



Regasification plants

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Dedication:

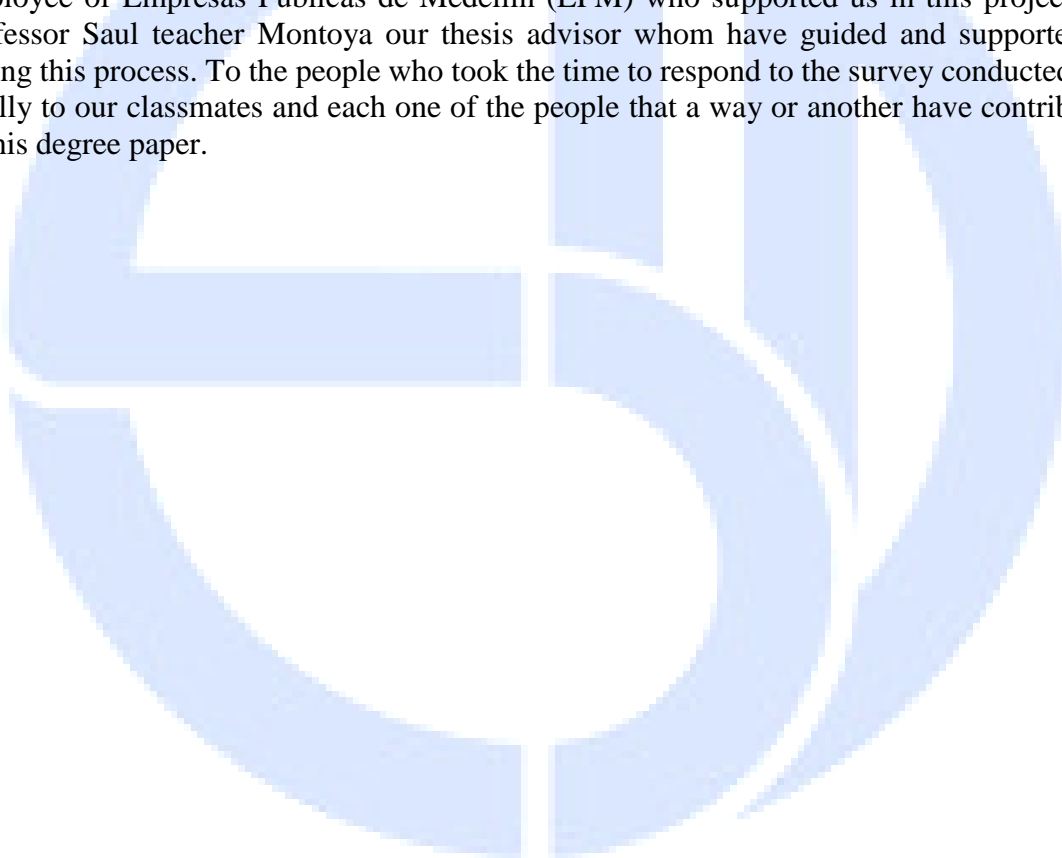
This degree work is dedicated first to God who has given us strength to continue developing the content of this research and to not give up due to the difficulties that may arise.

Likewise, it is dedicated to our family, who have given us their unconditional support and confidence in everything needed to fulfill part of our goals as students and as people.



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Summary

This degree paper discusses regasification plants and natural gas, since this is indirectly impacting Colombia at this moment, due to the controversy of information there is on the subject and, especially, the events that have been occurring lately as the Fenómeno Del Niño, and shortages of energy and water. This thesis contains three main topics: the technical process of regasification plants and their link with the natural gas, national and international marketing of natural gas, and the friendly impact it has on the environment, being the cleanest fuel in respect to others. The methodology is based on gathering reports, news from reliable sources and the interviews of two people familiar with the subject, an academic image being: Mr. Federico Atehortúa Hurtado and an labor field image as Mr. Juan Miguel Higuera Gaviria who develops professional work as Regulatory C., Transactions and Markets of EPM.

In addition a survey developed with 60 ordinary people whose outcome will indicate the level of knowledge they have about natural gas, especially the consciousness present about how friendly this fuel is with the environment.

Keywords

- Regasification plant
- Liquefied Petroleum Gas
- Lng carrier
- Dispel

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List of symbols and abbreviations

BUT: British Thermal Unit calorific value.

CO₂: Carbon dioxide

EPM: Empresas Publicas de Medellin

GBTUD: Giga BTU day

GN: Natural Gas

CNG: Compressed Natural Gas

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gas

HC: Hydrocarbons

MoPDC: Millions of cubic feet per day

PDVSA: Oil of Venezuela S.A.

TCF: Tera cubic feet

UPME: Mining and energy planning unit



Introduction

The exploitation, production, marketing and level of daily consumption of natural gas to internal or external level brings along benefits of great importance in different aspects such as environmental, technological, economic and commercial. On the other hand, natural gas demand has been increasing over time due to the high consumption, low natural gas prices, among other factors present in national and international communities. Emphasizing the research in Colombia, based on the above, the offer must be at increased participation in the exploration, exploitation, regasification and marketing of the object of study.

With regard to the factors described above and others on the natural gas in Colombia and its current interaction with the market, this research arises, in which topics such as the importance and benefits that brings natural gas in our daily consumption, how the demand for it has been increasing, and what are natural gas most common means of marketing will be included. Natural gas is also characterized for being a sustainable fuel that helps the environment and economic development, as well as in reducing emissions of greenhouse effect gases in the atmosphere. As it is the decreasing emission of hydrocarbons (HC) and carbon dioxide (CO₂) compared to oil, carbon, etc. Causing these effects in most domestic, energetic, industrial, thermoelectric sectors among other sectors. Thus making this fuel the most competent and efficient.

Additionally, this thesis will also discuss the technical process of regasification plants, which consists of the transformation of liquefied natural gas to natural gas. Environmental impacts, being one of them the aspects to be discussed, such as the emission of greenhouse gases as a result of the regasification process, among other both positive and negative impacts that have been prevented through special purpose equipment, trained personnel, security, etc. This research also infers briefly on technological impacts of the plant mentioned. It should be noted that the development of the subject is focused on the regasification plant of Cartagena-Colombia, which will start operations as indicated by some documents and news during the second quarter of 2016.

Moreover, issues such as possible reserves, current reserves etc. will be addressed. With which Colombia counts or will count, also a brief discussion at the national level on the relationship between supply and demand will be made. The Colombian and Latin American markets will be analysed too, where we can evaluate the gas flows and potential supplier countries that can supply to us in the future, as Colombia aims to reach a trade balance, since demand has been growing over time to a level greater than current supply, noting that Colombia will begin importing natural gas from Venezuela from July of 2016. In addition, the Colombian territory in Latin America has made improvements compared to years ago, both in the increase of domestic supply and demand.

To expand the knowledge and research, we resorted to information through interviews, surveys and investigations by reliable virtual sources and books. In the interview we resorted to two characters with knowledge of the regasification plant and natural gas, one being an academic teacher (Federico Atehortúa Hurtado) and the other character with expertise in natural gas, Mr. Juan Miguel Higuera Gaviria performing professional tasks such as:

Regulatory C., transactions and Markets at EPM. Similarly, a survey was conducted to verify the level of knowledge that 40 people have about natural gas and its environmental impacts.



1. Project formulation

1.1. Background

The natural gas market in Colombia starts to be known in the mid 70's, when in Guajira in the year 1986 the discovery of this fuel is made and the "Gas Para el Cambio" program is created, which extends the demand for natural gas to the major cities of the country. Because of this Ecopetrol entered leading the national interconnection in 1993 by decision of the National Government. By the year 1997, the Fondo de Solidaridad y Redistribución de Ingresos is created, gas transportation was separated from Ecopetrol and the Empresa Colombiana de Gas (EMCOGAS) was created, which later became the (TGI) whose acronyms refer to the inner gas carrier. Colombia ranks ninth in Latin American countries on the production of natural gas and expectations grow that the proven reserves of this fuel increase over time.

Reserves with which Colombia counts now come largely from two plants, which are the Guajira (Chuchupa-Ballena) and the inner one, Cusiana. Counting the first plant with 41% of the natural gas reserves, producing a 65% operated or supported largely by the company Ecopetrol and Chevron Texaco. On the other hand Cusiana plant has a reserve ratio of 49% and its production share of 21.7%.

Keep in mind that in this market of natural gas also participate small plants that contribute very little to the production of gas. It can also be said that in the Colombian market regarding natural gas, those with the major participation are the big cities and where the thermal power generation plants are located.

Domestic demand for Colombia reaches around 1,036 million cubic feet and produces about 1,160 million cubic feet of gas daily. As with this production capacity sufficient volumes are guaranteed to meet national demand, however the surplus was exported to Venezuela for the past seven years. The export process is no longer being implemented, as both governments established through a contract the supply of gas at two times, where they agreed that Venezuela would import gas from its neighbor up to seven years, and then the flow would be reversed allowing Venezuela to export; This means that Colombia from July 2016 will be importing natural gas from our neighboring country (Venezuela). With this agreement, both countries were benefited: on the one hand, Colombia gave its surplus production and prepared to cover its deficit of gas, projected for 2017. On the other hand, Venezuela not only covered part of its deficit, but also ensured market for part of the gas of the new projects of PDVSA.

Besides this, Cartagena (Colombia) is planning the construction of a regasification plant, which will be in charge by the Spanish firm Sacyr Industrial, it is not only positive information but also a guarantee that the country will have the fuel needed to meet demand looming by factors such as El Niño. Harbord Pagnozzi and Von Der F., (2011) reports that:

In Colombia the natural gas is divided into four categories such as: residential and commercial with a participation rate of 19%, industry with 45%, electricity generation with 24% and finally the gas used in combustion vehicles with 12 %. Also they show that demand in the central part of the country is 52% and around the Atlantic coast approximately 34% and 14% of natural gas in Colombia is subject to export.

The country took great pains in creating a culture and generating demand for gas in Colombia but they forgot that in order for this to be a success supply had to be generated as well. Colombia currently has a deficit in natural gas. According to a university study by the UPME we will not have gas by 2017, something worrisome because this culture has been increasingly imposed in the country and many homes, cars and industries have switched to this system and they need it to keep running. However, the shortage of fuel is concerning, because there were investments in the expansion of the Cartagena refinery. In the first instance it was thought to be a backup system in time of drought. In case of not increasing the national supply, it is expected that those using natural gas should pay a higher price than normal. Cavero and Suarez, SF state that: "The regasification plants, are an example of sustainable boost of the efficiency from maintenance, as they have improved strategies to optimize the availability of equipment and critical systems".

Gas reaches the ports in liquid state, as indicated on the official website of the Puerto La Paloma (2013): "This combustible in liquid state is odorless and colorless, being lighter than water and will not burn, where the main danger lies in drastically reducing the volume in turn helping to reduce transportation costs." Meanwhile Romero (2014) explains:

The process of regasification of liquefied natural gas (LNG) is a source of energy that can be very susceptible to be recovered. Its origin is at the low temperature which natural gas has when liquefied, for facilitating its transport and storage. For the final distribution to consumers, the gas must be regasified. In the regasification using conventional systems, either through heat exchangers with seawater or submerged combustion vaporizers, this energy available is released without performing energy use.

