ESCOBAR LNG: A CHALLENGING REGASIFICATION ENTERPRISE ON THE RIVER PARANA - AR GENTINA

Juan José Rodríguez[1], Carlos Weis[1]

1.- YPF – Argentina

Keywords: LNG, Regasification, River, Argentina

www.YPF.com

1. Abstract

Within the context of a significant growth in the gas demand, Argentina has been conducting activities in the LNG market since 2008, when the first regasification operation using a FSRU took place in Bahía Blanca, a city located 700 km to the south of Buenos Aires.

After two years of a successful and growing operation, the Federal Government encouraged the search for new scenarios to develop similar ventures and YPF became in charge of envisaging those sites that could meet key conditions for a new regasification project of quick implementation.

An exhaustive analysis of all possible alternatives have been conducted and all advantages of accessing to the northern main gas pipelines have been considered, at the beginning of 2010, a new manner to regasify LNG using FSRU, alongside the river Paraná de las Palmas, was proposed in order to reach an injection volume of up to 17 million cubic meters per day in an area absorbing almost 40% of Argentina's total natural gas consumption.

In a challenging way, a site located next to the river Paraná de las Palmas was detected in the district of Escobar, 70 km to the north of the capital city of Argentina. However, certain critical aspects have to be dealt with accordingly, such as navigation limits of vessels being longer than 290 meters with a deep draft and the need for dredging almost 3 million cubic meters of lithologic material from the dock area and the maneuvering area required for LNG carriers.

Fast track works conducted in 8-month record time involved the erection and construction of a new dock as well as civil, mechanical and electric facilities for the unloading system of high-pressure gas, including the construction of a 30'' diameter and 31 km long gas pipeline and a fiscal metering system ("custody transfer") at Los Cardales where there is a connection to the "Central West" pipeline.

After stressing work conducted by almost 1,500 employees allocated to the different areas of the project, the regasification system facilities at Escobar terminal were authorized to operate at the beginning of winter 2011.

The uniqueness of the Escobar enterprise lies in the following aspects:

- A need for lightering by cargo ships to enable navigation in the rivers Río de La Plata and Paraná de las Palmas.
- High frequency of "Ship to Ship" (STS) operations results from the limit on LNG cargo volume.
- Gas injection almost directly into the distribution ring feeding the City of Buenos Aires and the area of Greater Buenos Aires, then additionally to the regular gas supply to main pipelines, Escobar LNG can be used also as a Peak Shaving service.
- Possibility of partially diverting gas towards the industrial corridor that reaches the city of Rosario; this is a reversal of gas flow received from the north of Argentina.

- Flexibility towards the operating schedule of Gas Delivery by Transportadora del Sur and Transportadora del Norte (TGS – TGN) as a consequence of the possibility that new daily requests related to volumes of flow to be injected may be placed.

As a conclusion of this paper, we must state that the experience gained during this first year of regasification operating services at the Escobar terminal has proved to be highly efficient, showing an immense adaptability to a wide range of operating conditions and recording more than 20 STS during 4 operating months and an average of 2 new daily requests related to volumes of gas flow to be injected, then fully satisfying customer's requests.

On the other hand, YPF has positioned itself as the leader in the LNG regasification market in Argentina as well as in Latin America; consequently, moving fast towards planning the implementation of new projects, and increasing and enhancing the operating capacity of current facilities located in Escobar and Bahía Blanca.

Introduction

On December 13, 1907 a well drilled to find water discovers oil at a depth of 535 m in Comodoro Rivadavia, a city located more than 1730 km from Buenos Aires. Since that time, until today, Argentina has had rich history in the field of petroleum and natural gas. From the beginning, and beyond the first half of the XXth Century, natural gas was somehow a hindrance, an inconvenience. However, as the industry became aware of the benefits that could result from a rational use of this resource, it began to develop this hydrocarbon. However, our natural gas history is not unrelated to the ups and downs experienced by Argentina in time. Industry activity levels were constantly subject to the changes in government mood *vis-à-vis* private investment.

Argentina has 5 sedimentary basins producing hydrocarbons, of a total of 33 sedimentary basins. These are, from South to North:

- Austral Basin
- San Jorge Gulf Basin
- Neuquina Basin
- Cuyana Basin
- Northeast Basin

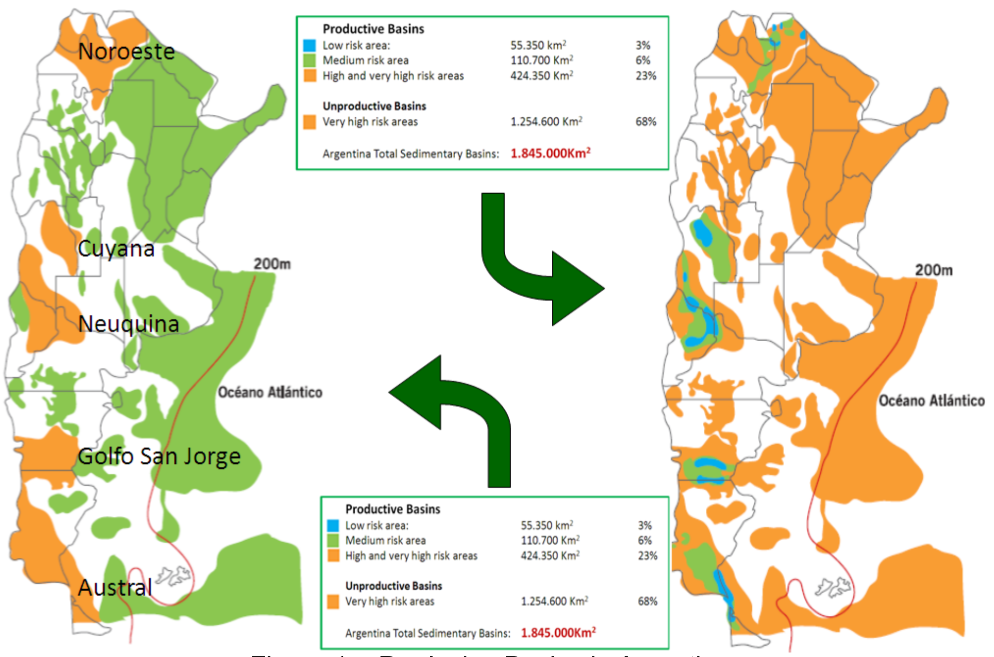


Figure 1 – Producing Basins in Argentina

Figure 1 shows a map of all the basins in the country, highlighting hydrocarbon-producing basins. The latter are mostly mature declining basins, except for the so-called Austral Basin.

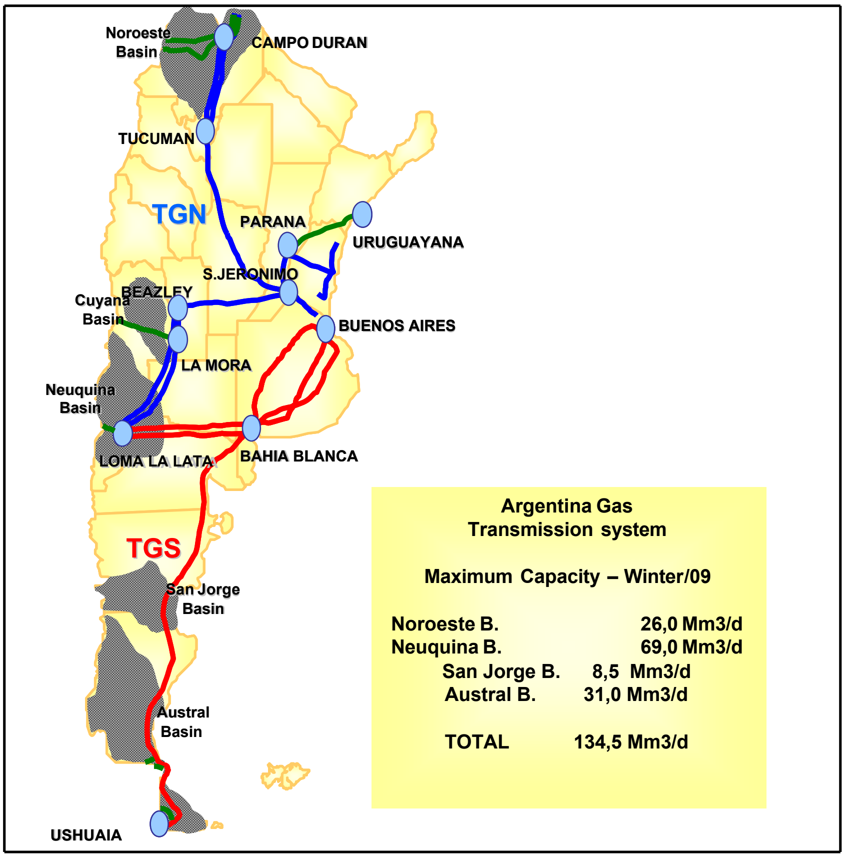


Figure 2– Main Gas Pipelines in Argentina

Figure 2 shows a map of Argentina, indicating the location of the different producing basins and main gas pipelines with their respective transport capacities.

