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Pricing and Royalties Calculation of Natural Gas Produced from Different Reservoirs in Producing Fields in Brazil

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ABSTRACT :*Oil and natural gas are natural resources that represent a very important source of income for any nation. In general, the countries that have such resources, establish the collection of government participation in their production. The COVID-19 pandemic has accelerated people's perception of the need to use cleaner energy sources. Natural gas is the fuel with the least environmental impact among fossil fuels, and will help to achieve a cleaner energy matrix. The precise pricing of natural gas is an important factor for the correct payment of government royalties for the better society welfare. This paper work proposes a pricing methodology for the natural gas produced based on the composition of the natural gas actually deriving from the producing wells. The methodology was able to influence the pricing of natural gas more immediately, the composition variations in the production process. This aspect of the proposal best complies with the objectives of government participation.*

KEYWORDS: *Natural gas, Natural gas processing, Natural gas composition, Natural gas pricing, royalties.*

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I. INTRODUCTION

I.I - The Importance of Natural Gas in the World Energy Matrix

The energy sector is vital for socio-economic development, with the progress of a country and adequate access to energy being inseparable (CAMPOS et al., 2016). The pandemic caused by COVID-19 has changed the way people are perceiving the world, allowing, for the first time, in several regions of the planet, to experience relatively cleaner environmental conditions. On the other hand, the resumption of economic activities will be more concerned with finding new sources of cleaner energy and seeking sources of public revenue, which may include an increase in the collection of taxes on fossil fuels (SARKIS, et al., 2020).

In the search for clean energy sources, natural gas appears as one of the alternatives. It is estimated that the global production of natural gas could reach a peak of production around 6.1 x 1012 m³/year in 2060, in a more optimistic scenario, while in more pessimistic scenarios, the production of natural gas would already have reached its peak in 2019, at a production rate of 3.7 x 1012/year (WANG, BENTLEY, 2020).

Considering the characteristics of cleaner-burning of natural gas concerning other fossil fuels, it should remain in a leading position in applications such as residential and commercial heating, electricity generation, and industrial heating processes (CASTANEDA, 2018 and AL- SOBHI, ELKAMEL, 2015). The International Energy Agency, IEA, estimates that the demand for natural gas will recover quickly from the fall that occurred in 2020, and that the demand should rise by almost 3% in 2021, reaching a level of 14%, above the levels of 2019 in 2030 (IEA, 2020).

I.II - Government Participations and Royalties

Petroleum and natural gas extracted from the subsoil are finite natural resources, being state-owned in most countries, including Brazil, state-owned. These resources are an important source of income for the countries, and the governments of the oil and natural gas producing countries have established, throughout the discoveries that occur in their territories, that their exploration must give rise to the payment of government participation, so that future generations, when such a resource no longer exists, may benefit (LIMA, 2007).

Government participation is a way for governments to participate in the economic results of oil activities, to compensate society for the exploitation of a non-renewable natural resource. Since in other economic activities, governments take ownership of only taxes paid, in activities of exploration and production of oil and natural gas, in addition to ordinary taxes, government participation is established as a source of additional resources (NETO, 2014).

Royalties are one of the forms of government participation that can be applied to the production of oil and natural gas (LUO DONGKUN et al., 2010). In Brazil, the royalties charged were established by Federal Law nº. 9,478/1997, and are defined as rates ranging from 5 to 10% on the value of the production carried out each month (POSTALI, 2009 and SEABRA et al., 2015) for the concession regime, and 15% for the production sharing regime (BRASIL, 2020).

Royalties are calculated based on the volume of oil or natural gas produced, and the hydrocarbon reference price. The volume produced must follow the standards and technical specifications established in each country. For example, in Brazil, the requirements defined in Joint Resolution ANP/Inmetro nº. 1/2013 must be met, and in Norway, the normative instrument that must be met is the Regulation on the measurement of oil for tax purposes and for the calculation of the CO2 tax of the Norwegian Petroleum Directorate, the NPD (NPD, 2020).

I.III - Natural Gas Reference Price

Each country determines how the reference price to be used for the calculation of royalties, will be determined. Especially in the case of natural gas, some countries use the price of natural gas at the point of delivery, as in Argentina, Ecuador and Norway; in Brazil, the price used is that of natural gas that emerges from producing wells, and not the one received at some delivery point.

In Argentina, the price of the natural gas produced used for the pricing and calculation of royalties is the selling price of natural gas, that is, the sum charged in the operations of companies with third parties. In case of no such price, it is used the current value of the product in the domestic market at the time of sale or industrialization (ARGENTINA, 2020). In Norway, the price of natural gas, for the purpose of pricing and calculating royalties, is based on the quantity and value of natural gas produced at the point of departure of the production area, that is, at the point of sale of natural gas (NPD, 2020).

Brazil uses, as a rule, to price natural gas for the calculation of royalties the ANP Resolution nº. 40/2009 (ANP, 2020). The National Agency of Petroleum, Natural Gas and Biofuels - ANP - is the body responsible for the regulation and inspection of oil and natural gas exploration and production activities (BRASIL, 2020). The ANP is responsible for establishing the methodology that should be used to price natural gas to establish the value of government stakes. Such an assignment should not be mistaken for pricing natural gas for marketing purposes. The sale price of natural gas is freely defined by the company that produces it, without any intervention by ANP.