1.1.1. State of the Art

Until 2015, research on the gas industry were made in Colombia, where it is mentioned that this sector is going through a key moment, because the production has strengthened, domestic demand has maintained its stability, and the volume of proved reserves in the country has increased. Today Colombia in the first instance intends to supply the domestic market, however some sources indicate that Colombia is also strong to the situation internationally.

The Ministry of Mines and Energy in the Balance of Natural Gas in Colombia (2015) reported the following figures:

The total volume of natural gas reserves is 6.41 TPC; the maximum gas production in 2014 reached a volume of 1,360 GBTUD; the average natural gas availability in 2014 is 1,331 GBTUD; between 2015 and 2017, the maximum output would be close to the 1,380 GBTUD, figure that indicated stability in production in the coming years.

In the next image the process that LNG takes from arrival to final consumers or their target market is observed.

Image 1. Current regasification process of the Cartagena Refinery



On the other hand, due to a bad decision in the selection of contractors for the construction of the refinery in Cartagena, up until today the cost overruns in the construction and modernization of these facilities is still news in the media, for the president of the plant (Reyes Reinoso, 2016) told the newspaper El Espectador that "There are 5,000 million dollars (debt), 3,000 million we owe to banks and 2,000 to Ecopetrol" who hopes that in 2028 the debt is cover.

Similarly, Reficar president is seeking to clarify with the operator in charge of the construction the cost overruns generated since none of the parties want to get into arbitration because it would be more costs and delay would increase significantly.

On the commercial side which is the topic that concerns us, Colombia ranks third in oil exports in Latin America with a daily production of 804,000 barrels, suffering the fall in the price per barrel. Since the entry into operation of the refinery.

Since the entry into operation of the Cartagena refinery. The natural gas market is benefiting the domestic and international trade, although during the development of this research it is evidenced that the supply has not been good enough to meet domestic demand and even less external. However, in a country like Colombia is further facilitated transport from one

country to another, responding to the demand due to climatic events and other possible needs that may happen in neighboring countries, this because in Colombia greater national investment is required in order to meet internal demand bringing this fuel to all corners of the country, because if so, it would quite strategic since it would guarantee the supply of natural gas and electricity, as it is another way to use the plant, plus this gives a new dimension on the map Colombian energy.

1.2. Problem statement

This research of the degree work arises because of the consequences and problems identified where it is mentioned that there will be a shortage of natural gas by 2017, so that in a few years investment which led to build the refinery in Cartagena may be lost because there would not be liquefied natural gas to process and market.

In this sense, the problem question that guides this research is: How efficient is the Cartagena refinery on international trade in relation to different scenarios of supply and demand? And, what is the response thereof to the Natural gas supply nationally and internationally?

1.3. Justification

1.3.1. Theoretical Justification

Due to the great challenges posed to regasification plants in all parts of the world where they operate such plants, including Colombia is our object of study, huge opportunities are evident to the naked eye from international trade, since this ensures that neighboring countries are supplied of natural gas as their offer is little or none. In addition, the LNG trade is increasing because demand has been increasing as well given that this fuel is cleaner and more sustainable compared to others such as diesel, coal and oil. However, the issues of scarcity of this latter fuel present today generate the need to find other cleaner and cheaper alternatives because oil, not being as clean, has generated for years serious pollution problems to the environment.

Colombia has a great chance thanks to the Cartagena refinery since it allows to store and process liquefied natural gas, although at the time the country does not have large reserves of natural gas and therefore this factor is a weakness and in turn a threat to long term, given that if the fuel exploration is not encouraged, we would be likely to run out of gas and losing the investment that entailed the construction of this refinery.

Significantly, what is intended with the construction of the Cartagena refinery is to achieve a trade balance, which aims to supply Colombia internally of said fuel and eventually export gas. As well as reduce pollution in the atmosphere that generate most fuels such as oil, diesel, coal and others.

1.3.2. Social Justification

An important benefit that gives us natural gas is that it is friendly to the environment, being clean and sustainable compared with other fossil fuels. The latter have been the most widely used until today and they are owed much of the serious pollution problems to the environment that are present today. Also they do not help to be sustainable with economic development. For this and many more social problems regasification plants have been built, as these help to be at the forefront in the gas system and take future preventions of a fuel shortage. In addition to this, these plants generate many jobs which help in turn to the economic sustainability of the country.

1.3.3. Personal Justification

The topic of regasification plants is not well known today, which is why we were encouraged to develop this theme, since we can instruct and publicize the benefits that these plants contribute to international trade and the environment, as these process a cleaner fuel and generate the need for further exploration of natural gas fields in Colombia. If it is not possible to find such fuel, it should be sought what neighboring countries have significant reserves of natural gas to help us supply longer the Colombian market and the possibility of building a pipeline from neighboring countries to minimize transport costs. Finally, this research will help us expand our knowledge towards the subject, we hope to answer questions and provide alternatives for the Cartagena refinery to stay in time with an execution for which it was built.

1.4. Objectives

1.4.1. Principal Objective

To Analyze the Cartagena regasification plant in the economic, commercial and environmental aspects.

1.4.2 Specific objectives

- To describe the technical process of regasification plants by focusing on the Cartagena refinery, taking as reference the environmental and technological impacts compared to current pollution problems
- To identify where the marketing flows of natural gas in Colombia and abroad move, determining the stage of supply and demand.

1.5. Methodological framework

1.5.1. Method

This degree research is a study where the deductive method was used, from a general context of international trade in gas, reaching the specific analysis in the Cartagena refinery. It is a

qualitative study based on consultation of documentary and physical sources, field interviews and surveys.

1.5.2. Methodology

Collection of secondary information: In the first instance, it was verified on the internet if there were other people doing the same work, or one related to this, of regasification plants, or at least people who have done related studies to natural gas, but focused on the regasification thereof. Most of the information in this work will be consulted on websites. Given that it is a relatively new topic, it is difficult to find other sources but further information will be sought in other documents.

Collection of Primary Information: To search Information on the books of the university library, related to the study of natural gas or regasification thereof.

Fieldwork: In this degree paper a small survey of 8 questions will be carried out, created in Facebook and shared right there, so that contacts may answer. A sample of 40 people who have answered the survey will be taken, this will throw us the level of knowledge that people have about the regasification plants, especially the Cartagena refinery. Additionally, we also propose to perform about 11 questions that will be sent by email to two people who will be Mr. Federico Atehortua Professor of Sustainable Economic Development at the university ESUMER and Juan Miguel Higuera, employee of Empresas Públicas de Medellín. According to their availability, it will allow us to know the perspective and opinion of these professionals knowledgeable on the subject about the objectives in this thesis, thus helping us with their great contribution to this work. SWOT matrix is also one conducted in order to assess the production capacity vs demand and supply of natural gas in Colombia.

1.6. Scopes

The research will be carried out in the course of four months, from February to May, it will be focused on the Cartagena refinery and the objectives are guided nationwide. The information acquired is in terms of technology that has the plant and innovation plans, how flows of domestic and international marketing move and also how this hydrocarbon helps the environment. It is very important to talk about these three aspects, since the trade issue which is concerns us is not as extensive and will be useful to have different perspectives.

2. Execution of the project

2.1. Theoretical Framework

Natural gas is the cleanest fuel, being an alternative that competes with other types of traditional fuels. It allows to be described as the purest fossil fuel, because its level of pollution to the environment is very low, besides being more economical.

This fuel is the third largest energy source in the world, after oil and coal. The best reserves today are located in the Middle East, part of the Asian continent which is where the biggest quantity of production takes place. Due to the shortage of oil expected by 2017, governments do studies to find new sources of natural gas and thus minimize the risk for later. However, the Spanish association Sedigas, says reserves in Asia ensure supply for at least about 62 years.

Most countries import natural gas via pipelines, but in 2010 it started to be known that 30% of the total imports were by LNG which requires LNG vessels to be transported. The regasification and liquefaction plants. According to Zeuslibrary source (2013) reports:

In early 2009 there were 25 operational liquefaction plants with a total of 82 liquefaction trains, located in 15 countries. There are also 5 additional plants under construction and numerous expansions at existing plants. The global liquefaction capacity is 208.2 million tons in 2008.

For a country to opt for the alternative of building a regasification plant, is because it wishes to minimize the risk of coming oil shortage and achieve sustainable development, however this requires to be based on the resources available, thus ensuring continuity and sustainability of economic activities. To strengthen the gas sector and improve the quality of life of people, the states with regasification plants must commit to meet the needs of the moment, taking the appropriate control of natural resources to ensure the continuity of activities, plus be friendly to the environment, being at the forefront of new increasingly cleaner and more efficient technologies.

The process of the plants is almost universal, it starts with the reception of LNG ships to port, who unload liquefied natural gas that reach the storage tanks via pipelines, then the regasification process begins which comprises heating it at very high temperatures to convert it into gaseous state.

2.2. Natural Gas Composition

The liquefied natural gas is 95 to 97% approximately of fluid methane (natural gas), and the rest consists of other hydrocarbons, such as ethanol and propane, among other gases. The natural gas is cooled to -162°C , its volume decreases 600 times and becomes an odorless and transparent liquid. This is stored and transported at a atmospheric pressure above the environment. In the regasification terminal LNG again returns to its gaseous state at the heat exchangers.

2.2.1. Regasification process

The manufacturing process begins with the reception of liquefied natural gas by the transport ships (LNG carriers), once the boat is securely tied to the head of the pier, the unloading of liquefied natural gas to the storage vessel is made by special arms, after the unload the transport ship retires.

After this the liquefaction activity follows. This is the purification process. It consists in the removal of water, carbon dioxide, sulfur and heavy metals for this to achieve a maintained a condition that prevents the cooling, freezing and condensation. Thereafter, the gas is mobilized to the cooling circuit where the sensible and latent heat is removed, thus is transformed from gaseous state by a high pressure to a liquid state, this being possible at a temperature of -162°C , reaching a relative density of 0.45. Thus, the gas reduces its volume 600 times (This means it will occupy a space of 0.0017 of the space required by an equal amount gas at room temperature and atmospheric pressure). This allows storage in containers or tanks thermally insulated as in the regasification plants, so as to minimize heat input from the environment.

Image 2. Structure of a Regasifier Vessel.



Once the liquefied natural gas is in the storage vessel, it is transported to the process area of the regasification terminal through a pipe that is along the dock. In the process Area of the terminal regasification is performed by heating of liquefied natural gas. The product obtained is natural gas in its original state (gaseous).

The regasification process is completed with the pressurization of natural gas, which is needed to allow transport and connection with the pipelines available.

For delivery it is necessary to have a station that measures the flow of gas transported to the pipelines.