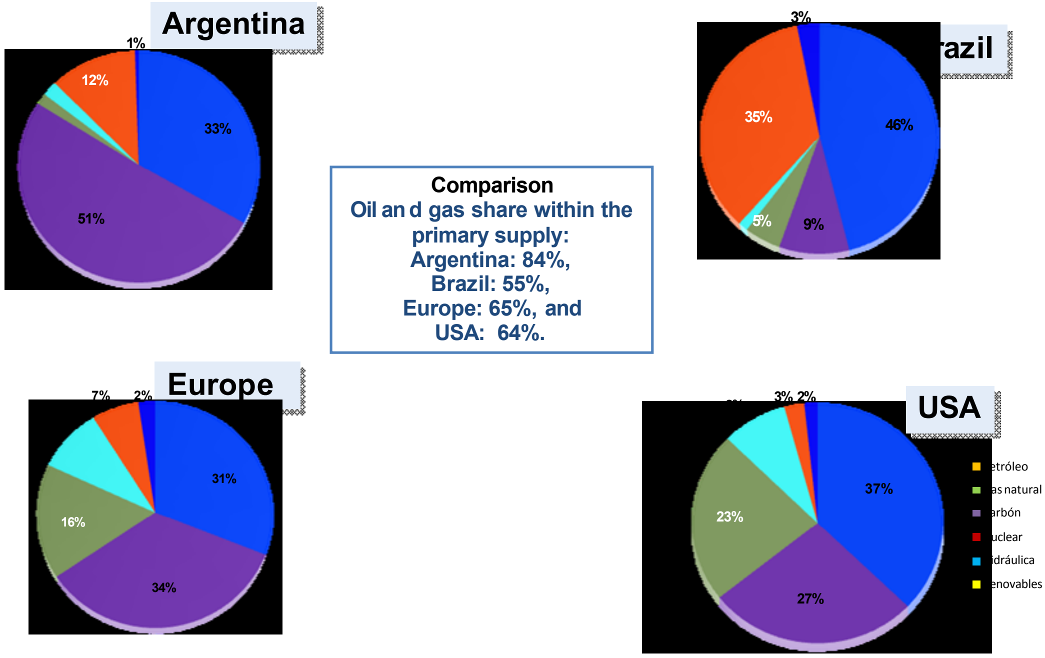
2. Present Context

The Project reviewed herein is within a context of high energy demand growth, resulting from the pace of economic activity in Argentina.

The energy supply structure in Argentina is noticeable for the substantial significance of hydrocarbons in its primary matrix (84%), especially the natural gas supply, which involves over 51% of the supply basket.

Argentina is positioned worldwide as one of the outstanding countries in this part of the energy matrix, in third place globally. It is one of the most developed countries in the natural gas industry, with a broad network of gas pipelines that supply such product from the North, Center and South of Argentina to the entire country

(except for certain regions in the Northeast, that will be supplied shortly by the Northeast Gas Pipeline, a project by the government-owned energy company, ENARSA).
Figure 3 shows a graph comparing the basic energy matrix as compared to other countries:



Año 2010

Figure 3 – Energy matrix international comparisson

These parameters macroscopically evidence certain peculiar features of the oil and gas industry:
Strong residential consumption: over 7.3 million households use natural gas for heating fuel and comfort in the winter season. Argentina has the largest gas supply regionally, and is the most sophisticated as regards its extent and distribution to residential consumers. Natural Gas for residential use is a utility that has penetrated Argentina's comfort culture, and household consumption is sometimes positioned and exceeds the standard in developed countries. This uniqueness causes the demand of natural gas to be seasonal. In terms of Summer – Winter differences, demand in the coldest month, usually July, can be 70% higher than the month with the smallest demand.
A supply system serving over 300,000 commercial consumers and government institutions.
A Compressed Natural Gas (car natural gas) consumption market with a fleet of 1.4 million vehicles using gas as fuel.
An industrial market, consisting of about 26,000 consumers, a sector that has experienced increase rates higher than in other market sectors, as a consequence of the development process experienced by Argentina in the last few years. Natural gas for industrial consumption is not only used as fuel, sometimes without substitutes because of the sophisticated requirements for its use in ovens, where the thermal gradients are extremely sensitive; but also as a raw material (steel, fertilizers, etc).
A fuel market for thermal power plants, for Combined Cycle, Cogeneration and Open Cycle, 53 plants in all, for this segment that, combined with natural gas, is under a strong impact due to the increase in consumption and productive development.

The GDP in the last 8 years has brought about the need to develop projects that are consistent with such energy demand growth rates, and caused the segment to be considered strategic, and its sustainability critical. Figure 4 summarizes the elasticity of the increase in the demand of energy, with the trend for the 2002-2003 horizon.

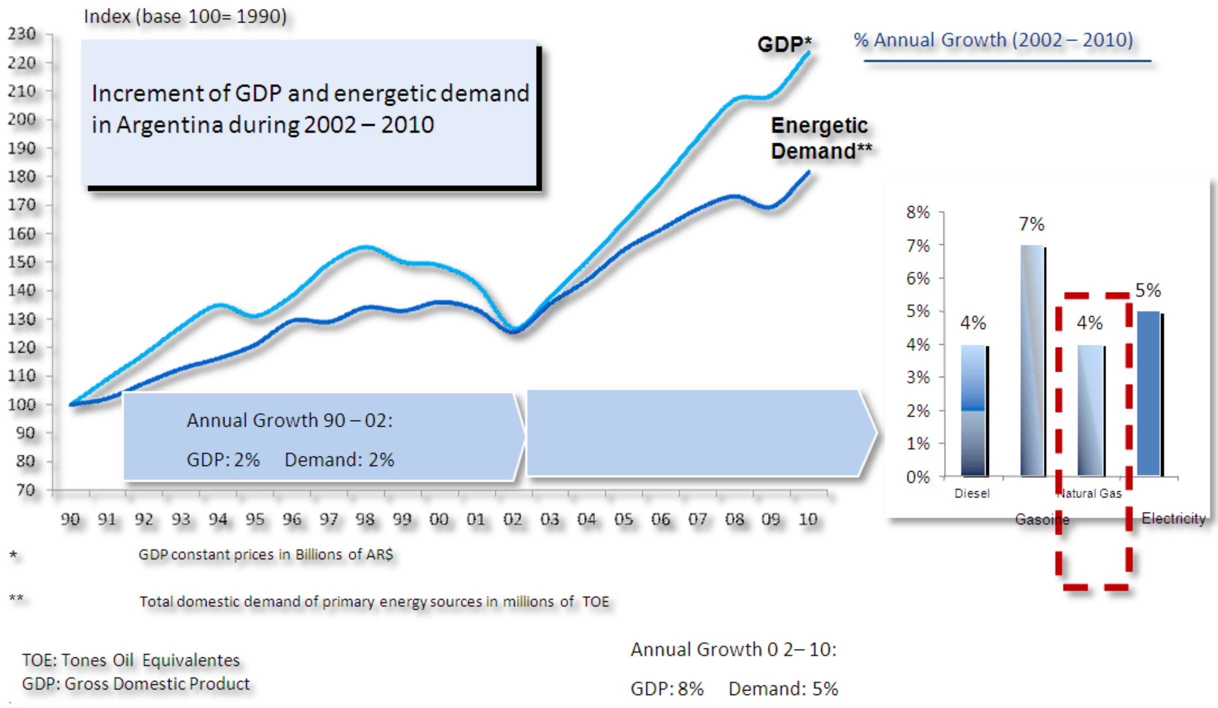


Figure 4 – Energetic demand in Argentina

Natural gas consumption in Argentina exceeds and will exceed the current supply of about 1.3 TCV/year (36,400 MMm3/d or 100 MMm3/d on average). Together with the seasonal nature of the demand, attending to such requirement implies a major challenge. An inter-annual growth of 5% is expected to occur in the next few years, as shown in Figure 5.

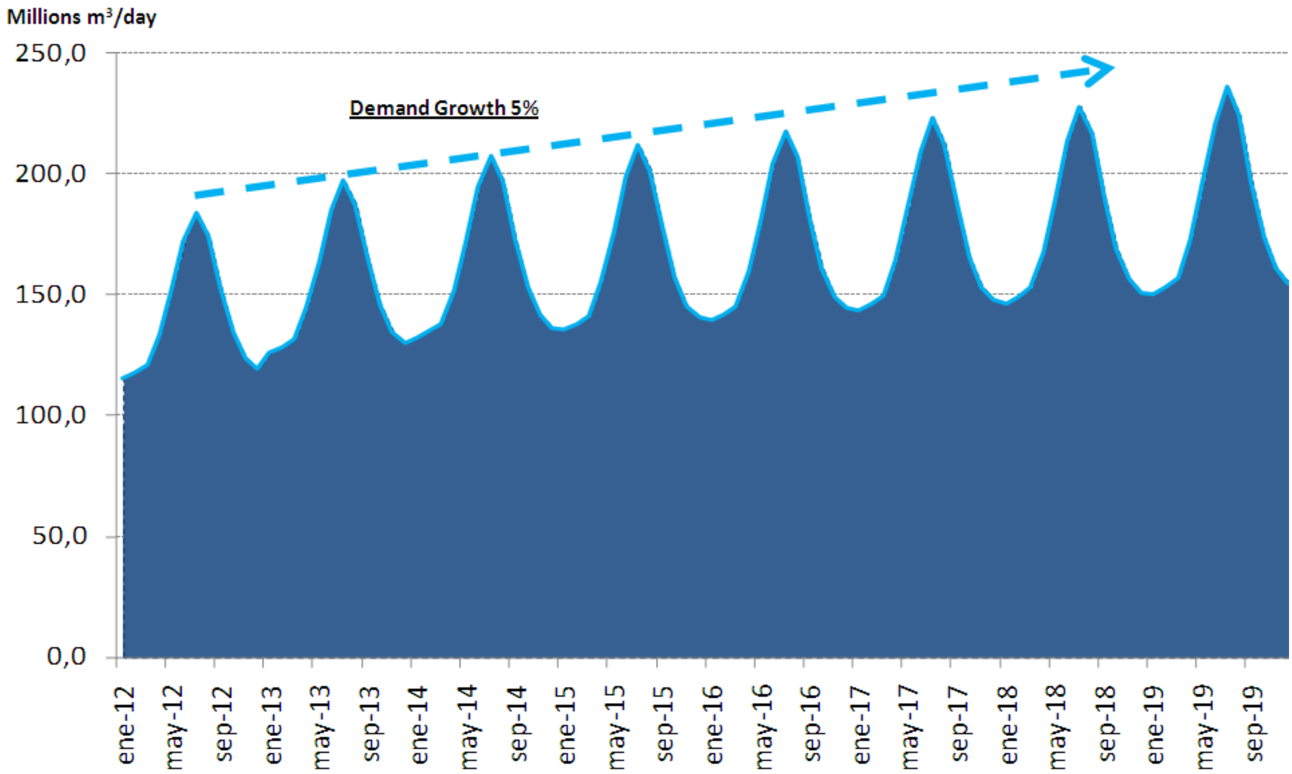


Figure 5 – Gas demand growth in Argentina

We should also note that natural gas is the most environment-friendly fossil fuel as regards its level of emissions and/or pollutants. In this respect Argentina is the most progressive country in the region.

