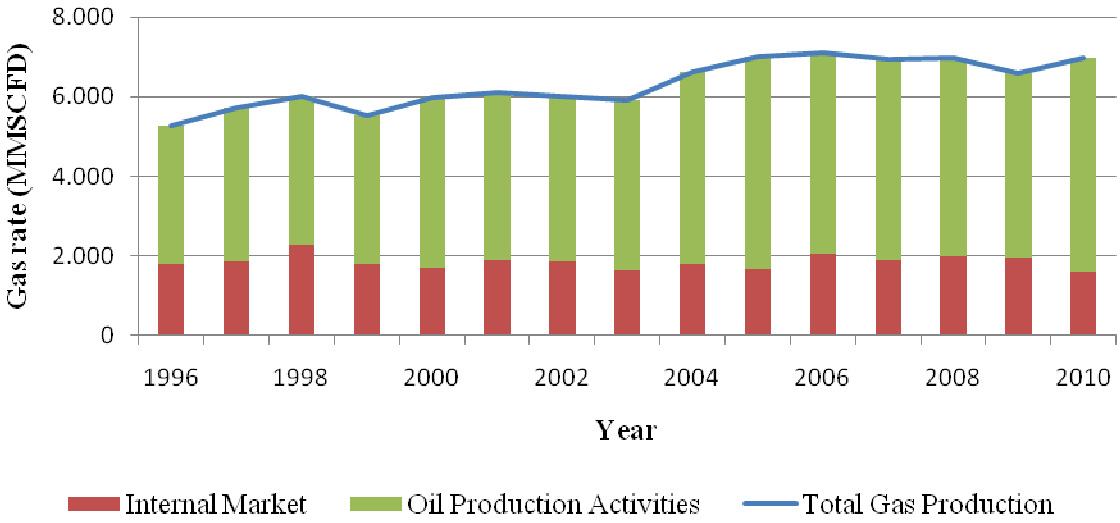

Figure 4. Production and Utilization of Gas in Venezuela. Period 1996 – 2010

Forecast of Gas Volumes

In order to satisfy the requirements of new gas powered capacity indicated in table 5, in table 5 is shown the forecast of additional gas flow rates that would be needed for electric sector during each year.

Table 5. Impact of new plants on gas market (Forecast)

Gas rate (MMSCFD)	Year				
	2011	2012	2013	2014	2015
Additional Gas rate - Related to 2010	934	1.261	1.558	1.863	2.156
Electric Sector Requirements	1.506	1.833	2.130	2.436	2.728
Internal Market	2.546	2.873	3.170	3.475	3.768

Internal market of natural gas would grow up 2156 MMSCFD in 5 years, representing a 377% increment, referenced to the gas flow of 2010. This increment in electric sector will represent 134% for internal market, an inter-annual variation of 6%.

In figure 5, the historical behaviour of natural gas consumption during the period 2005 – 2010 and the gas consumption forecast for 2011 – 2015 are shown. Both curves have different incremental inter-annual rates: 5% (historical) and 23% (forecast). The historical supply to electric sector has been subject to limitations related to infrastructure (pipelines, compressor

and processing plants) and volumes; meanwhile the forecast is based in the full availability of gas volumes and gas pipelines systems.

The electric sector would generate an increment in gas production of 9117 MMSCFD and the global energy consumption of Venezuela will grow up until 2000 MBoed, meaning an increment of 25%.

All of these values indicate that Venezuelan natural gas market will require a lot of natural gas supply that probably will open the Venezuelan natural gas business to new producers (offshore and onshore gas reservoirs exploitation), new prices and tariff policies and new infrastructure to handle the incremental volume of gas (at least 2000 kilometres of new gas pipelines, and several processing, treatment and compression plants).

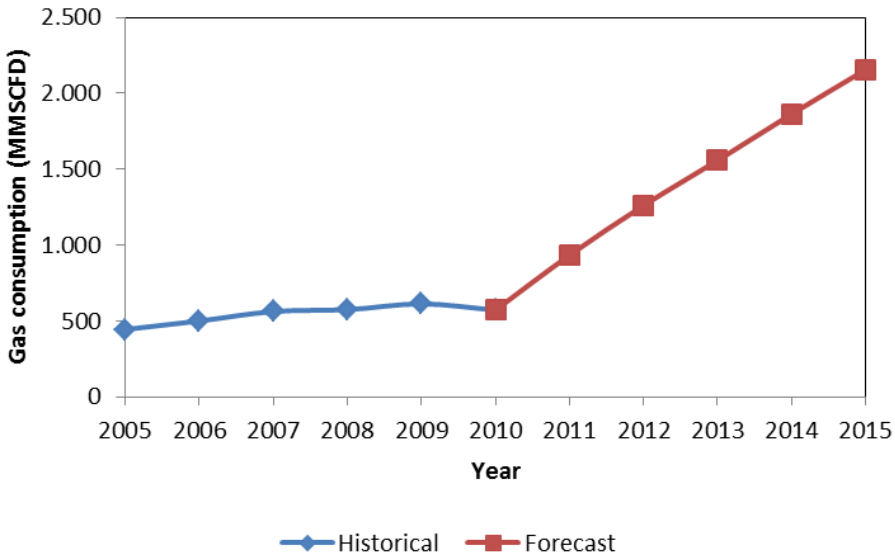

Figure 5. Natural Gas Consumption. Period 2005 – 2015

Summary/Conclusions

In this work, a study of the influence of new thermopower plants in Venezuelan natural gas market has been developed. It has been shown that if new power plants for electric sector are installed for satisfying the incremental electricity demand, the gas supply to electric sector would rise 2156 MMSCFD in 5 years representing an incremental of 377 % in 5 years, and as a consequence, the size of internal natural gas market in Venezuela would grow 134%. All of which will represent big opportunities for increasing the weight of the natural gas in the Venezuelan energy matrix, such as the government has established in its energy policies, and possibly to generate changes in the structure of natural gas market, such as new gas producers, traders and plant operators, and new business models related to gas infrastructure.

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