According to an article of "El Tiempo" newspaper (December 15, 2014) this would be the importance of the regasification plant in Cartagena:

The construction of a regasification plant in Cartagena, which will be in charge of the Spanish firm Sacyr Industrial, is not only positive news but also a guarantee that the country will have enough fuel to meet demand looming by factors such as El Niño.

So was stated by Pizano (2014), president of the Asociación Colombiana de Gas Natural, who said, further noted:

This will prevent a shot in gas prices to the extent that there will be an additional source of supply to meet demand, especially from the thermoelectric.

According to "El Tiempo" (December 15, 2014) the following is stated:

The firm Sacyr will oversee the construction of a maritime terminal for importing liquefied natural gas (LNG), which will require an investment of nearly 250,000 million pesos. The contract includes the design, construction and commissioning of a terminal that will have a capacity of 400 million cubic feet of liquefied gas a day and is estimated to be ready in September 2016.

The construction of the regasification plant was awarded by the Port Society El Cayao (SPEC), formed by the Colombian company Promigás and the foreign capital investment fund, Baru LNG. Sacyr will also have to build a gas pipeline whose length is about 10 kilometers, through which the gas will be transported to the national transportation system. Pizano (2014) states that:

The rains in the country are steady these days, and it is clear that a dry season is coming, in which thermoelectric will require fuel such as gas, to produce energy, which you can shoot the price of fuel, as recently happened in La Guajira. The importance of having alternative sources for gas supply, because that will keep costs from skyrocketing.

2.2.2. Cartagena refinery

The Cartagena refinery opens the door to start operation on December 4, 2015, being the most modern refinery in Latin America. This engineering work will carry out the production of more sustainable fuels, also in its opening it is mentioned that it will bring great environmental benefits and boost the national economy.

In the Cartagena refinery every detail that is linked to environmental is taken into account, this, to prevent any contaminants in the atmosphere, water or soil. Which are calculated in an investment of more than \$ 870 million, only on improving fuel technology.

Today Colombia is going through a really unthinkable a few years ago when saying that Colombia would run out of natural gas, but due to El Niño, the demand continues to outstrip supply facing the fall of hydropower production. However, the only bet that is designed to prevent such shortages and put off fuel demand is in the pipeline between Cartagena and Sincelejo, this would be the same as saying we depend on a neighboring country. That is why both countries should strengthen their trade relations for mutual benefit.

President of Ecopetrol (J. Echeverry, 2015) states that:

The future way of the gas sector is that this in northern corner of South America there must be a much deeper involvement and interaction in economic dynamics.

During the first quarter of 2016 is expected a deficit of up to 245 million dialy cubic feet, where the only guarantee for such supply is to take as an alternative the neighboring country of Venezuela to meet gas demand in the short term. In this connection T. Gonzalez (2015), minister of mines and energy states:

Colombia has the necessary infrastructure to make this agreement operational, but before commencing operations, the neighboring country must make some adjustments to improve its infrastructure. Until June of this year, Colombia benefited from some 58 million cubic feet per day from the Bolivarian nation.

In Colombia there are other alternatives. Gonzalez (2015) confirmed the following:

Since the first of December 2015 the pipeline that runs between Cartagena and Sincelejo will begin operating. The action will extract gas from the fields of Sucre and Córdoba to deliver an average of 50 million cubic feet per day.

Additionally, as Echeverry (2015) emphasized:

In this December Canacol must have ready the capacity to offer about 65 million cubic feet per day and, also, the new refinery in Cartagena (Reficar) will be able to provide additional 20 million cubic feet by February 2016.

In this context, Eduardo Pizano (2015), president of Naturgas, stressed that an essential issue on the agenda of nations must be the long-term vision to ensure the supply of hydrocarbon.

Be aware that the world is in a process of climate change and that the remedy to this is to try that there are increasingly fewer fossil fuels affecting the environment. Within these, the cleanest of all, the one that has better ecological footprint, is natural gas. Of course, this too will have to be supplemented by renewable resources, not only photovoltaic and wind, but others such as biogas from solid waste.

Likewise, the source of Mines and Energy (2015) states the following about the summit:

A total of 131 members of the International Gas Union (IGU) attended this year's World Summit Gas, including the president of the IGU. David Carroll, as well as members of the Coordination Committee, Executive and his Council. This body represents 95% of the gas market around the world. The annual meeting, which this year had Cartagena and Colombia as host, was organized by the World Association of Natural Gas (Naturgas).

Opinions

Juan Carlos Echeverry - President of Ecopetrol:

"There is great interest both Colombia and Venezuela to improve and strengthen the energy sector."

Tomas Gonzalez - Minister of Mines and Energy:

"There is a huge demand from thermals to generate cheaper energy counting with gas."

2.2.3. Supply of Empresas Publicas de Medellin

Empresas Públicas de Medellín (EPM), is a Colombian company in charge of providing natural gas by network since 1996. These services are provided to domestic, commercial and industrial sectors of Aburrá Valley, Medellín and other cities in Antioquia. Offering environmentally friendly alternatives.

The natural gas that the company markets and distributes is extracted from one of the greatest productive reserves of Colombia, La Guajira-Mar Caribe, where this fossil fuel, after the extraction process, continues with the separation of waste or liquids that are with the product. At the same time, the gas is transported through pipelines that conduct fuel to a point where it can be distributed to the company (EPM) so that it can proceed with the marketing or distribution to municipalities, residences and sectors dependants.

2.3. Managing environmental impacts in regasification plants.

Regasification plants handle certain both positive and negative environmental impacts facing its conversion from LNG to NG. At the same time, the plants have been taken corrective measures for the negative impacts.

To start talking about plants one should know first, that natural gas is the fuel that generates less environmental impact relative to other fuels such as: oil, carbon, Diesel and others. Since this object under investigation as indicated (Petrotechnical, Natural Gas and sustentabilidad. its role in mitigation, 2009, p 71) in the next extract is feasible: "Depending on the quality of

the gas mixture and according to the development of the burner appliances, its combustion emits 40% to 50% less CO₂ than coal."

With regard to the above, natural gas also reduces the emission of hydrocarbons (HC) and carbon dioxide (CO₂) based on other fuels. Besides this, natural gas also has smaller amounts of sulfur and as more hydrogen atoms, causing the above described characteristics a decrease in respiratory diseases and reduction in global warming. Based on the factors above natural gas brings great demand especially in the domestic sector and for power generation.

Finally, the object under investigation entails the production of methane, which is characterized for being highly aggressive to the environment, thus promoting global warming; in other words this fossil fuel has a negative effect to the environment in the long term.

Regasification plants handle the following environmental impacts:

NG emissions: No emissions of natural gas exist in the operations of the regasification plant, but the plant has a gas capture system, to avoid the emissions. In addition to this the plant will have cold vents to be implemented in emergency situations or security.

Gas emissions: As for the Liquefied Natural Gas (LNG) when entering the supply chain from its conversion, transport, and current state from liquid to gas. Given these processes, CO₂ emissions increase by 11 to 18 percent, which is the main cause of climate change. The following Chart displays in a clearer way the CO₂ gas emissions generated by each process, cooling, transportation and regasification.

It is most relevant to this research the gas emissions latter stated. Which shows us in this Chart the amount of additional gases emitted by 2-3. The following data shows as an example the emissions of greenhouse gases in the carriage of LNG to California as some greater or lesser effects can also be generated on other regasification plant.

Chart 1. Percentage of the different uses of natural gas by 2004.

Pasos del proceso	Uso de gas adicional (Por ciento)
Gas natural doméstico	Caso base
Licuefacción	9 – 10
Transporte	7 – 9
Regasificación	2 – 3
Dioxido de carbono en el gas	0 – 18
Total adicional gas consumido	18 – 40

Fuente: Powers Engineering 2004, 1 junio 2004, Global LNG Summit Presentation.

Evaporation: Liquefied natural gas (LNG) as indicated by Mr. (. Arias, 2006, p 13) in the regasification plants has as an effect "The large amount of methane that is vented at different

stages, with the coefficient of contribution to greenhouse effect of methane almost 22 times that of carbon dioxide". This gas is called "flash gas". This gas occurs due to heat generated by the environment, barometric climate changes and tank pumps.

Moreover, the plants are characterized by not emitting harmful liquid smoke or gases to the atmosphere, also bringing along cooling at low levels of fresh or salt water depending on the methods of regasification plants.

The water is returned to 3-5 ° C colder than the temperature of uptake (used seawater) It is not expected to make any chemical treatment to seawater, however if necessary the water would be treated be returned to the sea in similar conditions to the acquisition. As the company states (Carrier of Gas Canarias, 2007).

Based on the above, it should be understood that some plants pour cold water from their regasification processes into the rivers, since the temperature will return to its current state in a shorter time compared to the seas.

In relation to the preceding paragraphs, Mr. Coequyt A. et alt. (2006) states the following about the LNG: "The open process of liquefied natural gas requires the removal of 500 to 1000 million liters of water daily, which is dissolve chlorinated like its conversion from LNG to Gas". It is important to note that this type of chlorinated water are toxic to marine life as they hurt the functions of reproduction, feeding and breathing of the species, and they can also cause effects such as gene mutation and death. Mr. Barragan (2010) reveals one of the effects caused by chlorinated water. He says "In the seas, chlorinated water does not dissolve but contracts with other substances, which would be forming a chlorinated organic compound, maintaining its toxic effect in the long term."

Waste management: These are classified in the plant as hazardous and non-hazardous, which are generated repetitively such as: office waste, packaging, waste oils, hydraulic fluids, used batteries, disposable chemicals and used containers of chemicals and other pollutants or residual factors.

Regasification plants to this factor have the implemented measures such as the separation of hazardous and nonhazardous waste recycling and reusing the first, thus causing elimination of hazardous waste.

Burning or combustion: A method implemented to remove carbon dioxide generated by burning the gas, which will only be implemented in plants under emergency conditions.

With regard to ships, they represent danger ,just as the regasification plants, of contracting explosion, jeopardizing the lives of beings who are in that environment, tragedies and expenses. Likewise, it is also important to know that the plant is located at a distance away from nearby communities to avoid causing any harm to the population.

On the other hand, regasification plants seek to prevent risks through equipment with spill prevention system, automatic fire suppression, fire and gas detection, LNG level, smoke

alarm system, spill containment system and video surveillance system, taking into account trained personnel for certain tasks.

2.3.1. Management associated with technological impacts of regasification plant

The regasifier features high efficiency engines, bringing lower emissions, and greater flexibility for configuring operations. Also regulates more strictly negative environmental impacts.

It also has the most modern control and security systems, providing maximum efficiency to the plant.

With regard to the above it should be noted that the plant technology is selected considering the temperature of the salted waters, water clarity and sea saline level, rules, type of regulations and energy consumption.

2.4. Marketing flows both internally and externally

2.4.1. Policy and regulation framework of natural gas service in Colombia

According to a research by the UPME called "Indicative Plan of Natural Gas Supply" the legal framework governing the natural gas in Colombia is enshrined in the Constitution of Colombia, the State maintains continuous regulation and oversight of public services as they are something inherent in social responsibility.