3. Escobar LNG Project

Escobar LNG is encompasses within a number of projects designed not only to ensure natural gas supply to the country, but also to encourage development growth. Importing LNG regulates the supply for a number of initiatives, in order to maintain and increase the guarantee of a natural gas supply, in a market that is overly anxious to have diversified supply sources.

The presence of ENARSA, a state-owned energy company, as a 50% partner in the development of the Project, with YPF as partner with the other 50%, as well as its Operator, shows the strategic decision of the National Government to provide the natural gas system with a tool that has proved to be efficient, to sustain growth in the country. The LNG Escobar Project supplements, as regards LNG, what has been carried on successfully since 2008 at the port of Bahía Blanca. A FSRU has been operating since May 2008, which has contributed to partly satisfy the increase of the demand in the last few years.

The Investment for the Escobar LNG Project amounted to about USD 180 million, which includes the dredging work at the operating wharf and the flare area, constructing and lining a dock, and laying out a gas pipeline about 30 km long, surface facilities both at the head and the end of the pipeline, and constructing the related operation rooms, fire-fighting systems and constructing and adapting access roads to the site.

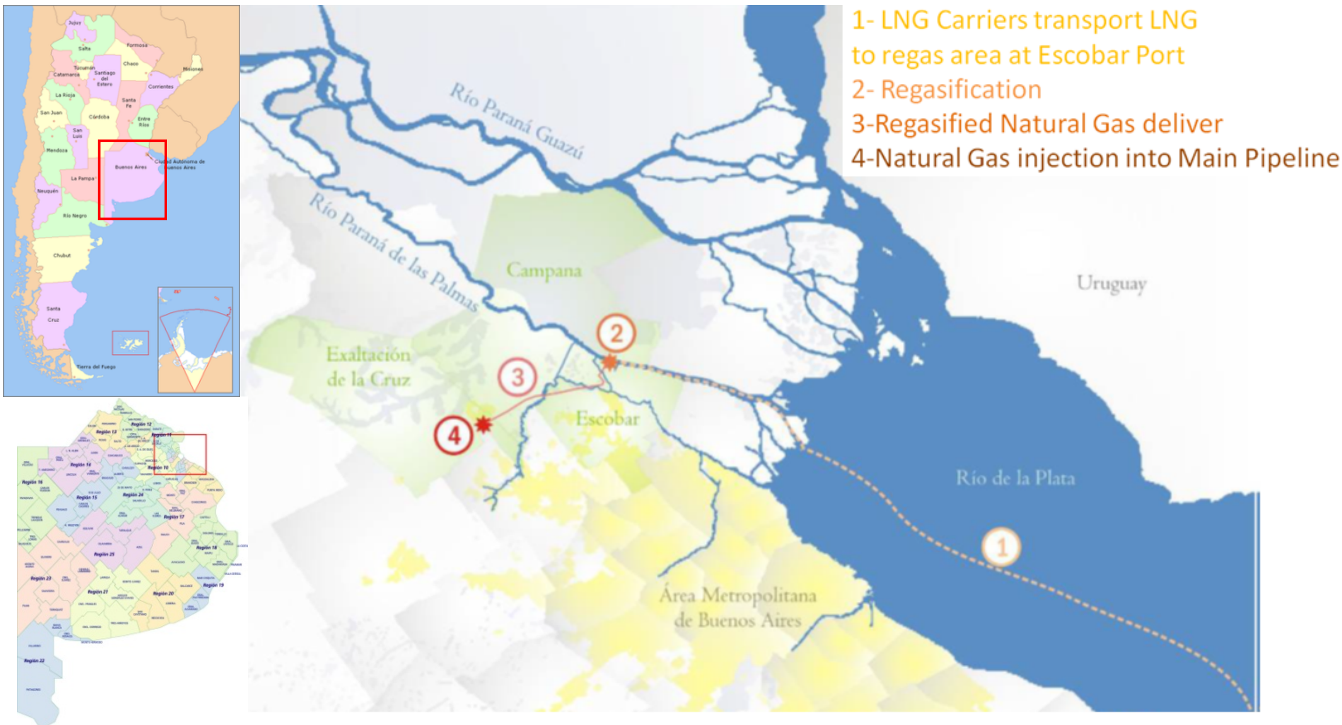


Figure 6 – Geographical location and general description of the Escobar Project operation

To determine the location of the project, YPF reviewed different issues that led to select the Escobar area, upon optimizing alternative locations. At the beginning, its determination considered supplying natural gas to the city of Buenos Aires and its surrounding belt, a location that concentrates the largest energy demand in the country. Its feasibility also considered nautical matters, connectivity to gas pipelines and environmental issues relating to the project.

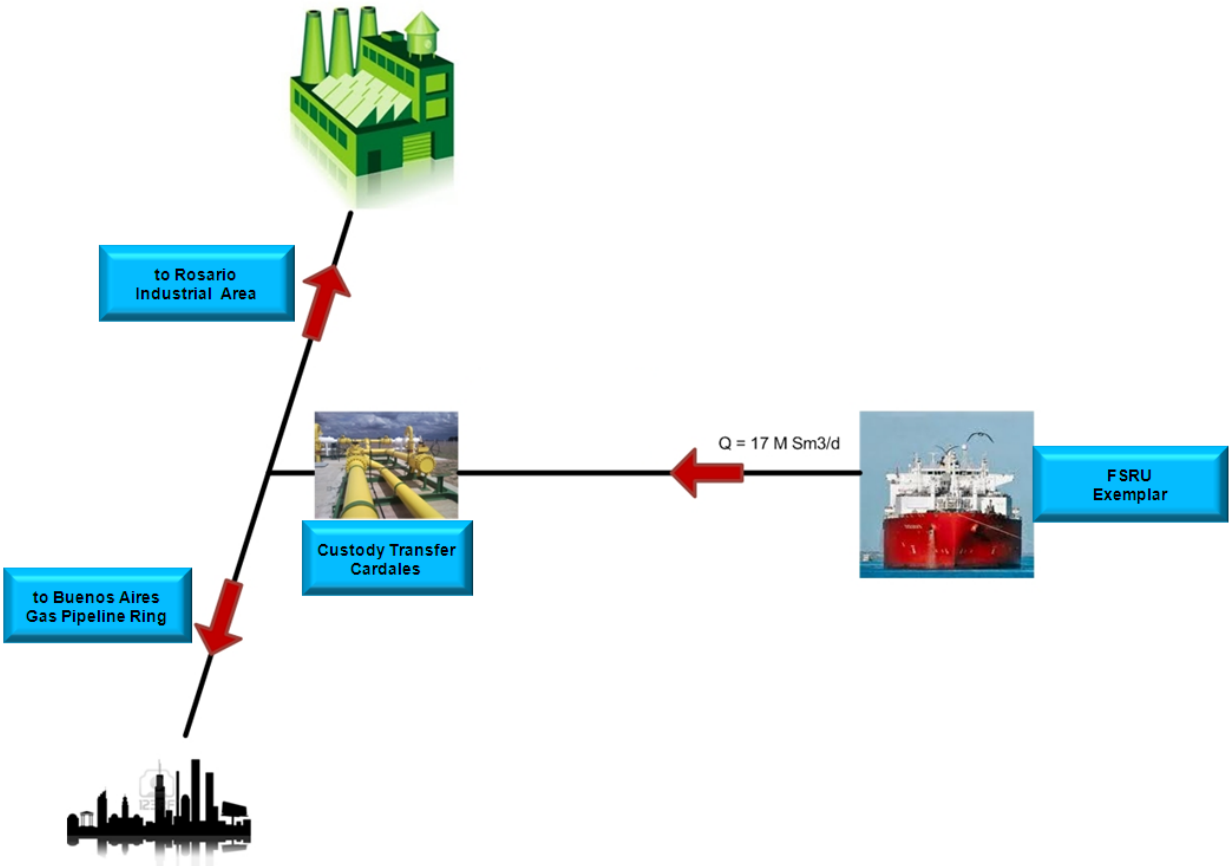


Figure 7 –Interconnection Gas Pipeline to Los Cardales custody transfer.

3.1. Logistic Issues

By using cartography, satellite imaging and specialized information, YPF identified different locations North of the City of Buenos Aires, which were preselected as likely venues for the project, and thus were visited for the purpose.

YPF concentrated its efforts in two areas of the river Paraná de las Palmas, the first near the Port of San Nicolás (between km 352 and 347,5), and the second in the area of the Port of Belén de Escobar (between km 70 and 80). Locations on the Paraná Guazú were discarded by principle, as this alternative would have implied crossing the river Paraná de las Palmas with a gas pipeline, with a cost and time that would have been inconsistent with the idea of the Project.