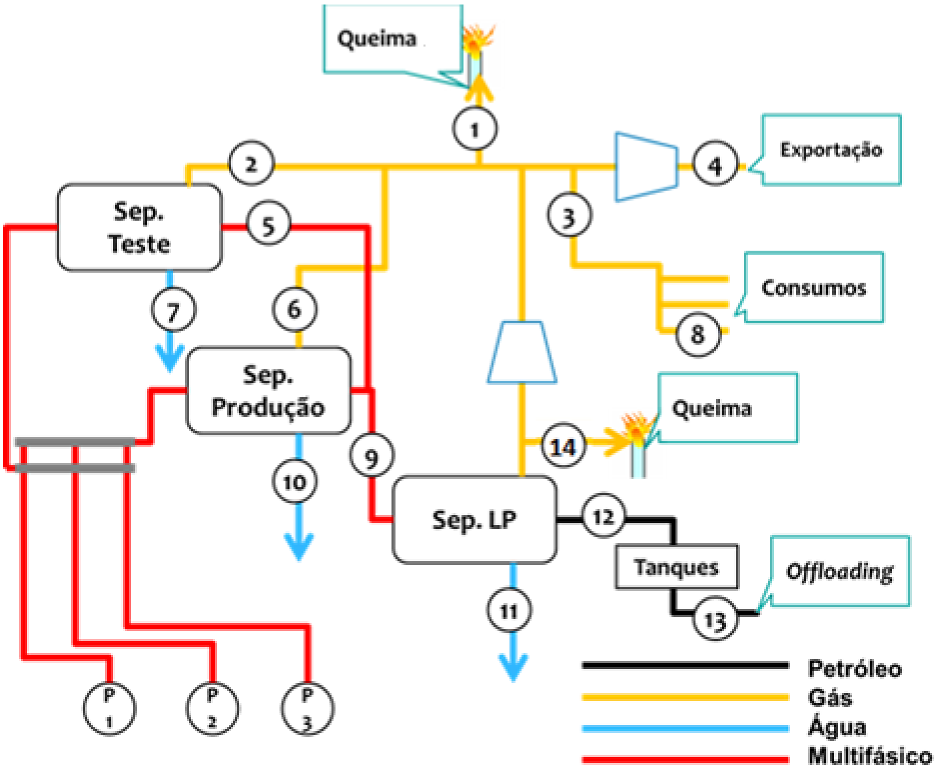
ANP Resolution nº. 40/2009, considered a milestone in the pricing of natural gas in Brazil, established that the calculation must be made according to the products that can be obtained from its processing. However, the Resolution does not clearly and objectively define how the natural gas stream on which the pricing will be applied should be determined.

I.IV - Primary Processing of Natural Gas.

Natural gas is produced from wells of non-associated natural gas, natural gas associated with oil, and condensate (ABDULRAHMAN et al., 2015). In this way, the production from the wells is directed to the facilities that will affect the separation of natural gas from other hydrocarbons produced and water (ALVES, GOMES, 2007).

Primary processing of natural gas is a part of common processing at production facilities, and typically includes (i) stabilization, (ii) removal of acid gas, (iii) (H_2S, NO_x and SO_x), (iv) dehydration, and (v) separation of liquids from natural gas. (AL-SOBHI, ELKAMEL, 2015 and PARK et al, 2014).

Due to the characteristics of the production and primary processing of natural gas in marine production units, several streams of natural gas produced coexist. Figure 1 presents a simplified example of hydrocarbon flow on a marine production platform.



Source: Adapted from ANP, 2020.

Figure. 1 - Example of flow of natural gas streams generated on a offshore production platform.

In the installation example in Fig. 1, the natural gas produced is present in currents number 1, 3, 4 and 14. These currents represent the natural gas that is being burned in the installation for safety reasons (currents 1 and 14) the o natural gas consumed as fuel in the installation itself, for energy generation (chain 3), and natural gas that is being made available to the consumer market (chain 4). Considering that these streams are in a different location from the primary processing plant, each of them will present a different composition for natural gas.

I.V - Natural Gas Produced x Exported Natural Gas (Available)

Considering that natural gas production facilities are always associated with primary processing, and, consequently, that there are different streams of natural gas, all of which are streams of natural gas produced, the difference must be established between the natural gas that is actually produced, the natural gas that is made available to the consumer market.

Taking as an example the installation described in Figure 1, the natural gas produced in fact has a non-real composition, since the theoretical calculation of its composition includes currents 1, 3, 4 and 14, of different compositions. In order to make it clearer, Table 1 presents the compositions of the different currents calculated in December 2018 of Platform P-52, which produces the Roncador field, in the Campos Basin, in the State of Rio de Janeiro, Brazil.

Table. 1 - Composition of natural gas streams from the offshore production platform P-52, in December 2018. Source: Adapted from ANP, 2020.

Composition	LOCATION IN THE PROCESS PLANT				
	EXPORT (4)	LOW PRESSURE FUEL (3)	HIGH PRESSURE FUEL (3)	HIGH PRESSURE FLARING (1)	LOW PRESSURE FLARING (14)
N_2	0,8399	0,9513	0,9586	2,6143	0,6324
CO_2	0,1972	0,2242	0,2171	0,3594	0,3452
C1	66,1744	74,1565	73,9963	65,9034	55,6569
C2	11,2423	11,3003	11,2971	11,0319	12,8669

C3	9,8838	8,2772	8,1788	9,1103	14,2835
iC4	2,0945	1,2296	1,1986	1,8507	2,9602
nC4	4,9564	2,4288	2,3331	4,3628	6,6369
iC5	1,3675	0,3709	0,3886	1,2497	1,4724
nC5	1,7777	0,4699	0,4744	1,7038	2,2021
C6	0,8746	0,1635	0,2215	0,5947	1,3942
C7	0,3672	0,0645	0,2014	0,4189	0,8286
C8	0,1115	0,0474	0,1914	0,2410	0,3271
C9	0,0686	0,1516	0,1829	0,0824	0,2813
C10	0,0443	0,1642	0,1601	0,0370	0,1122
H_2O	0,0000	0,0000	0,0000	0,0000	0,0000
He	0,0000	0,0000	0,0000	0,0000	0,0000
O_2	0,0000	0,0000	0,0000	0,4398	0,0000
CO	0,0000	0,0000	0,0000	0,0000	0,0000
H_2	0,0000	0,0000	0,0000	0,0000	0,0000
Ar	0,0000	0,0000	0,0000	0,0000	0,0000

It can be seen in Table 1 that the compositions at the various points of the process plant are different, and none of them is equal to the composition of the natural gas produced on the P-52 platform taken as an example. Stream 4 of natural gas exported from the platform, which is the stream made available in Argentina, Ecuador and Norway, would be the stream to be priced for purposes of calculating royalties. In Brazil, although the ANP Resolution nº. 40/2009 has the rules for the pricing of natural gas, it does not determine which stream 4 of natural gas produced should be priced.

According to the explanations above, the objective of this paper is to propose a methodology to price the natural gas produced for the calculation of government stakes in offshore fields producing natural gas in Brazil, which will be validated by choosing a model field so that the variations in the composition of natural gas are immediately reflected in the price of natural gas. According to the ANP Resolution nº. 40/2009, companies producing natural gas should update the composition that is used for pricing only if the higher calorific value has a variation over 5%.

II - METHODOLOGY

II.I - Classification of Chains

The streams can be classified into two groups, according to the number of producing fields that originated them. Compositional streams from more than one producing field will be considered as mixed streams, and streams from a single producing field will be considered as simple streams. For the choice of the field to be used as a model for the application of the proposed methodology, considering the sharing of the installations, in this paper work the streams of natural gas produced will be called either mixed or simple streams, and for this last classification there is still a subdivision into single or multiple.