According to the provisions of Law 142 of 1994, marketing of gas and its complementary activities are part of essential public services and therefore the State ensures the provision, quality and arrangement thereof through official, joint ventures or private enterprises.

Due to shortages of natural gas in 2007, they gave rise to Decree 2987 of 2008, by the Ministry of Mines and Energy

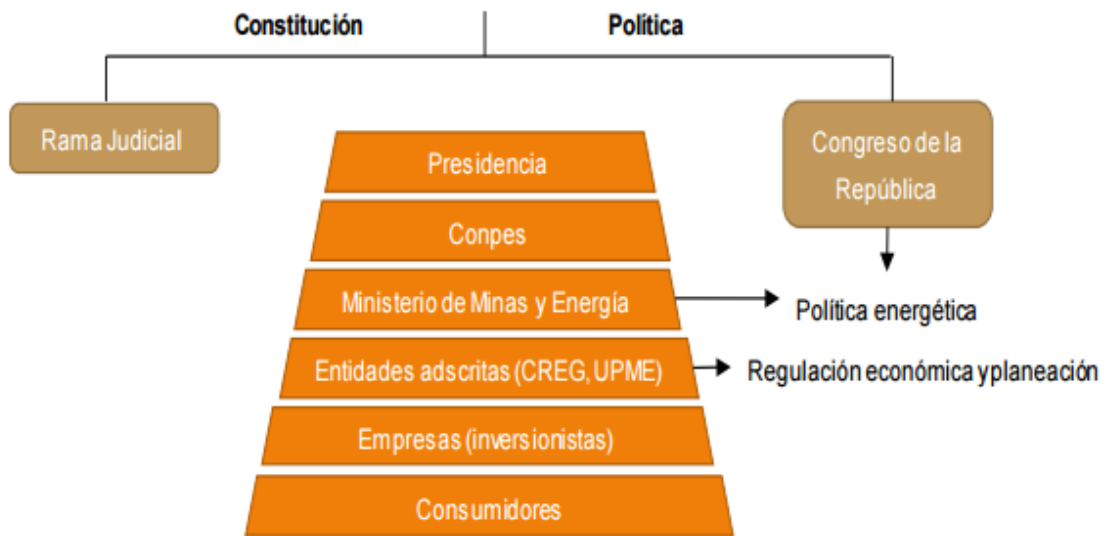
"Who ordered that transporters and distributors of natural gas and any other agent, could include in their investment plan those required to ensure reliability in providing the public service of natural gas" (UPME, 2015)

In progress of this decree, the CREG issued the Resolution No. 075 of 2008, which gave incentives for companies to start marketing and distribution projects that could ensure the security of gas supply. Then the National Government issued Decree 2730 of 2010, which established other duties to obtain better reliability. This was supplemented by Decree 2100 of 2011.

The natural gas industry is characterized for being an industry that needs a lot of capital since the beginning of its chain, due to the costs in its infrastructure, processing, transportation and storage among others. It is necessary that the government is continuously regulating the industry as it directly affects the whole country by the increase of its demand.

These laws also established duties for producers and importers of natural gas, such as making a report on the quantities of natural gas (a monthly daily average) that were available for marketing and the other amounts that were committed by supply contracts, this is written Article 9 of decree 2011 of 2011. Regarding this, the Ministry of Mines and Energy issued resolution 2014 72206 which publishes a report on the production and marketing of each natural gas producing agent. (P. 30-31)

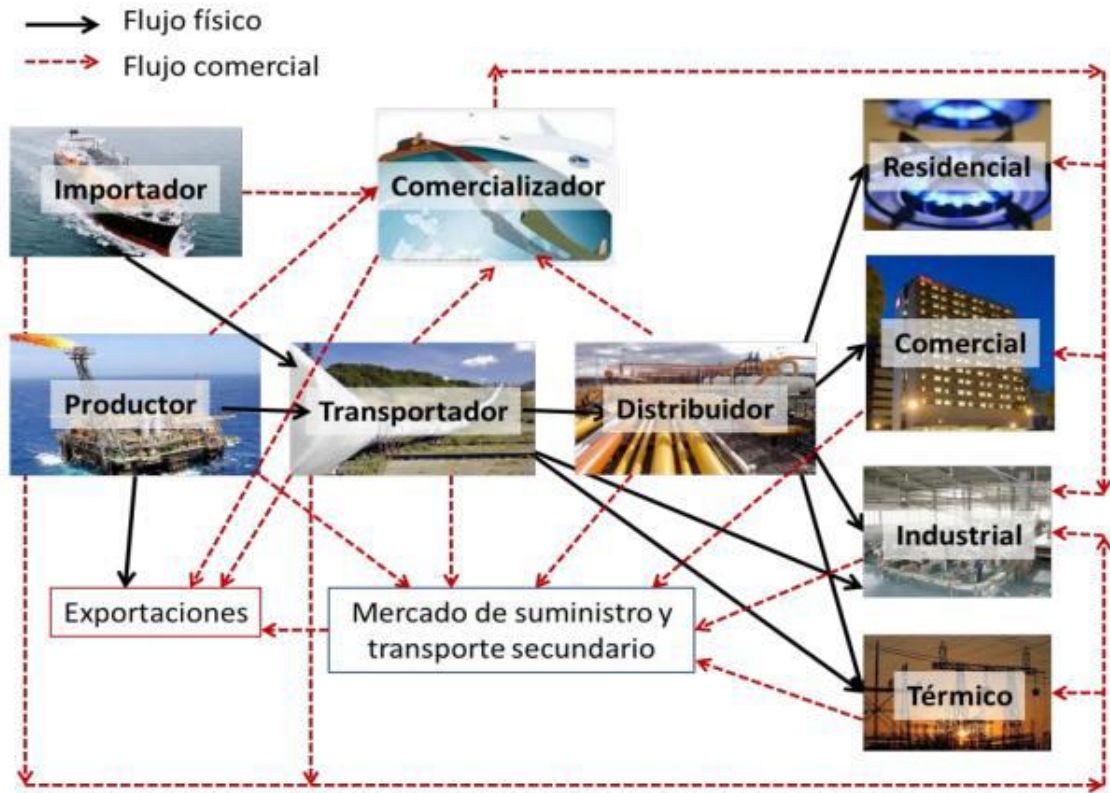
Image 3. Institutionalization of the natural gas sector in Colombia.



Fuente: UPME.

2.4.2. LNG marketing flows in Colombia:

Image 4. Commercial Structure of natural gas in Colombia.



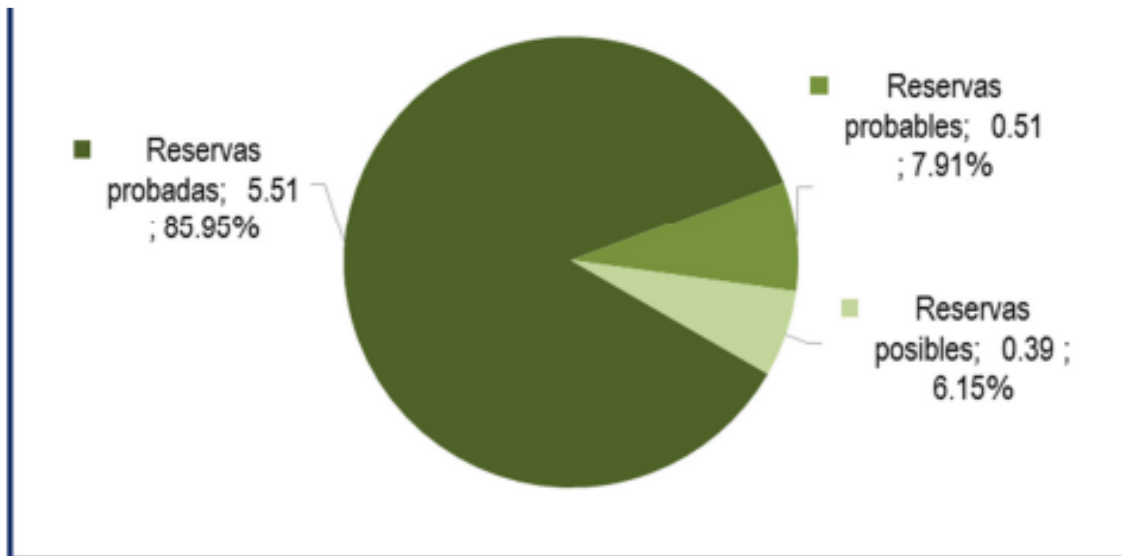
Fuente: UPME.

In the first instance natural gas reserves in Colombia and where they are located will be discussed, then, the issue of supply and demand that natural gas has in Colombia and its relation to international will be addressed.

According to a report of the Mining and Energy Planning Unit (2015) it was indicated that:

The country as of December 31, 2013, registered a total of 6.41 TCF (Tera cubic feet) of natural gas reserves. 86% are probable reserves with 0.51 TCF, 6% is for the possible ones with 0.39 TFC. Speaking as proven reserves, these are mainly located in the basin of the Llanos Orientales (eastern planes) (50%) of the total, after, the basin of La Guajira (31%) and the remaining are located in the basins of the lower valley of the Magdalena , Middle Valley, Upper Valley and Catatumbo (19%). Probable reserves are located in the Llanos Orientales and the lower Magdalena valley with a relative share from 34% to 37%. Finally 58% of possible reserves are in the lower Magdalena Valley, and the other 18% in the Middle Magdalena Valley and 15% in the Llanos Orientales basin. In the following graphic (graphic 1) total reserves (probable, proven and probable) of Colombia on the date mentioned are shown.

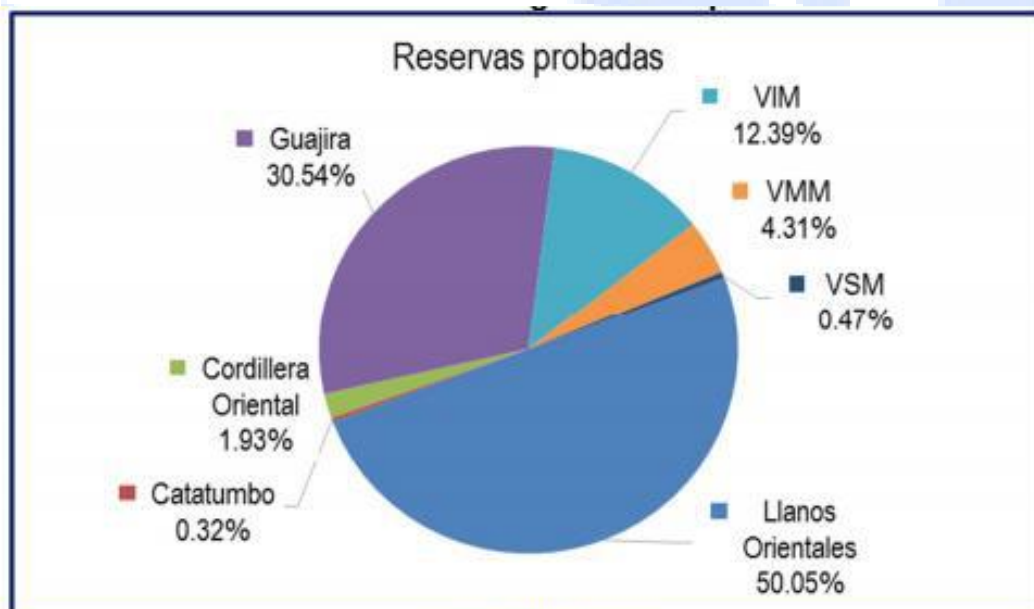
Graphic 1. Natural gas reserves in Colombia



Fuente: MME. 2014

The fields in the basin of the Guajira (Chucupa, Ballena, Riohacha) do not contribute to the category of probable and possible reserves. The graphic No. 2 shows the distribution by basin of the different categories of reserves.