From its mouth at the Emilio Mitre channel and km 83.5, the river Paraná de las Palmas has a virtually straight alignment, with slight curves from km 83.5. With the Tordillo and Hinojo curves, the river is featured by meanders and strong curvature. This feature caused the San Nicolás option to be discarded, because it could have made (over 300 m long) methane tanker maneuvers more difficult in such waters.

Upon identifying the Escobar area (between km 70 and 80) as the best location for the Project, YPF worked to seek a suitable location for operations therein. Several visits were conducted by land and by the river to identify alternatives. At all the sites, the project was considered on the right-hand side of the river, because making it on the opposite side would have implied crossing the river with the pipeline, with increased time and cost requirements.

The areas upstream from km 78, the mouth of the Las Rosas creek, were discarded because there are two natural preserves in the area, one national (the Otamendi Natural Preserve) and the other provincial (the Río Luján Provincial Preserve). Although practicable locations were detected for the installation of the dock, and the distance to the main gas pipeline was very short, it would have been impossible to construct the gas pipeline without crossing environmentally protected areas.

After different reviews, the selected area was at km 75 on the river Paraná de las Palmas, which has the following advantages:

- The location where the river and the canal are widest in the area
- The river has a good natural depth
- Minimum distance to the flare area
- The location is before the sharp curves on the river
- There are waiting areas upstream and downstream from the dock
- There are no wreckage remainders indicated on the charts
- The river bed has features such that it can be dredged within reasonable time.
- Reasonable connection distance to the gas pipeline.
- There is available space to construct the dock and associated facilities onshore.
- There are premises available for a second phase involving a regasification plant onshore. There is sufficient space to construct and install the related storage tanks.

3.2. Ship Operation

The ship used in the LNG regas process is known as an FSRU (Floating Storage and Regasification Unit), which is basically a methane tanker with equipment on board to regasify Liquefied Natural Gas and deliver it at high pressure. In this way, the ship can operate three different processes at the same time:

a) Receiving LNG product (at -160°C)
b) Regasifying it
c) Delivering gas to the pipeline at high pressure

In turn, the ship operates as a methane tanker and stores product without regasifying, if the regasification or delivery is not necessary, or for the event of weather conditions that prevent unloading or make delivery unnecessary.

The FSRU (Floating Storage and Regasification Unit) is supplied by a LNG Carrier (LNGC). To this end, the LNGC approaches the FSRU once every 7 days.

If we take into account that the River Plate access has a depth of 34', the supplying methane tankers must guarantee a draft of not more than 34'. Due to this restriction, 138,000 m3 ships cannot enter with full cargo, so they must either enter with a smaller volume or go with full cargo to the so-called Charlie Zone before entering the Access Channel, in order to lighten the ship by transferring volume to a ship with smaller capacity. Upon completion of this operation, the methane tanker proceeds upstream by the river and completes the transfer to the FSRU at the port of Escobar.

Upon completing this first step of the operation, with the methane tanker outside the port, the lightening ship proceeds upstream and transfers its cargo.

Then, the lightening ship proceeds to the lightening area to wait for the next methane tanker. In this way, within 15 days, the FSRU is approached once by the methane tanker and another by the lightening ship, which determines a fuel unloading frequency from one ship to another of one ship per week. We should note that this frequency may change depending on the volumes being regasified, so more or less ships can be received as the case requires.

In order to determine the logistics described above, a number of studies has been performed to determine the navigability and feasibility for different types of ships that could be moored to the dock to be constructed, and those that could be moored to the FSRU. The studies are the following:

- Lightening maneuvers in "Charlie" Zone
- Navigation maneuvers between Recalada and the Common Zone
- Navigation maneuvers between the Common Zone and Escobar
- Physical compatibility between the ships involved
- Mooring the FSRU to two approached ships.
- Unmooring the FSRU and methane tankers and flare maneuver
- "Passing Ship" in the operations Zone at Puerto Escobar
- HAZID/HAZOP

Figure 8 shows the access navigation route at Escobar LNG Port, indicating the times involved until arriving at the operations zone.

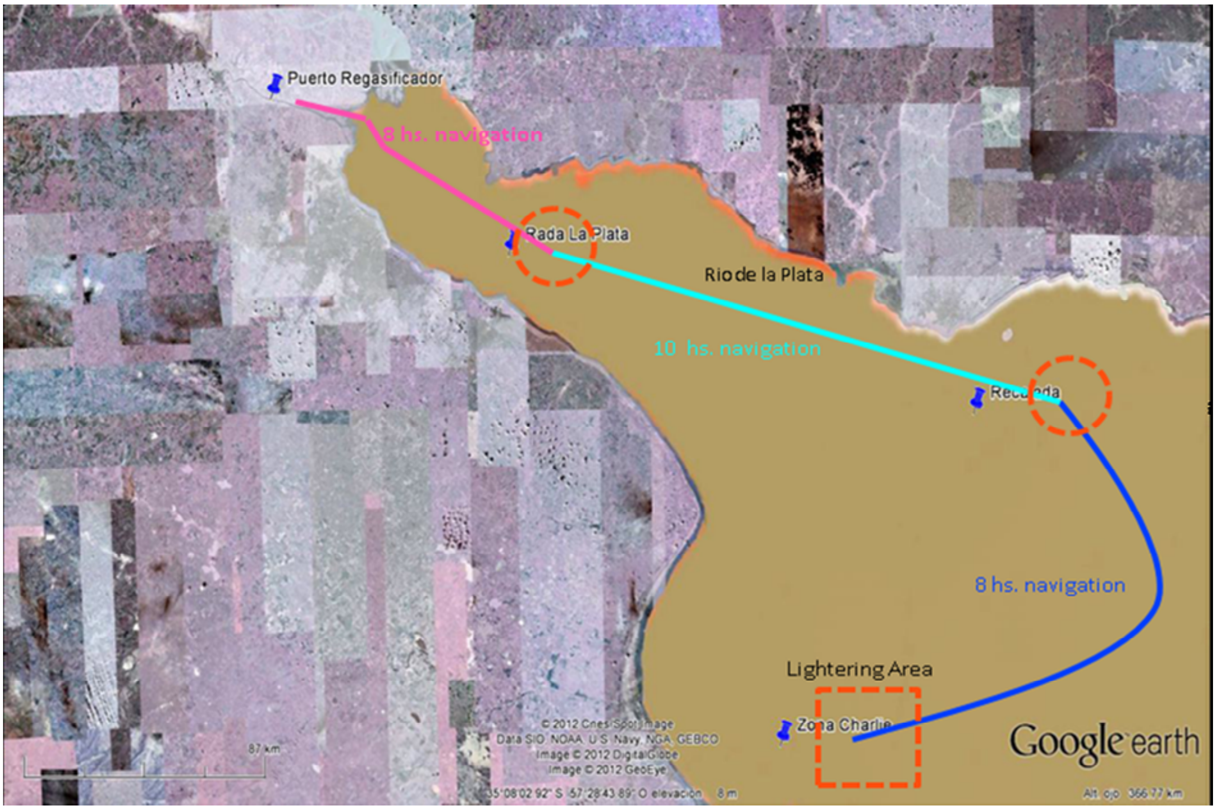


Figure 8 –Acces Navigation Route to Escobar LNG Port

3.3. Main Features of the FSRU

3.3.1. LNG Storage – Tanks

The FSRU has a total LNG storage capacity of 151,072 m^3, distributed among four tanks.

The equilibrium temperature of LNG is about -160 °C, at atmospheric pressure. The design conditions and the work conditions at the FSRU are -163 °C and 200 mbar (above atmospheric pressure).

3.3.2. LNG Regas Plant

Regas facilities consist of six vaporizers located on the upper deck of the stern: three on the starboard side and three on the leeboard side. They are of the case and pipe type, heated with hot water in a closed loop. Each exchanger has a regas capacity of 100 MSCFD (2,8 M Sm^3/d).

The plant has a maximum sustainable delivery flow of 600 MMSCFD, equal to 17,000,000 Sm^3, using 6 regas trains, with a maximum spot flow of 690 MMSCFD (19,500,000 Sm^3/d). Pressure at the vaporizer outlets can range from 75 to 104 Kg/cm^2 M.

3.3.3. Regas Process Layout

In order to clearly view the regas process, we present the following layout showing the main operating items of equipment in the system.

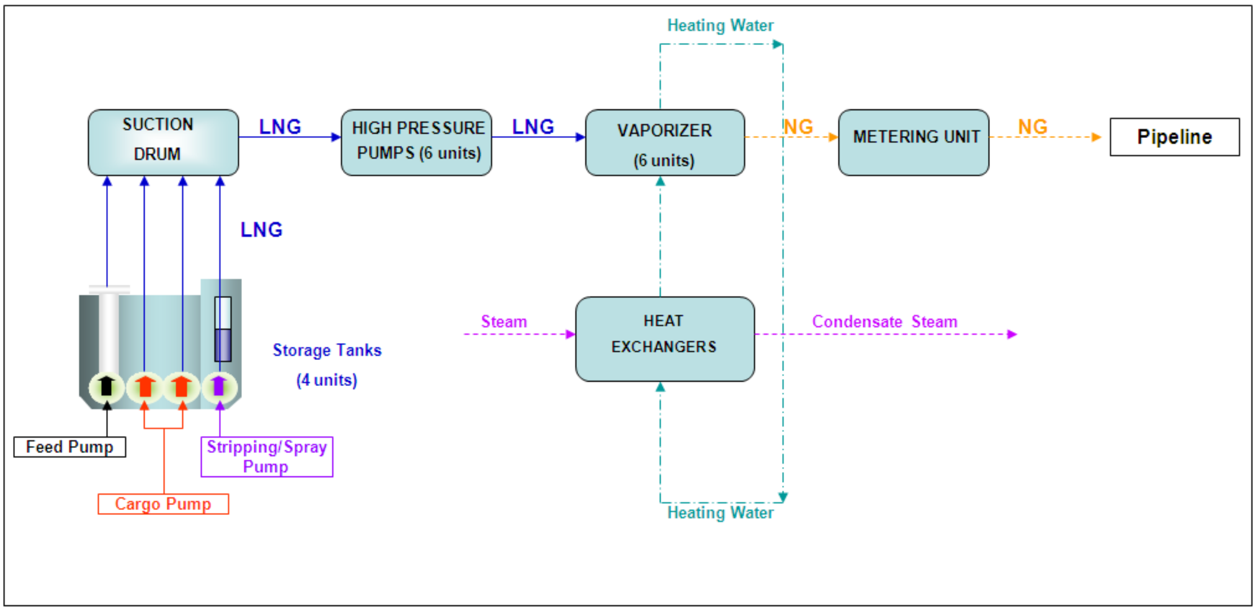


Figure 9 – Regas Process Layout

LNG is pumped into the regasi area in two stages. The feed pumps drive the LNG from the storage tanks to the suction drum (7.7 Kg/cm^2), where the high pressure pumps raise LNG pressure up to vaporizers operative pressure (up to 100 Kg/cm^2).