Regarding the different origins of natural gas in the composition of a single stream, it is emphasized that the simple streams can be subdivided into a single stream and multiple streams. The simple stream whose origin of the natural gas that composes it, belongs only to a producing reservoir, having the same physical-chemical characteristic of the natural gas produced, being considered as a single simple stream. The simple current is composed of natural gas from the same producing field, but coming from different reservoirs, presenting different physical-chemical characteristics, which are called multiple simple currents.

II.II - Choice of Model Field

The field chosen to demonstrate the methodology for defining the natural gas stream for the purpose of applying the existing pricing rules, was the Roncador field. The field is offshore, located in the Campos Basin, facing the States of Rio de Janeiro and Espírito Santo, in Southeastern Brazil. This field started its production in January 1999, and it is in water line ranging from 1,500 to 1,900 meters in depth, and has a development area of 397.6 km². Figure 2 shows the location map of Campo de Roncador in the Campos Basin, in Brazil.

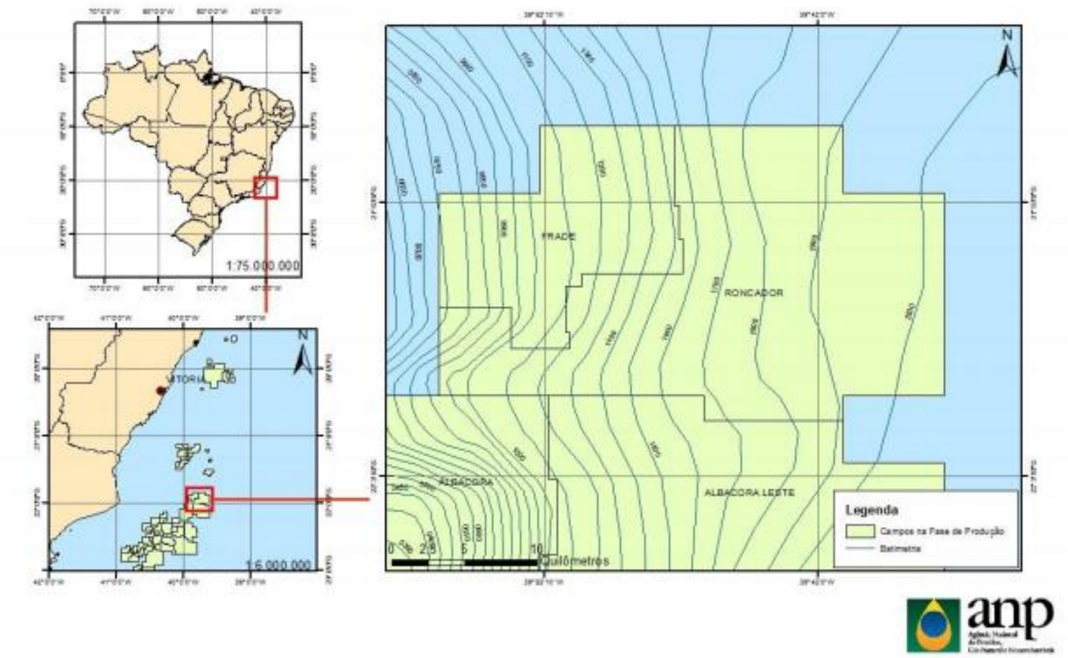


Figure 2 - Roncador Field Location Map (ANP, 2020).

The Roncador field currently has four platforms in production, the P-52, the P-54, P-55 and P-62. Each production unit produces a different reservoir, each of which produces natural gas with different characteristics.

The P-52 platform has the following natural gas streams: exported gas, high pressure fuel gas, low pressure fuel gas, high pressure burnt gas, low pressure burnt gas, burner pilot, assist gas and imported gas. The P-54 has natural gas streams: exported gas, high pressure fuel gas, low pressure fuel gas, high pressure burnt gas, low pressure burnt gas, burner pilot, assistance gas and imported gas.

In the case of P-55, the natural gas streams are as follows: exported gas, high pressure fuel gas, low pressure fuel gas, high pressure flared gas, low pressure flared gas and imported gas. The P-62 platform has natural gas streams: exported gas, high pressure fuel gas, low pressure fuel gas, high pressure flared gas, low pressure flared gas and imported gas.

As described, each stream of natural gas on each platform represents a part of the natural gas produced from the Roncador field. The stream of natural gas produced by the Roncador field is considered to be a simple multiple stream, as the production comes from multiple reservoirs, with different compositions.

The Roncador field has four producing reservoirs, with API grade variation of the oil produced from 18 to 31 API grade. Each reservoir represents a production module, and in each of them, one of the platforms that carry out the production of the field is allocated. In module 1A, P-52, in module 2, P-54, in module 3, P-55 and finally, in module 4, P-62.

The choice of the Roncador field as a model for the use of the proposed methodology is due to the fact that there is the formation of simple and multiple streams of natural gas produced.

II.III - PROPOSED METHODOLOGY FOR DETERMINING THE NATURAL GAS REFERENCE PRICE

The calculations were made according to data collected in the year 2018 of daily production of natural gas and chromatographic analysis of all streams of natural gas produced from the four platforms of the Roncador field.

From the volumes and compositions determined for each day, the equivalent compositions of each fraction of natural gas are calculated for each stream of natural gas in the month, measured at their respective measurement point, for each of the platforms in the Roncador field, using equations (1) and (2).

$$C_{eq/month} = \sum_{i=1}^{n}(\%Vol \times C_{\alpha}) \qquad (1)$$

Where: $C_{eq/month}$ - is the equivalent composition of fraction α in the natural gas stream i for the month; %Vol - is the percentage of the volume of natural gas produced from stream i for the day in relation to the volume of natural gas produced from stream *i* in the month; and C_α - is the equivalent composition of fraction α in the natural gas stream *i* for the day of the month.

$$\%Vol = \frac{V_i}{Vt} \qquad (2)$$

Where:%Vol - is the percentage of the volume of natural gas produced from stream *i* for the day in relation to the volume of natural gas produced from stream *i* in the month; V_i - is the volume of natural gas produced from stream *i* for the day in the month; and V_t- is the total volume of natural gas produced from stream *i* for month.