Graphic 2. Reserves of natural gas per basin



Fuente: MME. 2014

For an even better explanation, UPME (2015) talks about the increase in domestic consumption of natural gas and states that Colombia has natural gas self-sufficiency until 2021.

2.4.3. Import or export of natural gas in Colombia?

In recent years countless news about the problem that Colombia is facing due natural gas have been published, as the country has made great efforts to amass the culture of using gas, in other words, generating great demand but forgetting to continue generating offer, because as demand increases we need will need more coverage.

The 2015 UPME report, which has been mentioned throughout this work, shows and confirms the status of medium supply and demand the country is going through, since according to its report and the news that have circulated it will be more likely the need for the Cartagena regasification plant to begin its operation urgently to achieve the supply of natural gas.

In this report, the (Mining Planning Unit, 2015) states: "the regasification plant will also have to be used to supply not only the thermal sector but also the non-thermal as it is the industry and housing sector".

According to a report in the "El Tiempo" newspaper, J. Guillermo Londoño (2015) president of the power generator Celsia discloses what would happen if the above is not complied with:

"In the absence of this additional supply scheme by the end of 2017, and given the middle scenario here raised, the country would be faced with serious problems of demand attention" says the UPME agency in its recent gas balance 2015-2023.

In this scenario there could be a shortfall of about 95,000 million BTU (British unit of calorific value) per day in 2023, shortage that could be advanced and available by next year (2017), by the order of 140,000 million BTUs per day. This case if there was high demand and low supply.

The concern of the heat sector lies in the fact that if the regasification plant was planned as a backup, mainly for times of extreme drought, with this new scenario where demand increases and supply does not increase at the same pace, those using gas will pay price higher than predicted.

However, the Colombian Association of Natural Gas (Naturgas) indicated that the offer could also increase with the expansion of the pipeline currently from Cartagena to Sincelejo. On the other hand the ANH (National Hydrocarbon Agency) signed 354 exploration contracts with international companies and the construction approved by the CREG (Regulatory Commission for Energy and gas) of the regasification plant located in Cartagena, as it is expected that the use of the plant releases larger volumes of natural gas, which mainly remain available on the North Coast market.

2.4.4. Supply and demand of natural gas:

Between demand and supply, both parties are described in a scale where first predominates the consumption of the service nationwide in four sectors and consumers abroad (Venezuela). However the behavior of these two factors has not been very sChart since 2013, as Colombia does not have enough supply to meet the demand that has been occurring for years now.

The offer has less participation since the Colombian territory is currently exploiting two reserves that are considered probable reserves and of greater contribution to the society. These Reserves are: the Guajira and Cusiana that currently contribute to the participation of 56% and 25% respectively of the local production. Where their participation together, adding the other small reserves, make an insufficient supply of 12.8 natural gas (CNG). Knowing well that the country aims to distribute and supply natural gas to the following domestic consumers: consuming compressed natural gas with 7.4% and 6.1% domestic use, increased consumption of industry was only 4,5%, while the consumption that presented contraction was Ecopetrol's, for self-sufficiency, reducing it by 11% among other national consumers. It should also be noted that Colombia is exporting natural gas to Venezuela giving this country 13.4% of its production mainly. Which by the month of July this year will start exporting this particular resource (natural gas) to Colombia.

With regard to supply, an increase has been occurring compared to previous years, since for 2014 a growth of a 31394 MCFD of natural gas is presented according to virtual documents, not being of great satisfaction for the Colombian people. Since, there is not still enough supply of natural gas relative to demand, given that there are occurring problems of over-regulation of the market and high concentration in the sector of production and transportation, among the most important.

Colombia has been evaluating and implementing new methods or strategies in 2016 to address this problem and controlling the demand that occurs internally. Firstly, Colombia will begin to supply (import) Liquefied natural gas to the city of Cartagena - Bolívar department. To fulfill that supply the regasification plant is at work, which would be completed based on documents for the month of December 2016. It should be emphasized that in addition to this new implementation to meet demand also the country appeals to the exploitation of possible and probable reserves. Based on probable reserves (oil, Plan Indicativo de Abastecimiento de gas natural, 2015) gives us to know the following:

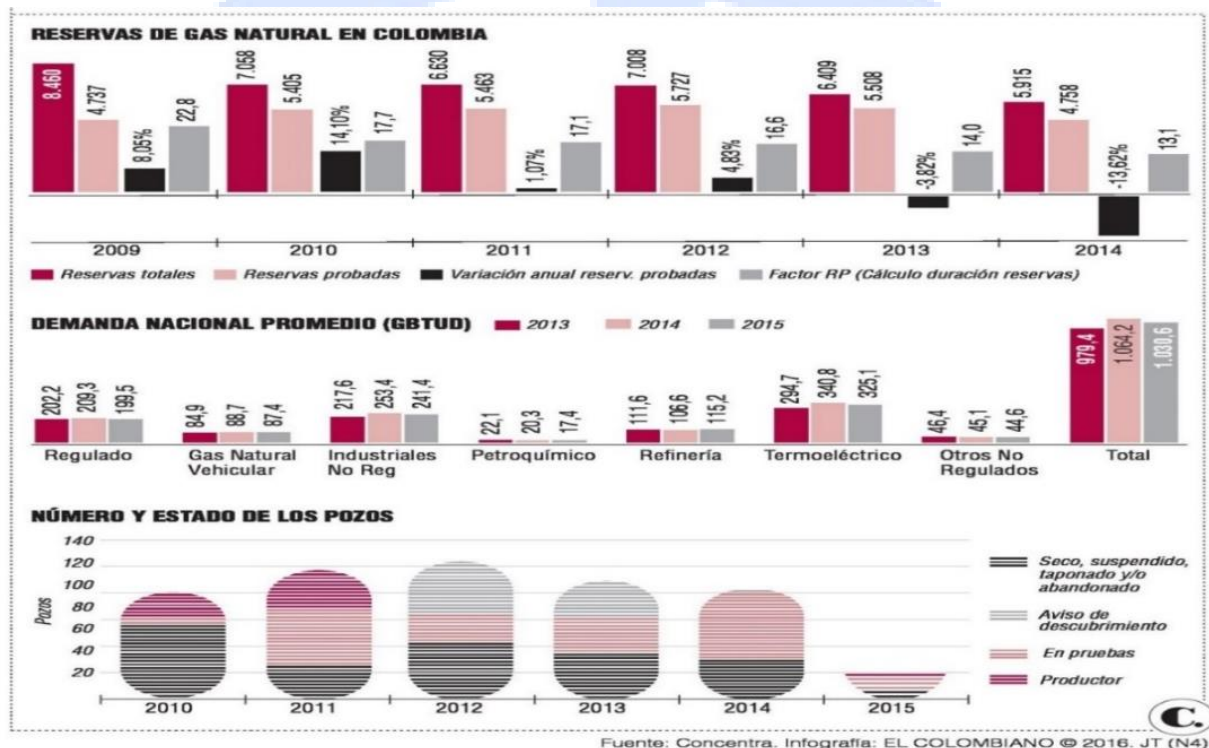
Given that the probability of having such volumes is of 50% and 10% respectively, uncertainty about the availability of these volumes is less compared to proven reserves. In addition, the current and prospective situation of oil prices could cause delays in necessary investments to produce natural gas from the mentioned reserves.

Regarding the above, stability, weakness and investment in supply, brings along multiple factors as the years go by, since natural gas is increasing in relation with previous percentages, having as a consequence the increased level of domestic consumption, which generates in the market the national price of Elastic natural gas to consumption, since this service or distribution presents short supply and great participation on demand. Therefore,

the rise of gas price is not well adjusted, being that if gas increases its prices demand would tend to lower. A clear example is as follows (UPME, 2014):

Regardless thermoelectric, price elasticity - demand increases by 0,035; without thermoelectric or Ecopetrol, the elasticity rises to 0.7. The sectors that have revealed demand sensitivity to changes in prices are CNG and domestic with 1.12% and 1.03%; this implies that a 1% increase in prices of gas produces a variation in gas demand more than proportional in domestic sector and CNG (decreased by 1.12% and 1.03% respectively).

Graphic 3. Figures of gas reserves from 2009 to 2014.



Domestic demand for natural gas is 1,100 GBTUD (Giga BTU-British Thermal Unit-day) counting and a temporary failure of NG of 390 GBTUD. This rapid increase in domestic demand has increased 9.1% (y.o.y), which is featured in both sectors (thermal and non-thermal). The following are highlighted: Households with 39.3% and 21.8% industry. These indicators show the growth in demand in the country given that it has become an efficient energy resource for housing and Colombian industries.

Although the demand is progressive, supply does not have the same luck, since the supply of natural gas is lower than demand or local needs from different sectors of the country that demand, since according to the producers, in 2014 It corresponds to an average production potential of 1100 GBTUD for the next 10 years. This will force a segment of demand that is not essential rationale, to not have access to this fuel.

Chart 2. Figures of the gas sector in Colombia from 2010 to 2014.

CONCEPTO	2010	2012	2014	TENDENCIA	AVANCES
EXPLORACIÓN					
POZOS A3	112	131	113		✗
SÍSMICA - km EQUIVALENTES	25.973	18.259	40.499		✓
RESERVAS TOTALES - Gpc					
PROBADAS	5.405	5.720	4.759		✗
PROBABLES Y POSIBLES	1.653	1.310	1.156		✗
PRODUCCIÓN - Gpc					
LLANOS ORIENTALES	818	775	684		✗
LA GUAJIRA	251	220	187		✗
VALLE DEL MAGDALENA	68	78	74		-
PUTUMAYO	4	6	8		✓
CATATUMBO	2	2	2		-
CUENCAS MENORES	0	2	3		-
SUMINISTRO - Mpcd					
LLANOS ORIENTALES	232	377	525		✓
LA GUAJIRA - CONSUMO NACIONAL	525	417	447		-
LA CRECIENTE	59	62	58		-
GIBRALTAR	0	27	31		✓
OTROS	54	57	46		✗
LA GUAJIRA - EXPORTACIÓN	156	186	85		✗
TRANSPORTE					
KILÓMETROS DE GASODUCTOS	7.356	7.643	7.702		✓
EMPRESAS TRANSPORTADORAS	7	7	7		-
GAS TRANSPORTADO - Mpcd	915	895	1.028		✓

Fuente: Acipet, ANH, Concentra, Ecopetrol, empresas del sector, Ministerio de Minas y Energía, SUI, UPME.