There is one high pressure pump for each of the six vaporizers. The pumps are centrifugal and are submerged in individual intake vessels. The pumps have a suction capacity of 205 m^3/h and a maximum working pressure of 100 Kg/cm^2. They are located at the stern, three on the starboard side and three on the leeboard side.

At the vaporizer outlet there are two metering units connected in series to record temperature, pressure, flow and gas quality. After the metering bridge there is a regulating valve that keeps the pressure upstream of itself at 75-104 Kg/cm^2. Finally, downstream from the valve there is a pressure drop that is consistent with the operating conditions in TGN's main gas pipeline. If for any reason there is a sudden pressure increase to 73.5 Kg/cm^2, the equipment shuts down.

The regas process uses running water in a closed loop.

3.4. Land Facilities

The High Pressure Arm wich connects the FSRU facilities to the land facilities, has a 12" diameter and is made of carbon steel, hydraulically operated. The arm is made for a design pressure of 134 kg/cm^2 and a test pressure of 201 kg/cm^2, i.e. once and a half the design pressure. The design temperature is -20 a +75 °C. It is provided with a quick connect/disconnect coupler and a control system starting the warning alarms if the ship moves outside the design parameters. It can move the three ways: dipping, stern/poop sideways movement and perpendicular to the the dock.

The gas pipeline linking the High Pressure Arm to TGN's main gas pipeline in Los Cardales is about 30 km long and 30" in diameter.

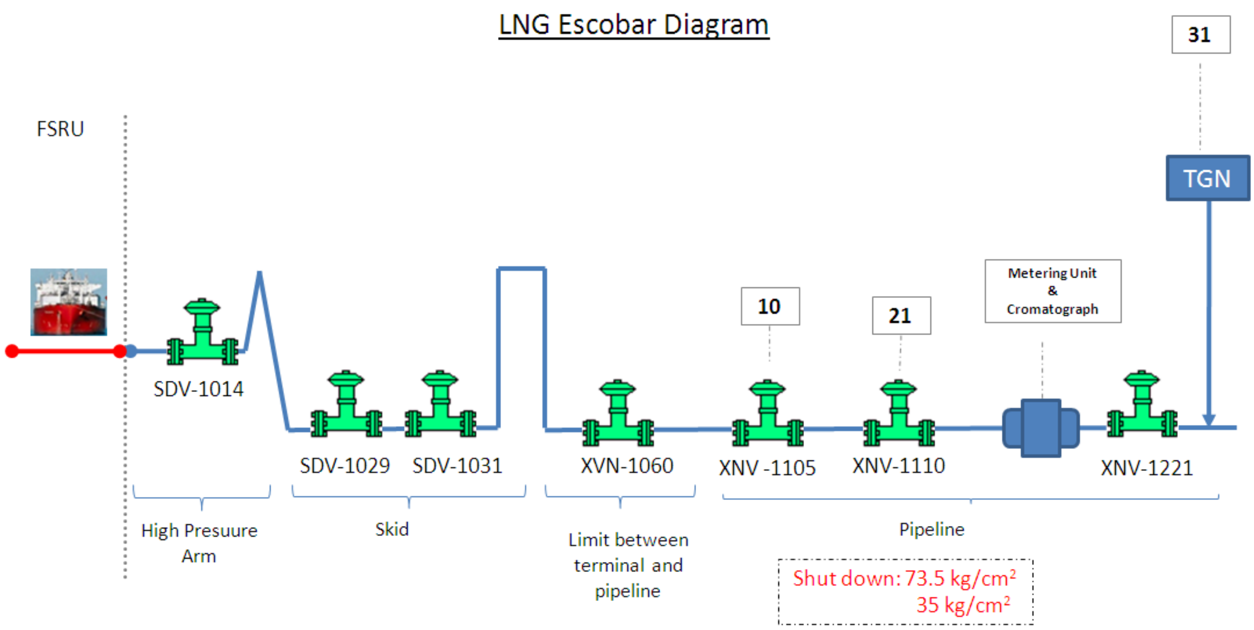


Figure 10– Safety valves onshore facilities

Emergency Shut Down Valves (ESDVs) are available, actuating upon high unloading pressure of regasified gas (73,5 kg/cm^2).

In the same way, the valves actuate to shut down the system upon low gas temperature (low temperature alarm: 6°C, low temperature shut down at 5ºC) and/or upon values in excess of 40% of the lower explosive limit (LEL) at the FSRU gas detectors and at the high pressure arm.

For protection in the event of a breakdown in the interconnection gas pipeline, there are High Low valves. The first is at the outlet from the dock, two at the interconnection pipeline and another in the Los Cardales area.

3.5. Communication

The primary measurement transmitters are connected to a Flow Computer, which sends information by Fiber Optic to the Communication Room. The information is then transmitted to YPF by the Corporate Intranet. The information is integrated into the Gasmed Corporate Measurement System, and the information is available on any PC connected to YPF's network with the required permissions.

The communication system permits online availability of information relating to the LNG Regas Operation (Flow, Pressure, Temperature, Chromatography, etc.).

From the operating viewpoint, such information increases maneuver safety and prompt detection of failures in the system.

Commercially, delivered flows are available and mass balance sheets can be produced to control delivered volumes.

3.6. Regas Operation

3.6.1. Commissioning – May 2011

The commissioning process took 3 Operative Days in order to test the proper performance of the delivery system and the facilities involved. The first day of delivery was May 21, reaching an instant flow of 7,000,000 Sm^3/d, which continued until May 23. The entire system was tested in this period, both the FSRU and the land facilities. On May 23 the flow continued to be increased, which was done stepwise, up to a maximum instant flow of 18,500,500 Sm^3/d, which was maintained about 15 minutes.

Upon successfully testing under the maximum operating conditions, ramp down commenced and the delivery was stabilized at the volumes required by the demand.

Figure 11 shows the different flows during the commissioning tests.

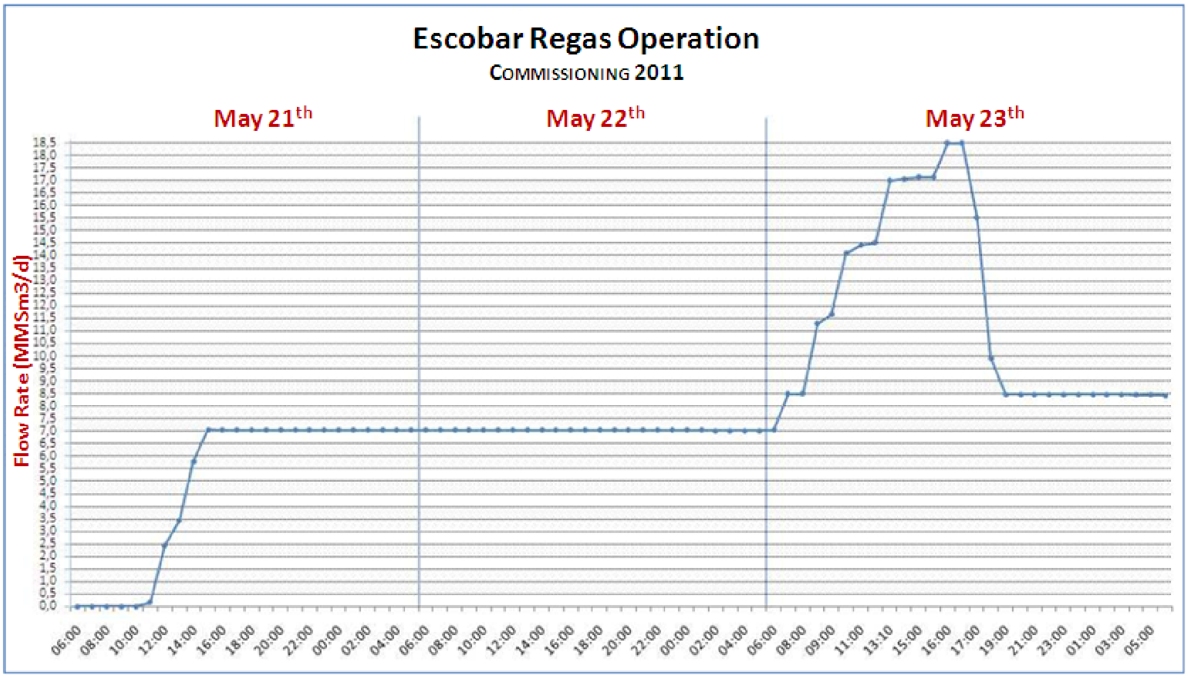


Figure 11– Commissioning flowrate chart

3.6.2. LNG Regasification – Nomination

Escobar LNG, in the same way as the existing LNG Regas Operation in Bahía Blanca, makes a substantial Natural Gas contribution to the Argentine Transport System, by delivering the requested volumes in accordance with the daily demand, on a daily basis

ENARSA indicates the daily nomination to the Head of the Escobar Plant, who reports it to the FSRU in order to perform the necessary maneuvers to fulfil such nomination. Figure 12 shows the flows nominated and actually delivered to pipeline in 2011.