With the equivalent composition of each fraction α of natural gas per month of each stream of natural gas produced, the equivalent composition per month of each platform is calculated, using equations (3) and (4).

$$C_{eq\ UEP/month} = \sum_{i=1}^{n}(\%Vol_{UEP} \times C_{eq}) \qquad (3)$$

Where: $C_{eq\ UEP/month}$ is the equivalent composition of fraction α in the natural gas stream for platform *j* for the month; $\%Vol_{UEP}$ is the percentage of the volume of natural gas produced from stream *i* for the month in relation to the volume of natural gas produced from stream in platform *j* in the month; and C_{eq} is the equivalent composition of the fraction α in the natural gas stream *i* for the day of the month.

$$\%Vol_{UEP} = \frac{Vol}{Vol\ t_{UEP}} \qquad (4)$$

Where:$\%Vol_{UEP}$ is the percentage of the volume of natural gas produced from stream *i* for the month in relation to the volume of natural gas produced from stream *i* on platform *j* in the month; Vol is the volume of natural gas produced from stream *i* for the day in the month; e Vol $_{t\ UEP}$ is the total volume of natural gas produced platform *j* in the month.

From the data of equivalent compositions of each fraction of the natural gas composition for each platform in the month, it is possible to apply the natural gas pricing methodology established in the ANP Resolution No. 40/2009, and thereby obtain the price of gas produced on each platform in each month of the evaluated period. With the prices of natural gas for each platform and the volume of natural gas produced by each of them in the month, the weighted natural gas current price for each month is calculated, according to equation (5):

$$Price_{ref/month} = \sum_{i=1}^{n}(\%Vol_{UEP} \times Price_{UEP})(5)$$

Where: $Price_{ref/month}$ is the reference price of the weighted natural gas produced for the Roncador field in the month; Vol_{UEP} is the percentage of the volume of natural gas produced on platform *j* in the month in relation to the total volume of natural gas produced in the Roncador field in the month; and $Price_{UEP}$ is the reference price for natural gas produced on platform *j* in the month.

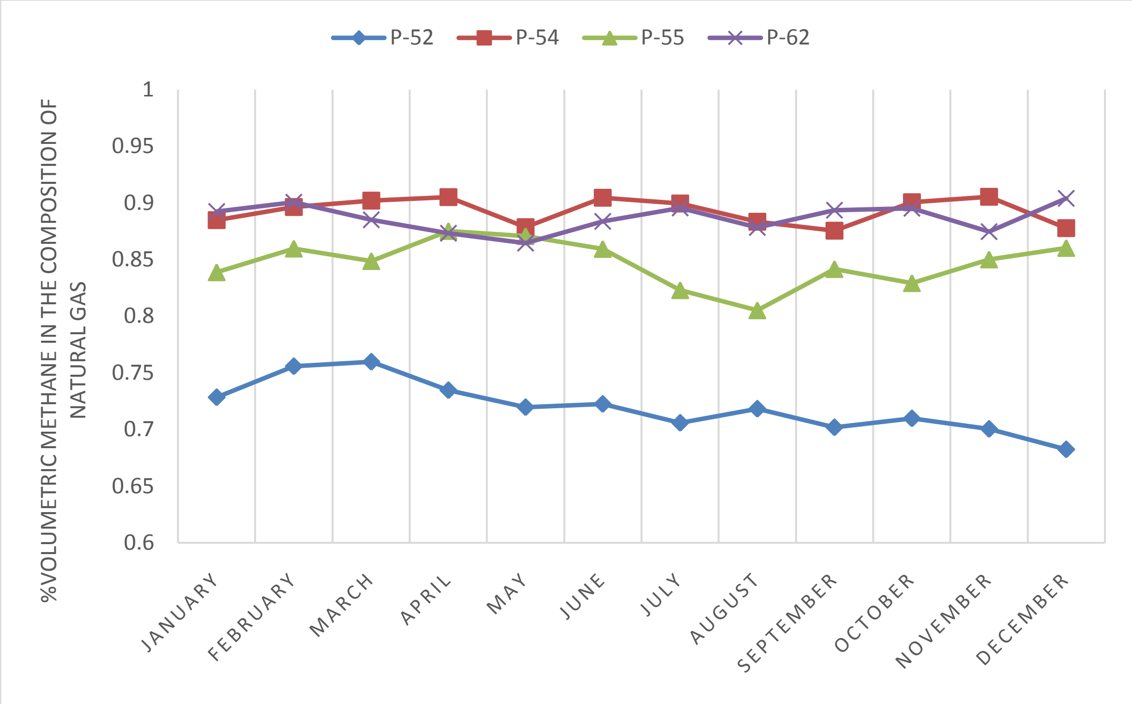
The prices of the natural gas stream in the Roncador field applied by the ANP, throughout 2018, were compared with the prices calculated using the proposed methodology. The composition data used by the ANP for the pricing of natural gas in the Roncador field, the sums of royalties paid during 2018, as well as the prices used to calculate government stakes were collected.

All production data, by measurement point, from the platform and the Roncador field, as well as the chromatographic analysis used in the paper are public information, obtained from the ANP website.

III - RESULTS AND DISCUSSION

III.I - PERCENTAGE OF C_1 COMPOUNDS IN THE NATURAL GAS COMPOSITION OF THE RONCADOR FIELD

The percentages of C_1 compounds, which, for simplification, will be considered to be only methane, in the composition of the natural gas produced on the platforms, month to by month, obtained using the equation for calculating the equivalent fraction of each platform in the month, are presented in Figure 3.