The Colombian territory must prepare retaliations to the situation of shortages of natural gas expected by 2018, to the import of hydrocarbon or the exploitation of new reserves since this fossil fuel has had great demand for the country at a local level and besides this, it registers lower prices compared to other fuels.

Given this situation and the limited production which Colombia currently counts with one can say that this country requires large investments to have new reserves for exploitation, unconventional reservoirs and also to prevent the shortage that is anticipated. Relatedly (Lloreda, 2015) states "between 2015 and 2028 proved reserves will decline 5% annually; that is, a deficit from 2018, and on the Caribbean coast from 2017".

On the other hand, Colombia will start importing natural gas from Venezuela. The country will also perform imports through the regasifier to another possible supplier, consequently resulting in higher prices for the plaintiffs of hydrocarbon in the Caribbean region, since it is

generated more expensive due to difficulties in transporting such fossil fuel. Having prices of 5 USD per million of BTU. Notably, the gas in Latin America is worth \$ 11 per million BTU, thus characterized for being cheaper than oil.

2.4.5. International Trade:

Chart 3. International Prices

COMBUSTIBLES	2010	2011	2012	2013	2014	TACC 2010-2014
PETRÓLEO WTI - US\$/bl						
Mínimo	64,8	75,4	82,3	92,0	59,3	(2 %)
Máximo	91,5	113,4	106,2	106,6	105,8	4 %
Promedio	79,5	94,9	94,1	97,9	93,3	4 %
CARBÓN 11.300 Btu - US\$/t						
Mínimo	58,9	96,9	73,4	63,5	62,4	1 %
Máximo	100,3	120,8	97,6	81,5	74,0	(7 %)
Promedio	76,9	108,4	83,2	71,1	66,2	(4 %)
GAS NATURAL HENRY HUB - US\$/Mbtu						
Mínimo	3,2	2,8	1,8	3,3	3,5	2 %
Máximo	7,5	4,9	3,8	6,0	6,0	(5 %)
Promedio	4,4	4,0	2,8	4,1	4,4	0,1 %

Fuente: EIA, Coalmymex, BP Statistical Review of World Energy 2015, Platts.

With regard to international trade in LNG, in 2014 the record high of 331.1 billion m³ was obtained, ending with this figure the downward trend of the years 2012 and 2013. The Asian Pacific region has become the natural epicenter of LNG trade. To this region belongs Japan, South Korea, China and Taiwan, recipient countries of 64% of world trade of this fuel. Additionally, in this same region are located large exporters such as Malaysia, Australia and Indonesia, which participate with 28% of total world LNG exports. (PROMIGAS, 2015)

Chart 4. Exporters of LNG in m2 billions – 2014.

EXPORTADORES

IMPORTADORES	QATAR	MALASIA	AUSTRALIA	NIGERIA	INDONESIA	TRINIDAD Y TOBAGO	ALGERIA	RUSIA	OTROS	TOTAL IMPORTACIONES	PARTICIPACIÓN
JAPÓN	21,9	20,3	25,0	6,5	7,8	0,2	1,0	11,5	26,3	120,6	36 %
COREA DEL SUR	17,7	5,1	1,2	4,4	7,1	0,2	0,5	2,6	12,4	51,1	15 %
CHINA	9,2	4,1	5,2	0,6	3,5	0,2	0,3	0,2	4,0	27,1	8 %
INDIA	16,2	0,1	0	1,2	0	0,1	0,2	0	1,2	18,9	6 %
TAIWÁN	8,0	3,9	0,1	0,2	2,8	0,1	0,1	0,1	2,9	18,1	5 %
ESPAÑA	3,0	0	0	2,7	0	2,0	4,9	0	2,8	15,5	5 %
REINO UNIDO	10,4	0	0	0	0	0	0	0	0,9	11,3	3 %
MÉXICO	1,4	0	0	2,5	0,3	0,4	0	0	4,7	9,3	3 %
OTROS	15,6	0,5	0,2	7,3	0,1	16,1	10,2	0,1	10,9	61,1	18 %
TOTAL EXPORTACIONES	103,4	33,9	31,6	25,3	21,7	19,3	17,3	14,5	66,1	333,1	100 %
PARTICIPACIÓN	31 %	10 %	10 %	8 %	7 %	6 %	5 %	4 %	20 %	100 %	

Fuente: BP Statistical Review of World Energy 2015.

2.4.6. Exports to Venezuela:

Since the late 2007 and early 2008 Colombia sends natural gas to western Venezuela through a pipeline that starts from Campo Ballenas (in northern Guajira), operated by Chevron (US) and oil company Ecopetrol. This natural gas helps make up for the deficit suffered by this part of Venezuela.

Although the company Petroleos de Venezuela SA (PDVSA) gave several statements which reported that they had decided not to proceed with the contract of gas supply with Colombia (Until June 30, 2015), as they explained that gas exports by part of Colombia were being very irregular in recent months and had even come to reach zero gas sent and that this was the reason that led them to make that decision.

Some Latin American countries have been implementing the natural gas market, this being termed as one of the most dynamic and fast growing markets nationally and internationally. At the local level natural gas continues to introduce increases, thus replacing other fuels such as oil and water power for power generation. Internationally natural gas has presented a change in South America going from 14% in 1994 to 19% in 2005. It is important to note that this growth has been unstable; this means that not all countries in South America have the same supply of gas.

2.4.7. Main markets of neighboring countries

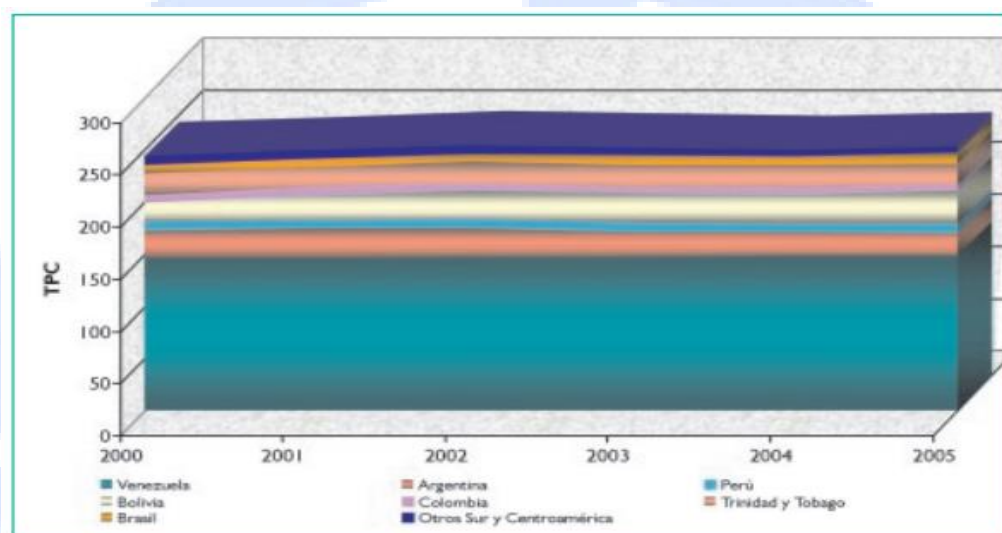
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Graphic 4. Evolution of natural gas reserves in Latin America



Fuente: BP Statistical Review of World Energy, 2005 y OLADE.

Performing a focus on the country of Venezuela, this is concentrated in the oil industry which consumes about 70% of the generated gas. 47% is taken for the recovery of oil, 24% is implemented for fuels and finally 9% for the transformation of natural gas to liquid and the rest is distributed to the other activities of input.

As it has been discussed in the development of this research on the export that the Colombian territory has been performing to the country of Venezuela, through a supply contract with the Colombian oil company Ecopetrol and its American partner Chevron to exchange methane gas through the pipeline, this contract will end in the month of July. Since PDVSA through (Hernandez, 2015) says the following about the termination of the contract. "The ending of the contract is due to the irregular supply by Colombian counterpart".

From the ending of the contract onwards, Colombia starts to import natural gas from Venezuela, ie, the country of Colombia will have increased supply of natural gas from Venezuela and the regasification plant, with which the demand is meant to be met (Equilibrate internal market).

2.4.8. Variation in prices and gas production

For a few years natural gas has gained strength in the energy sector as an option to generate power, therefore is increasingly getting demand and a little less supply. Based on this inequality, irregularities have been generated along with changes in prices and in the production of natural gas.

According to an article in Dinero magazine (2015) which cited a report of the Unit of Mining and Energy Planning (UPME), indicates that the reasons for this problem are based in the fact that this fuel is playing an important role in the demand that has been present specially in energy because of the low costs that it has in respect with other fuels and energy sources.

In this same article it is shown that the most expensive production is unconventional due to the technology required for extraction. Between 2010 and 2014 total production passed from 15% to 20%. It is expected to represent 29% of the world's gas production in 2030.

Although a drop in production was registered in 2012, a 3% increase was recorded in 2014. A precise example is the United States since it has 23% of the world supply of gas and by the end of 2014 it was increased by 17, 4% of its production, compared to the end of 2013.

2.4.9. Prices

As for the fall in international oil prices, this is making an impact on prices of natural gas. In April 2015 oil prices plunged 43.8% compared to April 2014, thus this behavior spreads in the dynamics of gas prices which fell 44.6 in the same period.

According to what is expected by the International Energy Agency (IEA) it is estimated that the reference price of gas 'Henry Hob' will present a fall if the pace of supply does not meet the pace of growing demand, therefore they suggest that a strategy must be created that allows to lower production costs, invest in research of possible reserves and thus achieving the leveling of supply and demand.