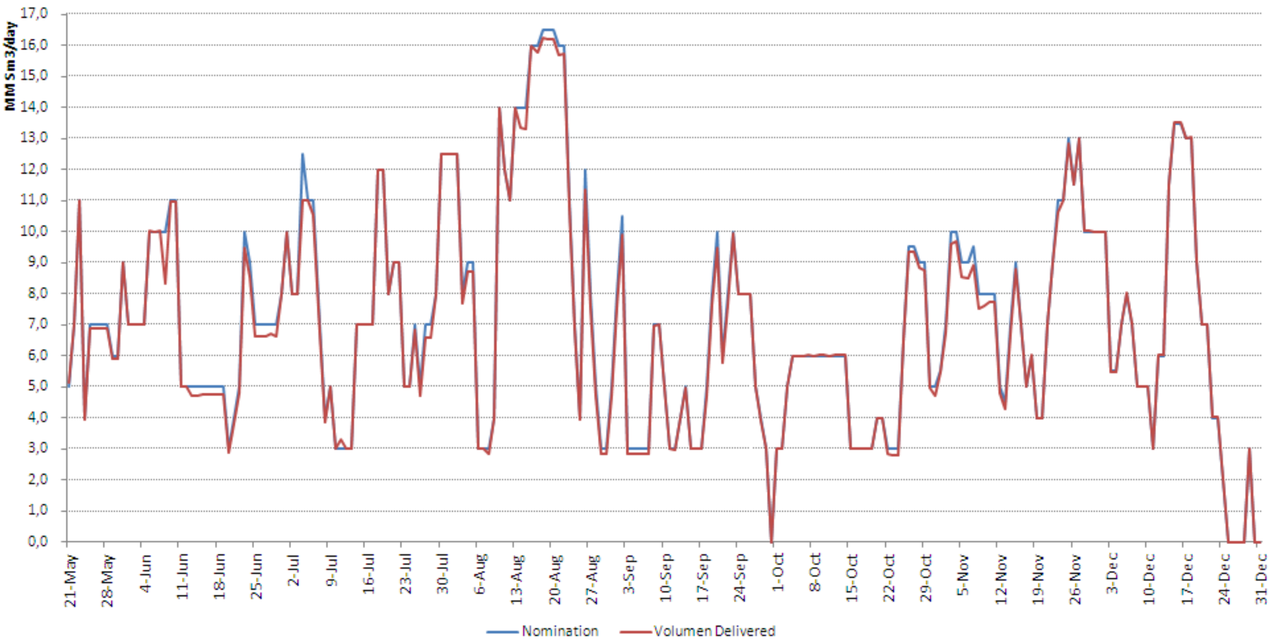


Figure 12– Gas nomination Vs. Sendout to pipeline

3.6.3. Peak Shaving Operation

Additionally to the regular gas supply to main pipelines, Escobar LNG can be used as a Peak Shaving service, which consists in maintaining gas delivery under a daily Nomination, with injection peaks at the time of highest consumption. For instance, Figures 13 and 14 represent a daily nomination of 7 MSm^3/day, with injection peaks from noon to 3 pm and from 7 pm to 2 am. This kind of operation enables delivery peaks to be made at times of highest consumption, and decreasing delivery outside such times, meeting the appropriate Nomination for the relevant day.

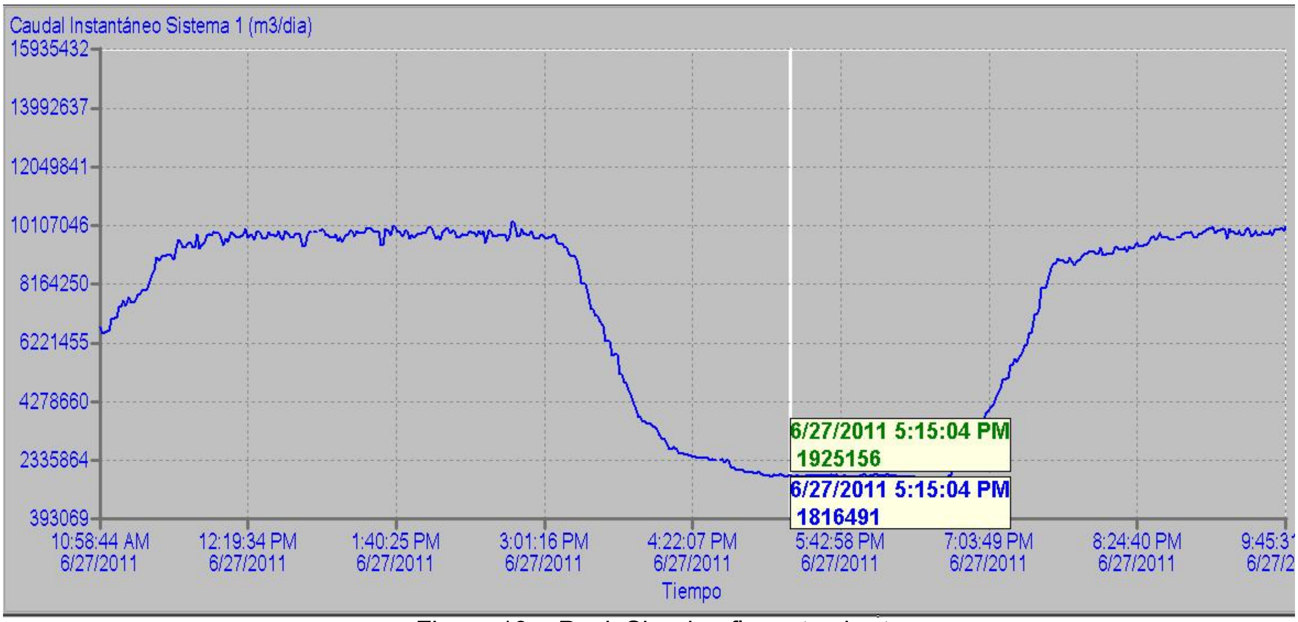


Figure 13 – Peak Shaving flowrate chart

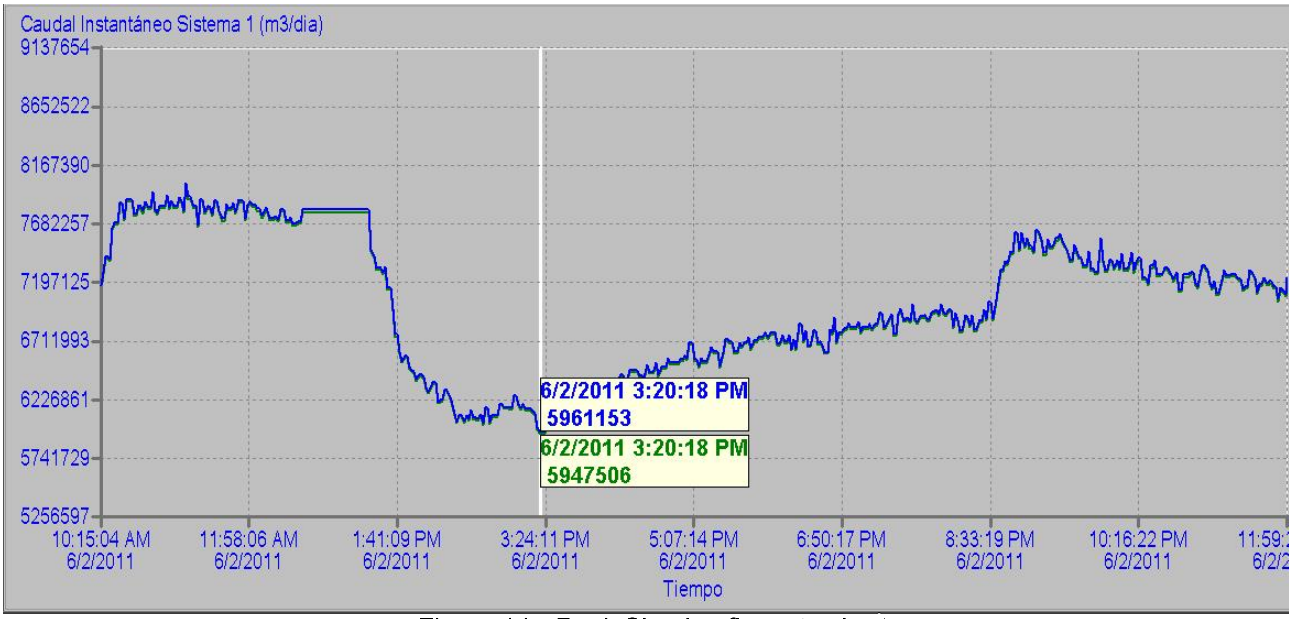


Figure 14 - Peak Shaving flowrate chart

3.6.4. Regas Season 2011 – Operating data

Table 1 shows the LNG volumes regasified, the LNG transferred and the Boil Off Gas asociated.