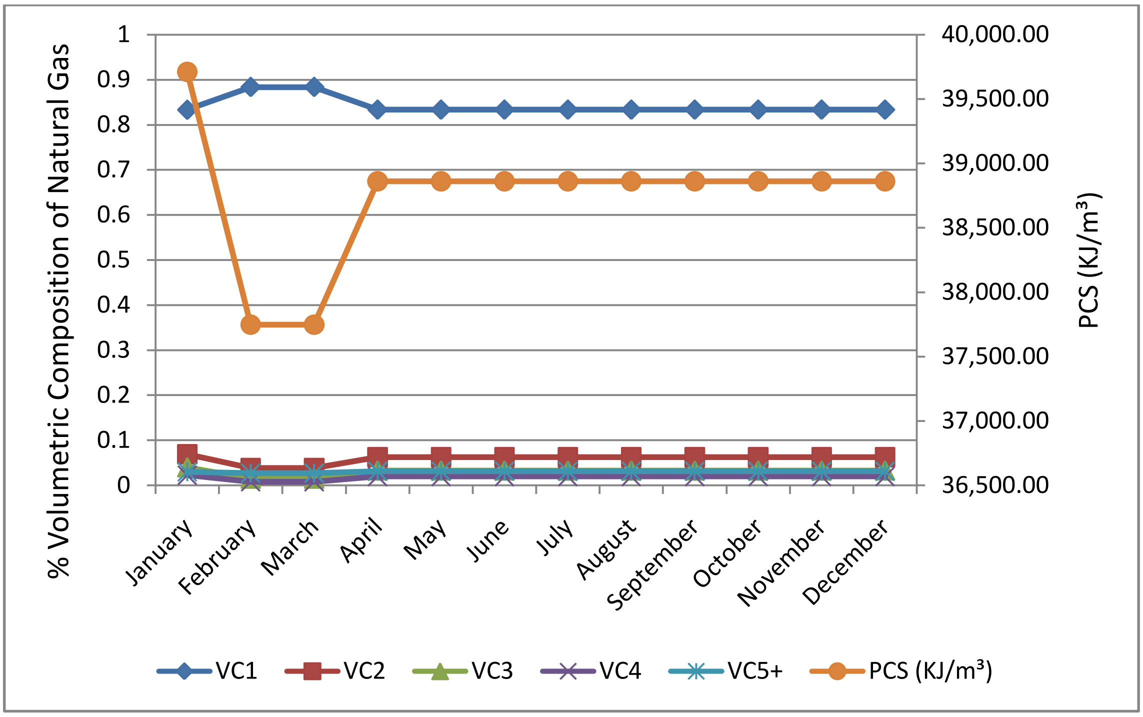
Source: Prepared by the authors based on ANP data.
Figure 3 - Percentage of methane in the natural gas produced in the Platforms in 2018.

The percentage of methane in natural gas produced on all platforms showed slight variations over 2018. At P-52, the maximum variation of 11.3%, was found when comparing March with December but the month to month variation was 7.5% at most. At P-54, the maximum change in 2018 was 4.0%, comparing the months of May and December, and the maximum change from month to month was 3.2%. On the P-55 platform, the maximum variation observed from April to August was the value of 8.4%, and the maximum variation from month to month was 4.4%. On the P-62, from May to December, the maximum variation observed was 4.6%, and the maximum variation from month to month was 2.4%.

The natural gas produced on the P-52 platform was the one with the lowest methane content in its composition, an average of 0.7234 as a volumetric fraction. In this way, the P-52 platform has the highest concentration of components with the highest added value, that is, C_2, C_3 and C_{4+}.

III.II - COMPOSITION OF NATURAL GAS USED FOR THE REFERENCE PRICE

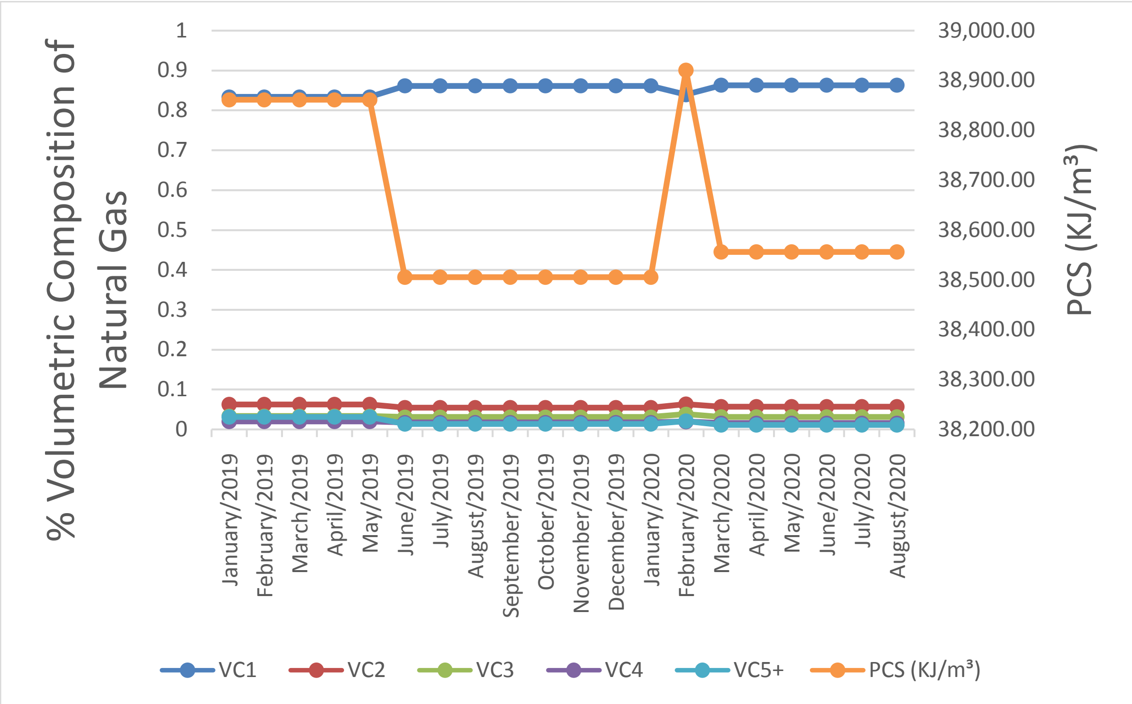
As companies are not required to update the composition of the natural gas produced to calculate the price and the utilization in government stakes, as can be seen in Figure 4, over 2018, the composition of the natural gas in the Roncador field was changed in February and in April, remaining constant from April to December.



Source: Prepared by the authors based on ANP data.

Figure 4 - Composition of the produced natural gas considered for pricing by the ANP in 2018.

The same output was observed in the year 2019 and from January to August 2020, when only the composition of the natural gas of the Roncador field changed in May 2019 and in January and February 2020, remaining constant from April to August 2020, as shown in Figure 5.



Source: Prepared by the authors based on ANP data.