2.4.10. Production and reserves from 1990 to today.

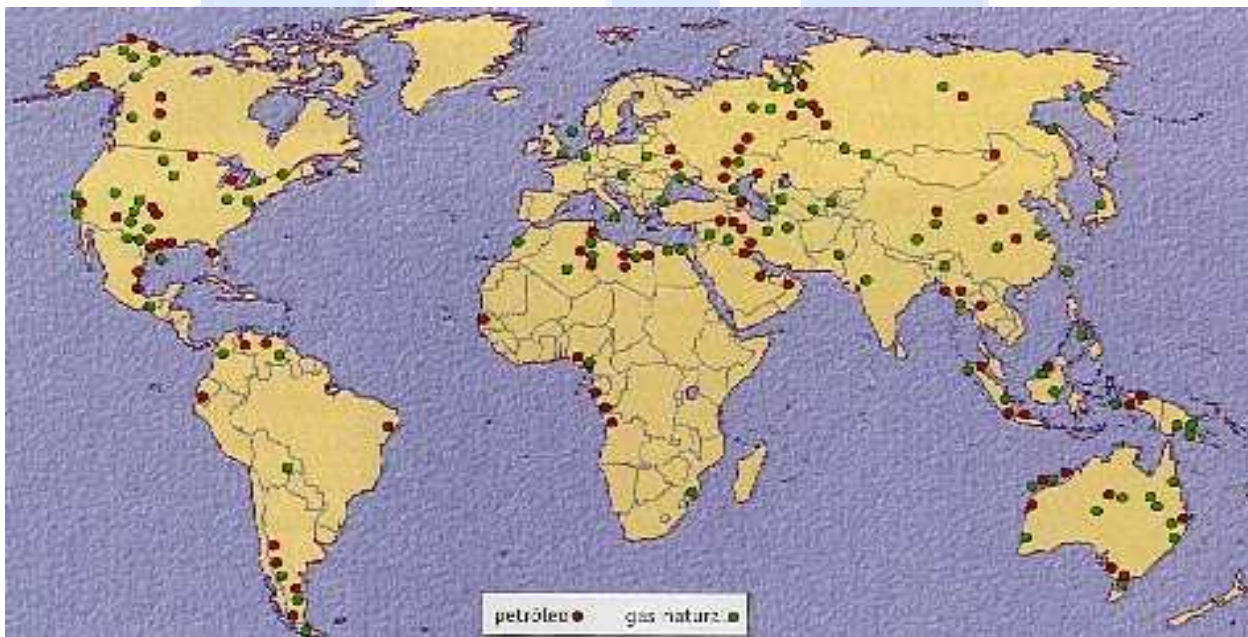
Before talking about countries that have large reserves of natural gas, it is worth mentioning that the deposits of natural gas can be continental or maritime. According to (Dunham, 1985) "the largest known reserve in the world of natural gas is in Western Siberia".

In 1994 a book entitled "Information technology vol. 5 No. 2" is published, where countries containing the largest reserves of natural gas are reported. In their order are: former USSR, Iran, United Arab Emirates, United States, Saudi Arabia, among others. As the largest producers of this fuel are: Former USSR, USA, Canada, Netherlands, United Kingdom, followed by others. This production is because these are countries that are increasingly strengthening the exploration and discovery of new deposits.

By 1995, the Commonwealth of Independent States (CIS) has the largest reserves and in turn is the largest producer since it has more than 600 gas wells, mostly located in Siberia, Ukraine and the Arctic Ocean. As its main export markets for natural gas are Europe and Japan.

Holland, France, Britain and Germany have large reserves of NG and are supplied through the North Sea reservoir. On the other hand, producing countries are the Netherlands, because it has a pipeline that starts in the reservoir of Groningen in the north of the Netherlands and which supplies most of Europe, followed by United Kingdom, which is also one of the largest producers thanks to constant explorations for gas in continental and marine deposits, but it does not have large reserves. And finally there is Norway, which contrary to UK does have large reserves that come from the North Sea deposits.

Figure 5. Reserves of oil and natural gas worldwide.



Over the years, we see the need for further exploration of this fuel, because demand is increasing, according (Echavarría, 1998) by 1990, "there were enough localized deposits of oil for another 40 years (until 2030) and of natural gas for about 60 years," according to this, we might conclude that there would be reserves of both oil and natural gas for at least the next 100 years. Another relevant data, as expressed on this page, is that fuels, both oil and natural gas, are more consumed in countries that do not produce them, for example, countries such as those in the Persian Gulf produce 26% and only consume 4,5%. However, this may escalate few years later, because the countries that consume less such fuels are exploring their lands and discovering new reserves of oil and natural gas. Today, it is known that reserves accumulate 57% of the countries of the Persian Gulf.

2.5. SWOT MATRIX

This SWOT matrix is performed to obtain a diagnosis on the situation of the Cartagena refinery in the natural gas market in Colombia.

<p>WEAKNESSES:</p> <ul style="list-style-type: none"> • Colombia no longer has sufficient reserves of natural gas. • Rising prices in this fuel. • The government does not encourage exploration and research of new natural gas reserves. • Termination of the contract in July 2016 where Colombia maintained trade relations with Venezuela. 	<p>THREAT:</p> <ul style="list-style-type: none"> • High levels of corruption. • Long-term recovery of investment in the construction of the refinery in Cartagena.
<p>STRENGTH:</p> <ul style="list-style-type: none"> • Natural gas helps mitigate environmental pollution. • Already has a plant, despite cost overruns. 	<p>OPPORTUNITY:</p> <ul style="list-style-type: none"> • To achieve balance in demand and supply. • Improve indicators of environmental pollution, if the use of this fuel is increased.

The above matrix helps to be clear about the strengths, weaknesses, opportunities and threats of this issue, providing a comprehensive and holistic view of the situation in which it is currently.

2.6. DEVELOPMENT OF FIELD WORK

2.6.1. Interviews

Here are presented the questions with their respective answers of the two respondents who were Federico Atehortua Professor of Sustainable Development at ESUMER University and Juan Miguel Higuera García employee of EPM. Answers shown as they were provided to respect their authorship.

2.6.1.1. First interviewee: Federico Atehortúa, Chemical Engineer, Master in environment and development. Training and research Coordinator of Knowledge Management S.A.S business consulting, and Professor of the course Sustainable Economic Development at the University Institution ESUMER.

- **How important is for Colombia a regasification plant in environmental, economic and commercial matters?**

The regasification is a stage of the gas chain, which converts natural gas into liquefied natural gas. It is essential for the distribution of gas, so the existence of this type of plants is essential for the country to make extensive use of this fuel.

- **Do you know what are the advantages of natural gas over other fuels such as oil, gas and coal?**

More than the plant (s) of regasification, the important thing is the mass use of natural gas, a cleaner fuel than other fossil fuels (such as diesel, gasoline or Castilla crude). In principle it is also cheaper, although with the current supply problems it is increasingly becoming more expensive.

- **What are the marketing flows in Colombia today? Are we importing or exporting?**

At present, our country is not self-sufficient in gas, which has created the need to import from Venezuela. Demand for gas has increased substantially with the shortage of hydroelectricity, which has forced generating companies to turn on thermal plants that consume gas.

- **Do you know where the largest reserves of natural gas in Colombia are located? If so, mention where these NG reserves are located in Colombia.**

Traditionally it has been considered that La Guajira area has the greater gas reserves in the country.

- **How prepared is Cartagena refinery towards facing the shortage of natural gas expected for the coming years?**

Since the refinery is a processing plant, it itself does not solve the supply of raw material. The coking plant Reficar can produce liquefied petroleum gas, but that production will be subject to the availability of oil for refining.

- **With which neighboring countries could have Colombia a business relationship to cover the shortage of natural gas for the coming years?**

Venezuela and Ecuador evidently because of their geographical proximity. Something might be thought about from Bolivia, but the distances and lack of suitable transport mechanisms hamper the gas supply logistics.

- **What were the reasons that explain why Colombia no longer has the reserves it once had and therefore not having enough to cover domestic demand?**

The combined demand that gas vehicles, companies that consume gas in their processes and thermoelectric generation represent was underestimated.

- **How much has changed the price of natural gas in Colombia in recent years and what is the reason for the variation?**

The price has increased to the extent that the supply has decreased and demand has grown. The other is that as the oil prices have fallen, gas prices have become less competitive.

- **What opportunities and weaknesses are present with the construction of the refinery in Cartagena to Colombia?**

The weaknesses have jumped into view after construction: huge cost overruns associated with alleged corruption and mismanagement of both agents of the Colombian state and contractors. Those overruns will have the consequence that the company will generate profits in a longer time horizon, while the investment is recovered. In terms of opportunities, it is evident the potential of refining that the country has, both to supply Colombia and to think about exporting. However, as the proven oil reserves in Colombia do not go beyond 8 to 10 years that will mean that crude oil is imported for refining in the near future.

- **How are companies benefited with the purchase and sale of gas emissions into the atmosphere?**

I do not see much the relationship of the question with the rest of the topic. But you could say that the main benefit for businesses is economic: they might access additional income on projects that develop when selling on the market the reduction of emissions of greenhouse gases.

2.6.1.2. Second interviewee: Juan Miguel Higuera Gaviria, an employee of EPM, C Professional Regulatory Management, transactions and markets.

- **How important is for Colombia a regasification plant in environmental, economic and commercial matters?**
-

The importance of this plant is that it will allow the country to have an additional source of gas supply, especially power plants that will be its natural client. The fact that power plants are supplied with this plant, will free gas from the Guajira sources for regulated demand, unregulated and VNG, which will boost these sectors and strengthen the growth of these demands, growth that is now unsafe because the deposits of the coast are in decline reflecting a risk to migrate to the consumption of natural gas, fuel economical and environmentally friendly. Environmentally, it would improve since as natural gas is a fuel friendly to the environment it will produce better environmental conditions in those demands that use other fuels that are not. On the commercial side, it will allow Colombia to open the doors to the world in relation to the marketing of natural gas, as currently, Colombia for being a producer does not import gas, so this plant will achieve an economic and trade liberalization in this type of fuel.

- **Do you know what are the advantages of natural gas over other fuels such as oil, gas and coal?**
-
- The combustion of natural gas leaves no consistent residue.

- There is much natural gas in the domestic and international markets.
- Natural gas is economical to extract, transport and burn.
- Natural gas is flexible in use.
- It continuously reaches the point of consumption.
- It has high energy efficiency

- **What are the marketing flows in Colombia today? Are we importing or exporting?**

Colombia currently does not import or export natural gas. Domestic demand in the country is supplied with Colombian natural gas. Until July 2015 gas was exported to Venezuela, with the condition that Venezuela would return the gas from July 2015. Up to date due to the political conditions in Venezuela the return of this gas has been unable to be reconciled. From December 2016, Colombia will import liquid natural gas through the regasification plant.

- **Do you know where the largest reserves of natural gas in Colombia are located? If so, mention where these NG reserves are located in Colombia.**

The largest production fields of the country are located in Guajira (Ballena, Guajira and Chuchupas wells) and Casanare (Cusiana and Cupiagua) which represent approximately 70% of the gas consumed in the country. The largest proven gas reserves are in Guajira (Orka - Off Shore) and Cordoba (kronos - Off Shore).

- **How prepared is Cartagena refinery towards facing the shortage of natural gas expected for the coming years?**

To this question you cannot have a concrete answer, since it is considered that Ecopetrol should have foreseen this fact to build the most modern plant in Latin America. However it should be noted that saying that Colombia will have gas shortages in the coming years may be premature, since negotiations are advanced so that if this situation presents it will not affected demand. The new proven reserves, the new gas exploration that are made every day, the regasification plant of Cartagena, the project of construction of the Pacific regasification plant in Buenaventura, are actions that are made within the country to avoid saying that there will be natural gas shortage.

- **With which neighboring countries could have Colombia a business relationship to cover the shortage of natural gas for the coming years?**

The nearest neighbor and by nature a producer is Venezuela. However the political status of this country does not allow a security of negotiation gas with it. Now, with the entry into operation of the regasification plant in Cartagena, it will allow Colombia to negotiate liquefied natural gas (LNG) with any producing country in the world.