Month	LNG Regas	TOTAL LNG Transferred (*)	BOG
		LNG m3	
May	124.224		4.748
Jun	334.570		9.632
Jul	381.734		9.919
Ago	507.023	2.719.816	14.093
Sep	256.850		7.370
Oct	264.954		7.322
Nov	401.642		10.283
Dic	300.391		10.048
Total	**2.571.387**	**2.719.816**	**73.415**

(*) Includes 40 STS and Exemplar inicial cargo.

Table 1 – Operating data

Figure 15 shows the gas volumes delivered to the gas pipeline during 2011:

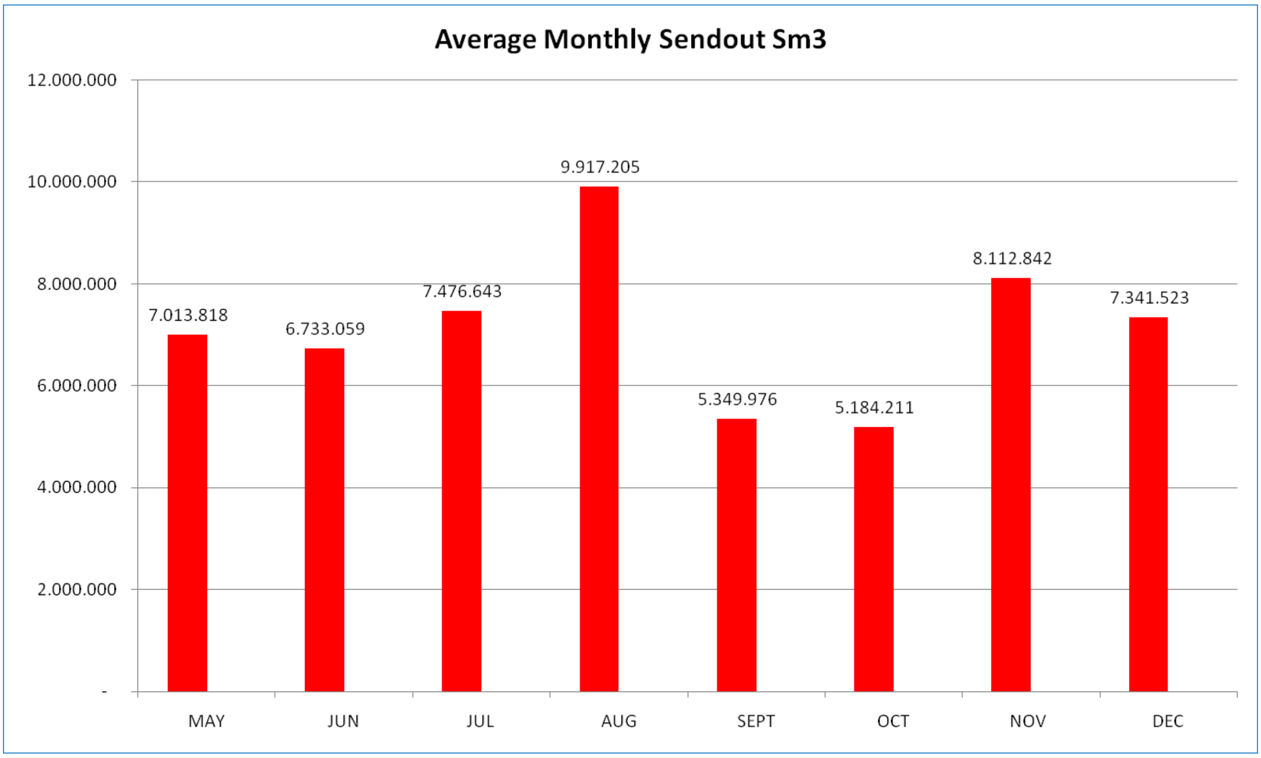


Figure 15 – Average Gas Delivery Flow (Source: Excelerate Energy)

3.6.5. LNG Quality

41 LNG cargos were received, which includes the initial cargo with which the Exemplar arrived. Of these cargos 26 came from Trinidad and Tobago, 2 from Qatar, 7 from Nigeria and 6 from storage tanks at other regasification plants (Colombia, Spain, Brazil). Such latter cargos are so-called "LNG Blend".

Cargo constituents vary according to their source, as shown in Figure 16. The constituents of LNG Blend are have not been taken into account, as it is a mixture of LNG from different sources, which are stored in tanks at the regasification plants they came from.

Tipical LNG Quality Received at Escobar Terminal				
		Trinidad y Tobago	Qatar	Nigeria
Methane	% mol	97,1176	93,0300	91,3076
Ethane	% mol	2,5066	6,3225	6,0483
Propane	% mol	0,3064	0,1550	2,1043
i-Butane	% mol	0,0298	0,0100	0,2796
n-Butane	% mol	0,0202	0,0175	0,1916
i-Pentane	% mol	0,0004	0,0000	0,0000
n-Pentane	% mol	0,0034	0,0000	0,0016
Hexane	% mol	0,0000	0,0000	0,0000
Nitrogen	% mol	0,0128	0,4650	0,0670
CO_2	% mol	0,0000	0,0000	0,0000
TOTAL	% mol	100	100	100
Gross Heating Value (*)	MJ/m^3	38,7123	39,5244	41,0797
	$Kcal/m^3$	9.249	9.443	9.815
Wobbe Index (*)	MJ/m^3	51,2376	51,4798	52,5098
	$Kcal/m^3$	12.242	12.300	12.546

(*) Calculated at 15 °C and 1 atm.

Wobbe Index: **Min:** 11.300 Kcal/Sm3 **Max:** 12.470 Kcal/Sm3 (by ENARGAS I - 259 Resolution)

Gross Heating Value: **Min:** 8.850 Kcal/Sm3 **Max:** 10.200 Kcal/Sm3 (by ENARGAS I - 259 resolution)

Figure 16 – Typical LNG Constituents

3.6.6.Boil Off Gas Evolution

Figure clearly shows the percentage increase of BOG for low delivery flows, causing the system to be less efficient.

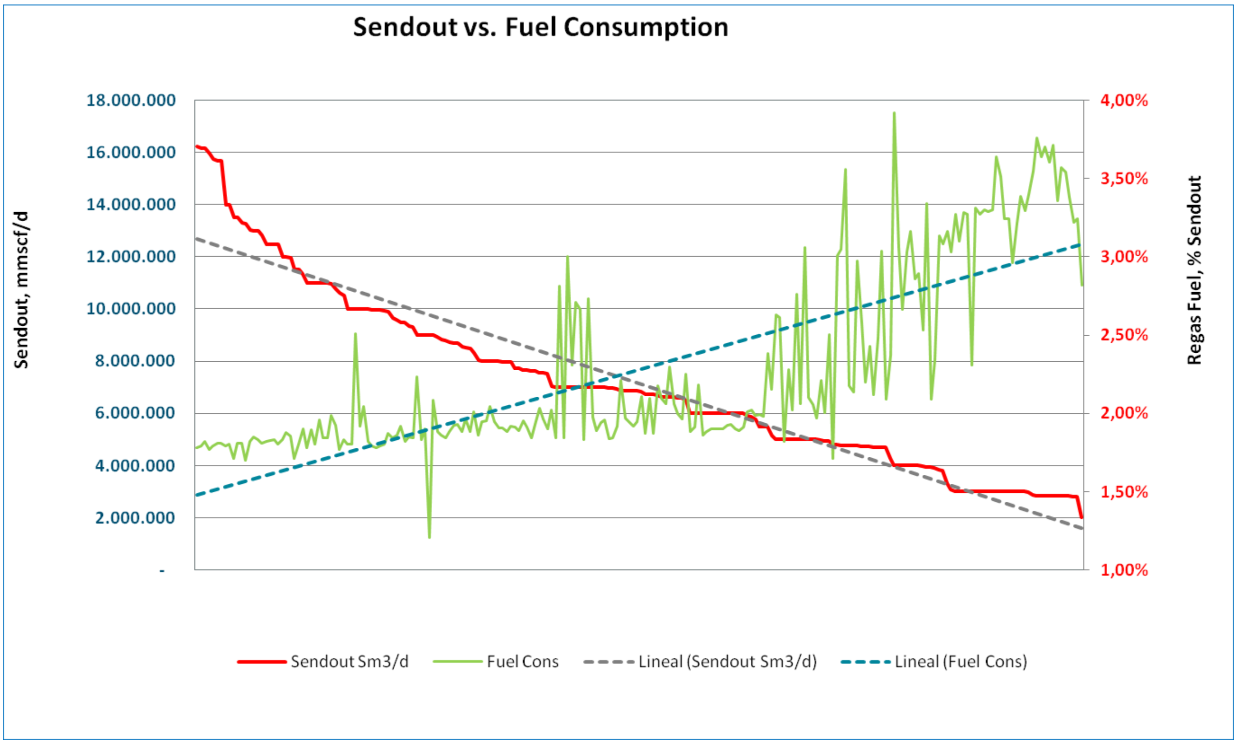


Figure 17 – Sendout vs. BOG Consumption (Source: Excelerate Energy)

3.7.STS Operation

The LNG transfer operation from one ship to another is known as STS (ship to ship).

The connection between the unloading ship and the FSRU is done with eight flexible hoses, six for liquid and two for gas, which are used to send LNG to the FSRU, as gas is sent from the regasifier to the other ship in order to equalize pressures, since no compressors are used.

The number of flexible hoses is so determined because it enables the maximum volume of liquid to be sent without reaching a critical pressure value in the tanks of the FSRU.

Prior to the transfer, meetings are held among members of both crews, to discuss any issues that could affect the STS operation. The relevant parties complete a safety statement, confirm the unloading schedule and the operating conditions on both ships, and information is exchanged in relation to the operations to be carried out during the unloading. Likewise, comments are made on prior experiences, suggestions and possible improvements, with a review of the weather forecast, since adverse weather conditions could cause the operation to be cancelled.