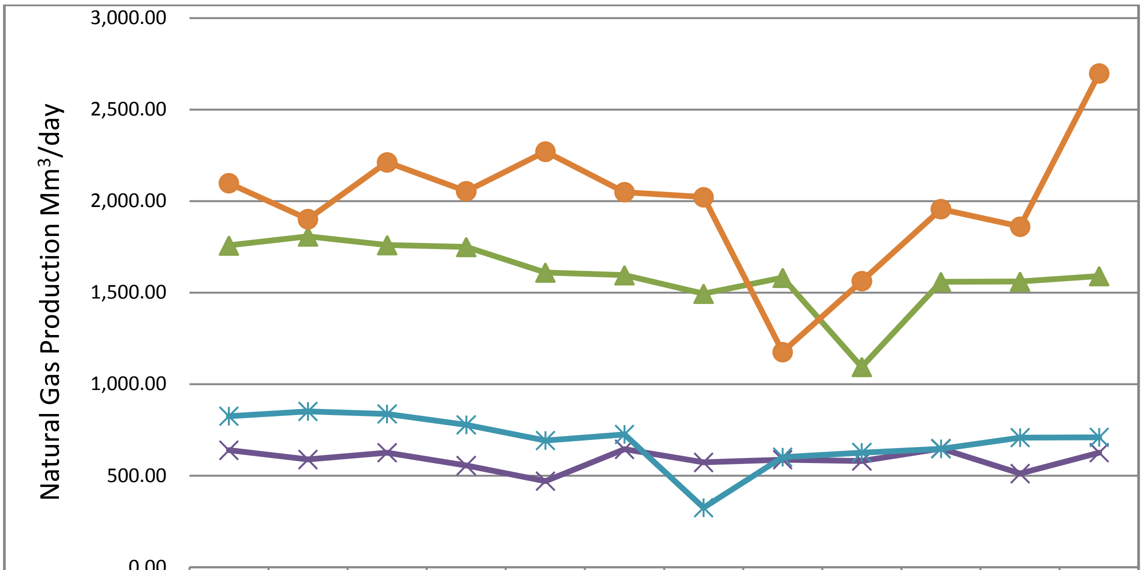
Figure 5 - Composition of the produced natural gas considered for pricing by ANP from 2019 to August 2020.

III.III - APPLICATION OF THE PROPOSAL METHODOLOGY IN PRICING

The proposal presented in this paper considers the composition of the natural gas actually produced and weighted with the volume produced by each of the platforms that make up the natural gas produced monthly in the Roncador field, making the pricing process connected with the production reality.

The result of the application of the methodology showed a variation in the result of the reference price of natural gas in a way directly connected with the occurrence of a variation in the composition of the natural gas produced, either by the entry into production of a new natural gas stream in the field or by the absence of any of the streams that normally make up the natural gas stream of the whole field.

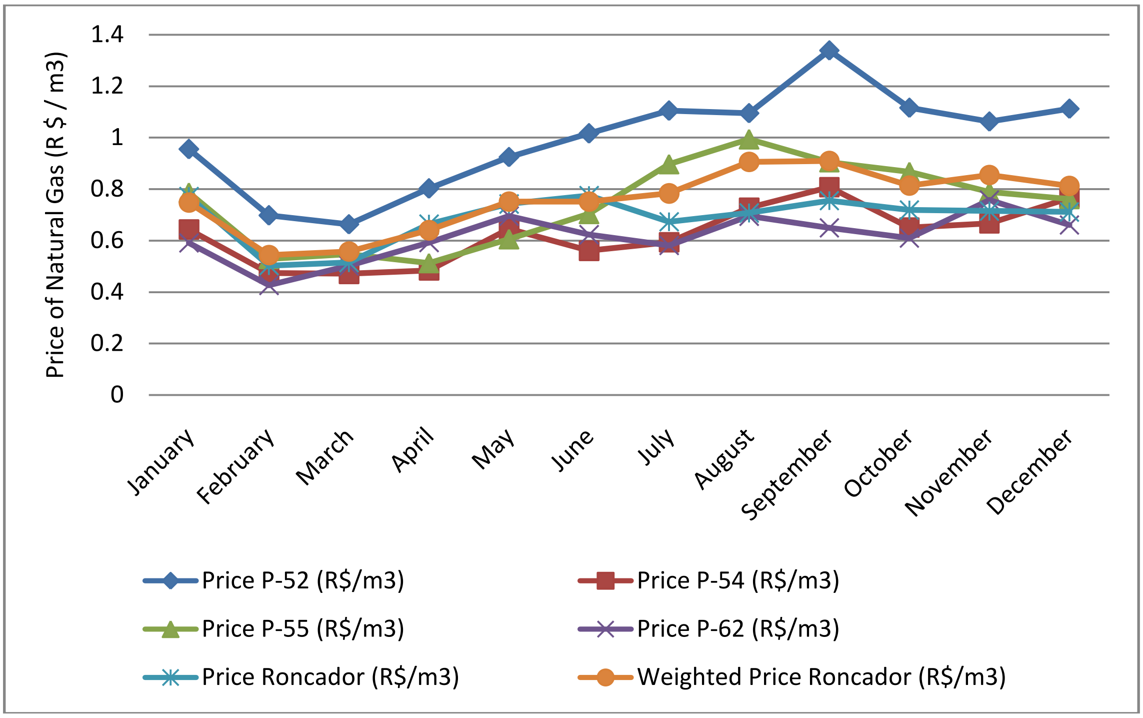
Figure 6 shows the natural gas production curve for the Roncador field platforms, P-52, P-54, P-55 and P-62, in 2018. In 2018, the platform with the highest volume for natural gas production was P-62, followed by P-52, P-55 and P-54. Only in August, the production of natural gas from P-52 was higher than the production from P-62.



	January	February	March	April	May	June	July	August	September	October	November	December
PETROBRAS 52	1,757.85	1,807.62	1,760.23	1,750.14	1,610.50	1,595.84	1,494.78	1,581.69	1,094.79	1,559.16	1,560.79	1591.04
PETROBRAS 54	639.34	589.00	626.53	555.85	471.39	644.13	573.09	587.87	580.87	648.33	512.16	626.21
PETROBRAS 55	824.66	851.25	837.70	778.17	692.89	725.47	325.23	601.50	626.48	647.25	707.61	710.1
PETROBRAS 62	2,097.52	1,901.32	2,211.33	2,053.58	2,269.62	2,048.35	2,021.20	1,175.79	1,562.80	1,955.87	1,860.59	2696.31

Source: Prepared by the authors based on ANP data.
Figure 6 - Production of natural gas from the Roncador field platforms.

Figure 7 shows the prices of natural gas, computed by applying the methodology of the ANP Resolution nº. 40/2009 for the equivalent natural gas for each platform. The price of natural gas produced at P-52 was the highest of all prices calculated in 2018, applying the pricing rules established in the ANP Resolution nº. 40/2009, for the equivalent natural gas for each platform. This result is consistent with the fact that the natural gas produced by P-52 has the lowest percentage of methane in its composition, being, therefore, the natural gas richer in fractions with greater added value.