- **What were the reasons that explain why Colombia no longer has the reserves it once had and therefore not having enough to cover domestic demand?**

The fact is that Colombia no longer has the same demand. Demand for natural gas has grown substantially and production wells have been decreasing by this fact.

- **How much has changed the price of natural gas in Colombia in recent years and what is the reason for the variation?**

Prices have changed significantly. Particularly until 2014 Guajira's gas prices were regulated and Cusiana's were free. When Guajira's prices were regulated, this price changed according to the international price of Fuel Oil No. 6 for the past 3 semester periods, which could change substantially. From 2014 both prices were freed and sold according to market performance Vs Offer Demand.

- **What opportunities and weaknesses are present with the construction of the refinery in Cartagena to Colombia?**

While this topic is of broad coverage and does not have to do directly in the production and marketing of gas in Colombia, it is considered important to have a plant of its kind that will allow the country to have not only the availability to produce petroleum-based fuels for own consumption, but also the possibility of exporting them. Today, many of the petroleum-based fuels are imported.

- **How are companies benefited with the purchase and sale of gas emissions into the atmosphere?**

N/A

- **Finally, do you know where EPM is supplied of natural gas?**

EPM is currently supplied from the two main areas of production in the country (Guajira and Cusiana). This can be done because of the geographic location and disposition of the National System of Natural Gas Transportation, a situation that not all regions and cities of the country can do.

2.6.2. PROBE

This survey was conducted through Facebook where a sample of 35 to 40 people was taken depending on their availability and willingness to collaborate answering the survey consisting of 8 multiple-choice questions. According to the results obtained in this survey we know the level of knowledge that these people have about cleaner fossil fuel.

The relevant statistics that leaves this survey were as follows:



2.6.2.1. Survey questions

The questions in the survey are appended below. These questions are multiple choice with single answer, no right or wrong answers as they are personal, that is, according to the knowledge and perspective of each person.

You know what your level of knowledge about natural gas is?

1. Choose which of these fossil fuels is friendlier to the environment:

- Petroleum
- Natural Gas
- Diesel
- Coal

2. What motivates you to choose the fuel you will use for your car or motorcycle?

- Habit
- Price
- Its environmental effects

- I don't have car nor motorcycle

3. Why is natural gas characterized for being friendlier to the environment than other fuels?

- 4. It causes no harm to the environment
- 5. It reduces emissions of carbon gases and hydrocarbons in the atmosphere
- 6. It has no carbon gases
- 7. It is the only fuel tasteless, colorless and odorless

4. Do you think that demand for natural gas for industrial use has increased in Colombia?

- YES
- NO
- N/A

5. What kind of diseases are reduced by increasing the use of natural gas?

- Respiratory diseases
- Cardiovascular diseases
- Bone diseases
- Cancer

6. The gas commonly used in home networks helps the environment because:

- The heat of the gas burners reduces global warming
- The gas is a renewable resource, unlike electric power
- It is economical and does not generate contaminating waste
- It is a mineral origin organic fuel

7. Which of the following cities in Colombia are committed to the environment by providing new alternatives for cleaner fuels?

- Pasto
- Cali
- Bogotá
- Medellín

8. What do you think is the percentage of satisfaction of paisas due to pollution in the current year compared to last?

- It fell from 29% to 21%
- It increased from 22% to 28%
- It decreased from 26% to 15%
- It increased from 18% to 27%

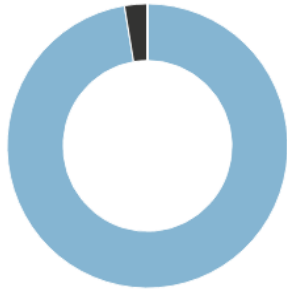
2.6.2.2. Poll results

Graphics with the percentages obtained by each of the alternatives for each question will be annexed below. At the end a general analysis will be presented.

Graphic 5.

Graphic 6.

Elija cuál de los siguientes combustibles fósiles es mas amigable con el medio ambiente:



97% Gas natural 3% Hulla 0% Petróleo 0% Diesel

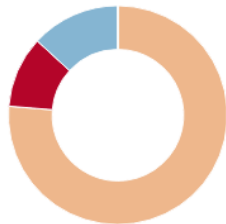
¿Qué lo motiva a usted a elegir el combustible que va a utilizar para su carro o moto?



61% No tengo carro ni moto 21% Por sus efectos ambientales
13% Por el precio 5% Por costumbre

Graphic 7.

¿Por qué el gas natural se caracteriza por ser amigable con el medio ambiente a comparación de otros combustibles?



76% Disminuye las emisiones de gas... 11% No causa ningun daño al medio ...
13% No cuenta con gases de carbono 0% Es el único combustible insipi...

Graphic 9.

Graphic 8.

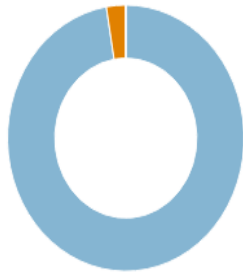
¿Considera que en Colombia ha aumentado la demanda de gas natural para uso industrial?



61% SI 24% NS/NR 16% NO

Graphic 10.

¿Qué tipo de enfermedades se reducen al aumentar el uso de gas natural?



97% Enfermedades respiratorias 3% Enfermedades cardiovasculares
0% Enfermedades de los huesos

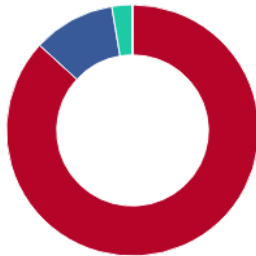
El gas utilizado corrientemente en las redes domésticas favorece al medio ambiente debido a que:



55% Es económico y no genera residuo 21% El gas es un recurso renovable...
16% Es un combustible mineral de origen natural 8% El calor de los quemadores a gas

Graphic 11.

¿Cuál de las siguientes ciudades de Colombia están comprometidas con el medio ambiente brindando nuevas alternativas de combustibles mas ...



87% Medellín 11% Cali 3% Pasto 0% Bogotá

Graphic 12.

¿Cuál cree que es el porcentaje de satisfacción de los países por la contaminación en el año actual en relación al anterior?



32% Disminuyó del 26% al 15% 29% Disminuyó del 29% al 21%
26% Aumentó del 18% al 27% 13% Aumentó del 22% al 28%

Overall analysis

We conclude with this survey of 38 people that their responses indicate that 97% of them are aware that natural gas is more sustainable for the environment, that it is increasingly being more widely used by people. 21% of the sample use it for its environmental effects, followed by 13% who consume it because they consider it more favorable than other fuels such as oil. At least these figures show that there is a precise awareness and education about how friendly the natural gas is to the environment because 76% of the votes considered that the NG reduces emissions of gases in the atmosphere and also considered that respiratory diseases decrease with 97%. According to the report Medellín Cómo Vamos (2016): "the percentage of people satisfied with the pollution in the air fell from 26 to 15 percent between 2013 and 2014".

Finally, with a figure of 55%, people think that gas used for domestic use helps the environment because besides being economical it does not generate contaminating waste, followed by 21% who consider it a renewable resource unlike the electric energy. In general, we see people are somewhat conscious and aware of this type of cleaner fossil fuel, but it is

still required to be developed projects from the government to ensure that at least that 97% of the population as shown by the sample is maintained.

3. Findings

- Based on the research conducted a scenario was found where demand is growing due to high consumption, low natural gas prices, the awareness that some people have made about the environmental benefits that this fuel entails and other factors that have been found in national and international communities. On the contrary supply it decreases each time because at the time Colombia has no natural gas surplus and for this reason it cannot establish surplus export-oriented trade relations.
- Colombia currently does not have sufficient reserves of natural gas since gas industry sector and the state have been limited to exploiting the most important proven reserves in the country, which are Cusiana towards the inner country and Chuchupa in Guajira. Added to this, the economic problems under which the Cartagena refinery is going through as to double its investment budget worsen. There are fears that in

such future investment would not be easily recovered and thus unable to fulfill the expectations for what the plant was designed, since in order for the plant to process and store its full capacity it has to count with significant quantities of this fuel.

- It was found that Colombia makes a minimal investment in academic research to look for other possible reserves of natural gas in the country. As there is a lack of initiative by the national government to create communication links with educational institutions to leverage the knowledge of professionals available to investigate and expand market with respect to natural gas.
- Corruption associated with the construction of the refinery in Cartagena will generate a significant delay in the advancement of Colombia in scenarios of internal and external demand, as the country invested more than what was projected and thus directly affecting the country's economy.
- Few efforts by government are evident in education and awareness to the Colombian population of the importance of using natural gas and thus discouraging consumption of fossil fuels with high negative environmental impacts.

4. Conclusions and recommendations

4.1. Conclusions

- The Cartagena refinery is now the most modern in Latin America, however, according to research, it is evident that it is not making the most of which it was designed according as explained in the findings above.
- Colombia does not currently count with sufficient natural gas reserves to give the proper use to the Cartagena refinery, because investment in the exploitation of reserves that are planned over the investigations of such fuel is not done, thus deferring the time to recover investment, reflected in turn in the increase in taxes.
- This plant has advanced technology like high-efficiency engines, bringing along lower emissions of greenhouse gases, also regulates stricter negative impacts that

helps mitigate environmental risks, as well as working with the cleanest and most sustainable fuel compared with oil, coal, diesel and others.

- Over the past three years the variation in the price of natural gas, even if it has been increasing, is still considered more favorable among the aforementioned fuels, generating increased international demand, given that with the passing of time people become more aware of its many environmental and commercial benefits.
- Colombia makes its greatest efforts to meet the domestic demand for this fuel, however, it is not enough. There is a need to look for other alternatives, in the first instance, exploring possible new reserves, on the other hand to exploit the NG reserves that have already been studied. It is for this reason that the supply does not exceed demand, as the country only has capacity to provide and supply the domestic market without surpluses that might open the doors to international markets. Without possibility of exporting and instead viability of importing, more costs for the country and the consumer would be generated.

4.2. Recommendations

- Colombia needs to make a good investment in exploitation of potential reserves found of natural gas, should not be found that fuel discard them and a study of markets in neighboring countries that can supply us such fuels to achieve to meet demand internally without generating a significant increase in terms of costs.
- Make training and / or campaigns for people to be increasingly aware on the use or implementation of natural gas, because as evidenced in this research, specifically in the survey, it was reflected most of the population, in spite their consumption of gas Natural, are not aware of the environmental benefits that the fuel brings, thus avoiding possible diseases in living beings. This would also help drive demand increase and perhaps with this the national government might be led to take action on the previous recommendation.
- The government should increase decentralized interagency work. That is, that all educational institutions and public and private entities in the gas sector commit to motivate and encourage, either with tax incentives, soft loans, training and consulting, among others, encouraging a greater commitment among the staff of such entities.



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ATTACHMENTS

Annex A Support Material .

- Colombia gas pipeline map [click here](#)
- Interviews performed to the Academic and commercial, consisting of 11 questions. [Click here.](#)
- Questions that are made to the survey, the graphs with the results obtained, consisting of 8 questions. [Click here.](#)
- Statistics respondents [click here.](#)