The transfer does not begin until the agreed safety conditions are met.

Prior to connecting the flexible hoses the tanks in the LNG receiving ship are cooled down to a temperature of about -130 °C. The LNG tanks must retain a liquid remnant of about 3,000 m^3, in order to keep the tanks duly cool.

If further cooling is necessary, liquid is sprayed from a ring located at the top of the tanks. The cooling time varies according to the initial temperature of the tanks in the receiving ship.

After this, the flexible hoses are connected and a watertightness test is done with N_2, by increasing the pressure to about 5 Kg/cm^2, at which time the N_2 injection is stopped. Pressure is controlled to verify that it is consistent throughout the hose, and consequently that there are no leaks. The installation is likewise checked for total inertization and absence of O_2.

Finally, the ESD (Emergency Shut Down) system is checked to determine its pneumatic and hydraulic operation.

Once the above activities are completed, the liquid lines of both ships are cooled, and then the flexible hoses are cooled and the torque test performed. As the cooling contracts the entire system, the test verifies that the system continues to be perfectly connected.

The operation takes about 3 hours to connect the hoses and 2 hours to perform the tests and cool the hoses.

Upon completing the above procedures, the transfer commenced at a low flow rate (about 800 m^3/h), and the system is checked to verify that there are no releases or other unsuitable conditions. Then the flow is increased until it reaches a maximum of 6,000 m^3/h.

Supply at the Escobar terminal is limited by the depth of the River Plate, so the ships must arrive at the port with a partial load. Depending on the type of ship and the commercial agreement, the ships arrive from their departure location with about 70,000 m^3 or perform lightening operations at the Bahía Blanca LNG terminal or at Charlie zone, a dedicated lightening zone in the Outer River Plate, as described in paragraph 3.1.

The transfer operation takes about 15 hours on average, depending on the flow per hour that the methane tanker can deliver to the regasifier.

Upon the transfer being completed, the liquid in the flexible hoses is sent to the tanker and the hoses are heated by spraying them with water in order to regasify any excess LNG.

Once the flexible hoses are hot and without pressure, N_2 is pumped from the regasifier to the mother ship, so as to remove any CH_4 in the line. N_2 is delivered until it reaches a value below 20% of the lower explosive limit (LEL) for CH_4. As the LEL for CH_4 is 5%, its content in the line should be lower than 1%.

After completing the inertization operation, the flexible hoses are disconnected from the ships and a new meeting is held among the crews of both ships, to comment on the results and review improvement opportunities.

A total of 40 STS were done in 2011. The LNG volume transferred was 2,570,626, m^3 with a maximum load of 86,312 m^3 and a minimum of 37,322 m^3.

3.8. Environmental Aspects

3.8.1. Solid and Semisolid Waste Features and Treatment

As the ships stay at the Docks for a long time, waste generation needs Management complying with Provincial and National legal requirements, and Internal Regulations of YPF SA.

Such waste Management is duly accepted by the relevant agencies and ensures unloading and transport to especially permitted locations.

From the time of Unloading to the Disposal of such wastes, traceability is a critically important issue.

The resulting wastes are usually the following:

- Organic wastes
- Glass and plastic bottles
- Paper and cardboard
- Etc.

Quantities in the period June – December 2011 were about 13,160 Kg of wastes acceptable for disposal at duly permitted treatment and final disposal centers.

Such wastes are removed to the relevant treatment centers about 10 times a month.

Special wastes generated may be classified into:

- Bottles with remnants of industrial lubricants and fluids
- Paint cans
- Fluorescent tubes
- Cloth with remainders of maintenance operations
- Etc.

In the same way as the former, such wastes are unloaded to the Port Facility, which has a Temporary Waste Storage Enclosure, where the wastes remain until they are removed by the relevant permitted business for their transport, treatment and final disposal.

Traceability of all Operation Wastes is made possible by strict compliance with these procedures.

Quantities in the period June – December 2011 were about 1,100 Kg of wastes acceptable for disposal at duly permitted treatment and final disposal centers.

3.8.2. FSRU liquid efluents

Figure 18 shows the balance of waters used by the FSRU and the resulting wastewater (from the regas process and as a part of general ship consumption).

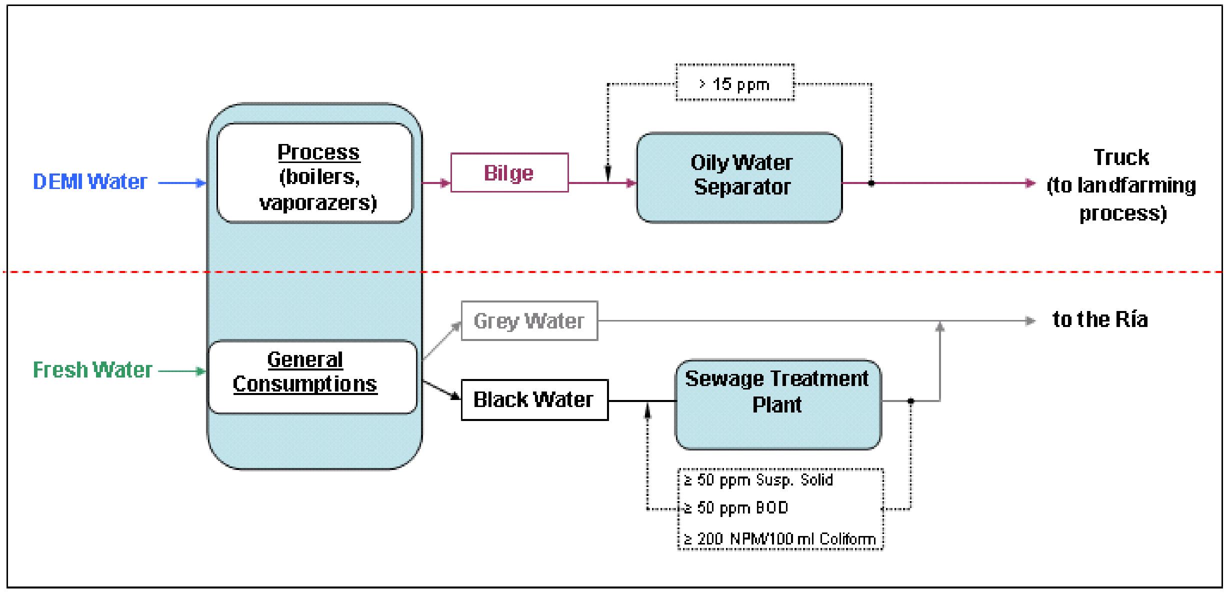


Figure 17– FSRU Water Balance

3.8.3. Bilge Water

Bilge water resulting from the FSRU is treated on board with a hydrocarbon separator, which ensures that wastewater at the outlet will have a concentration below 15 ppm of hydrocarbons.

The bilge water with concentrations below 15 ppm is removed about 3 times a month, and sent to industrial plants to recover any hydrocarbon in the wastes, which are classed as special wastes.

The treatment and/or recovery processes consist of settling, separating the aqueous phase and drying at room temperature or in a vacuum.

Where the FSRU is outside the dock, it can pour treated bilge water into the sea and use the burner to burn any hydrocarbon separated by such treatment.

The amount of bilge water generated by the FSRU in the period May-December 2011 was 674,170 Kg.

3.8.4. Sewage

The so-called "Black Water" flow includes sewage passing through a treatment plant. Such Black Water, once treated, joins the "Grey Water" (from kitchen wastes, clothes washing, personal hygiene, etc) and unloaded into the river.

The FSRU has a sewage treatment plant for 40 persons, including activated sludge and chlorination, which ensures a wastewater meeting the following parameters:

- Suspended Solids: < 50 ppm
- DBO: < 50 ppm
- Coliform Feces: < 200 NPM/100 ml

FSRU personnel verifies compliance with such parameters on a daily basis.

3.8.5. Gas Emission Features and Treatment

The fuel used for the boilers to generate steam is natural gas resulting from the evaporation of the tank cargo, i.e. boil off gas (BOG).

In order to determine the physical and chemical properties and concentrations of gas wastes, a Gas Emission Monitoring Plan is carried on with monthly frequency.

Such monitoring is done by certified businesses to determine any gas released to the environment by the boiler ducts on the Ship.

Measurements relate to:

- Particulate Material (PM1O)
- Nitrogen Oxides
- Hydrogen Sulphide
- Volatile Organic Compounds
- Carbon Monoxide
- Sulphur Dioxide
- Sulphur Trioxide

The above should be below the Air Quality limits determined by the relevant Authorities.

4. Conclusions

The coordination and commitment of the whole work team responsible for designing, developing and operating the project has been essential to fulfil YPF's agreement to ENARSA on behalf of the national government.

Argentina was the first country in South America where the first infrastructure project was made to receive regasified LNG, and also a forerunner worldwide in the continuous operation of an FSRU moored to a dock, while conducting simultaneous STS operations.

The operations in the regas seasons from 2008 to 2011 were a clear success, which confirms that Argentina has adopted LNG as a major source of supply to offset declining production in its fields and growing market demand.

YPF's commitment to energy supply has enabled the first steps to be taken in the LNG industry, which is the basis for future projects causing the business to consolidate and grow in Argentina.

5. Acknowledgements

A special word of thanks to YPF S.A. for permitting the publication of this work, and we gratefully acknowledge our colleagues, Carla Catá and Martín Oms for their important collaboration in the preparation of figures and revision of work.

6. References

- YPF Escobar Regas Season Internal Report - 2011.
- Oil and Gas Statistics - IAPG (Oil and Gas Argentine Institute) – 2010
- Excelerate Energy Statistics.