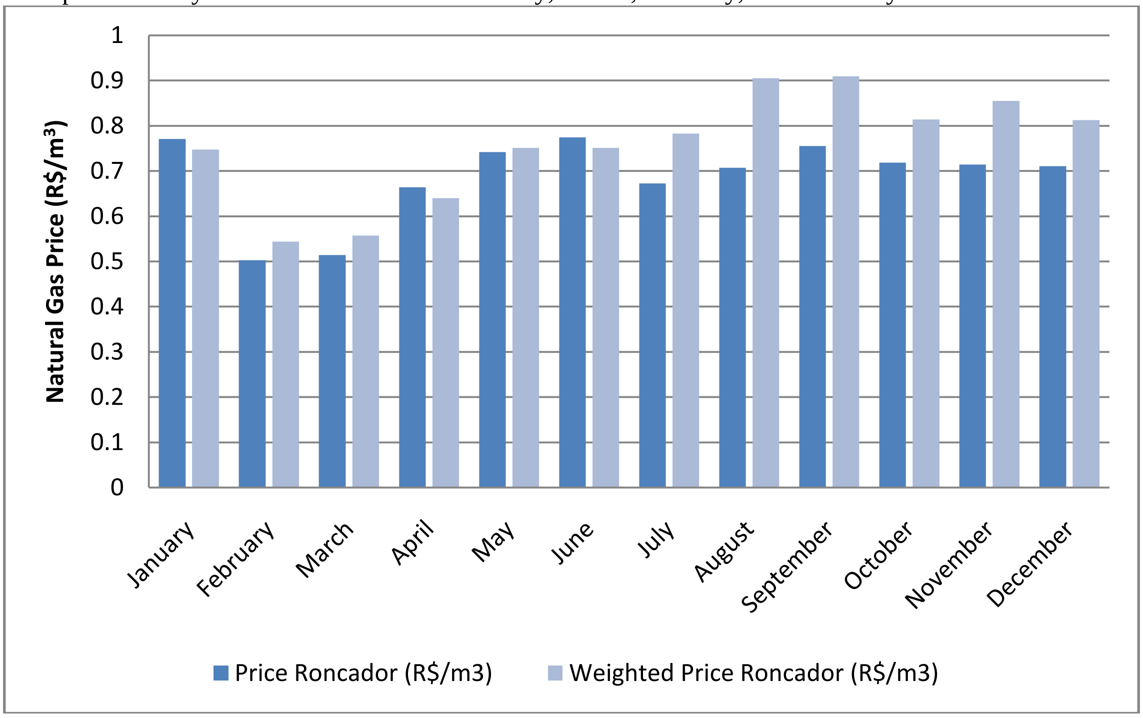


Source: Prepared by the authors based on ANP data.
Figure 7 - Price of natural gas produced equivalent per platform.

The P-62 platform had the largest volume produced, even so, the price of its natural gas produced presented one of the lowest values, only being higher than that of the P-54, which is the lowest among all platforms, from March to June, and November 2018.

III.IV - Proposal Methodology x ANP Methodology

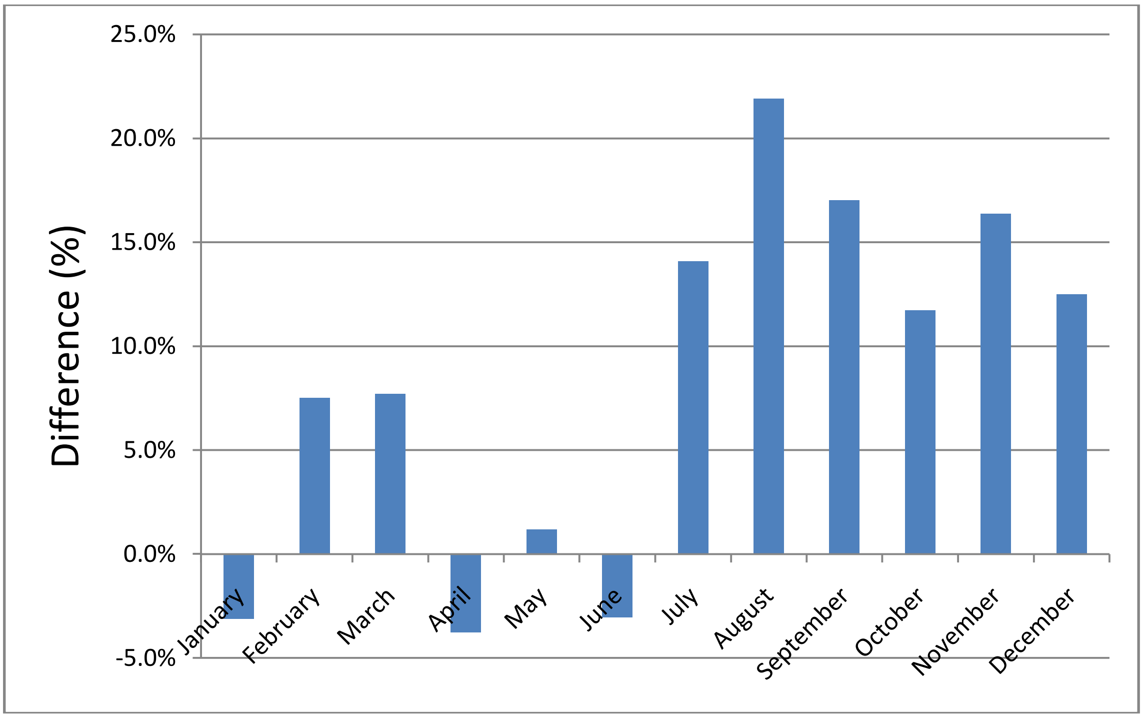
The prices of natural gas produced using the methodology proposed in this paper and the value actually used are shown in Figure 8. It can be seen that applying the proposed methodology, the price of natural gas was higher than the price used by ANP in the months of February, March, and May, and from July to December 2018.



Source: Prepared by the authors based on ANP data.
Figure 8 - Price of natural gas produced used by ANP and calculated using the Proposed Methodology.

The only difference in the calculation of the price of natural gas produced in the Roncador field and obtained with the proposed methodology lies is exactly in its application, that is, all the other parameters established in the ANP Resolution nº. 40/2009 and used monthly for the definition of the price of natural gas are exactly the same.

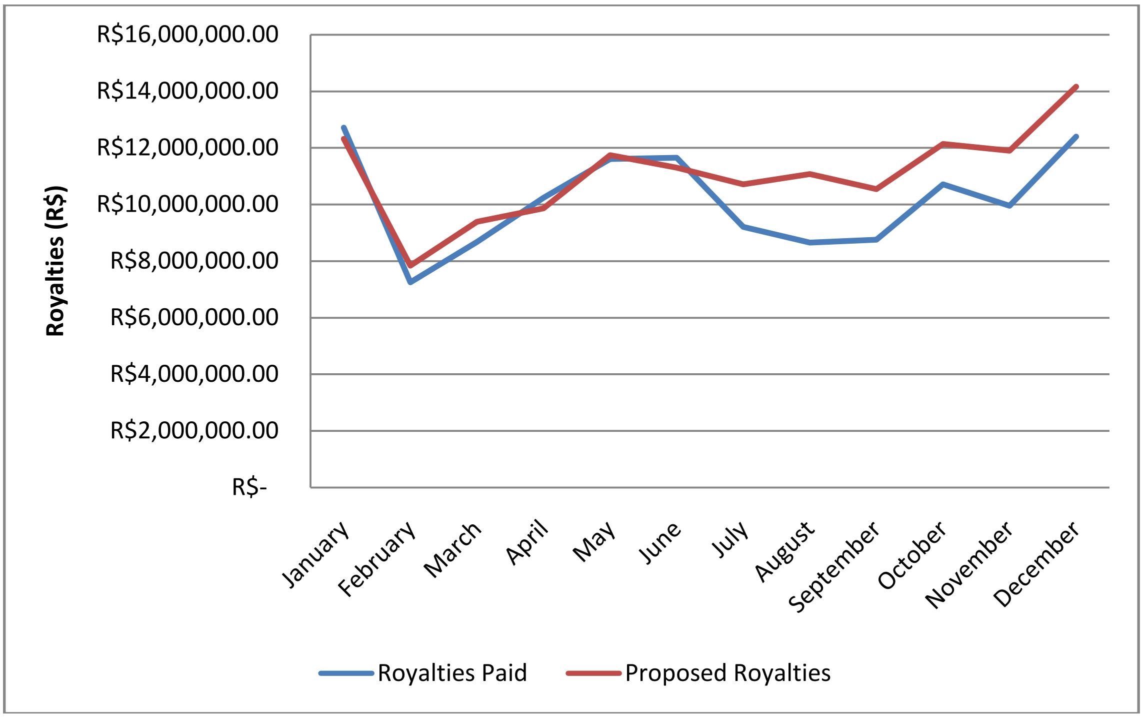
From July to December 2018, the price calculated using the proposed methodology was more than 10% higher than the price used by the ANP, as can be seen in Figure 9.



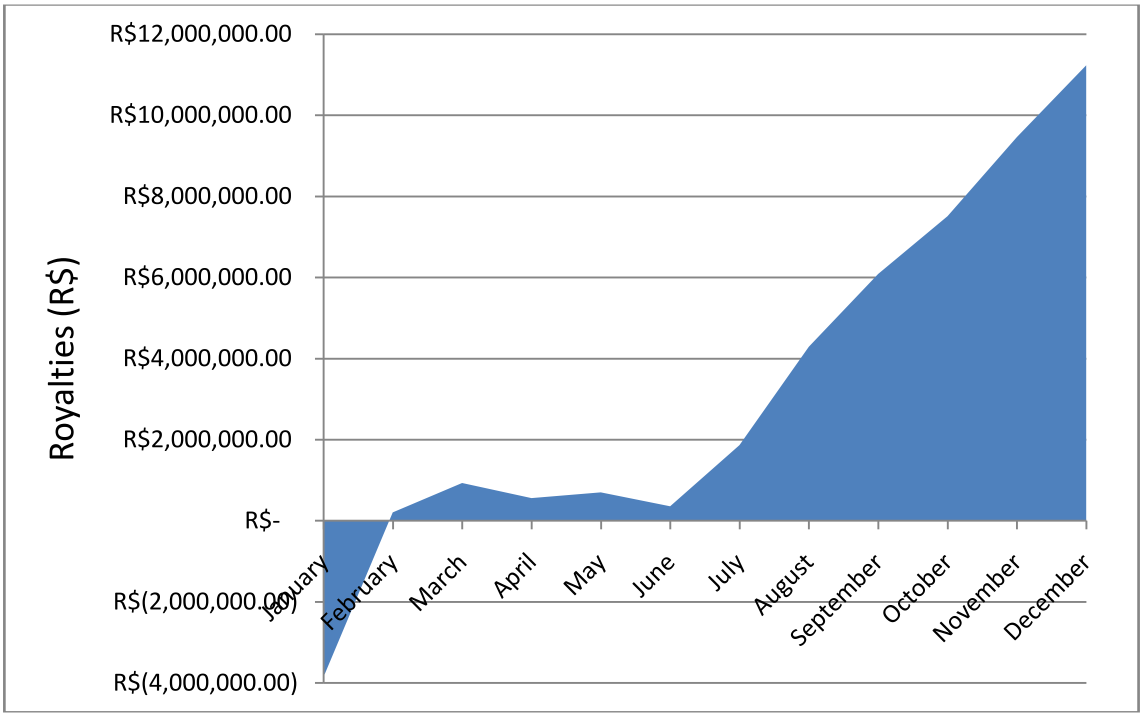
Source: Prepared by the authors based on ANP data.

Figure 9 - Percentage Difference between the Price of the natural gas produced used by ANP and that calculated using the Proposed Methodology.

The calculation the value of the reference price of natural gas applying the methodology proposed in the calculation of royalties in 2018 for the Roncador field, and its comparison with the sums actually paid it result in the accumulated difference shown in Figures 10 and 11.



Source: Prepared by the authors based on ANP data.
Figure 10 - Values of royalties applying the Proposed Methodology and the price used by ANP.



Source: Prepared by the authors based on ANP data.
Figure 11 - Difference in Royalties Amount applying the Proposed Methodology and the amount actually paid.

At the end of the one-year period, applying the methodology proposed in this paper, we have an accumulated difference of more than 11 million reais. The application of the methodology in the case of the Roncador field led to a positive difference, that is, the composition of the natural gas that the company is using to price natural gas has in its formation fractions of components with lower added value than natural gas equivalent calculated using the proposed methodology. In other words, the natural gas actually produced by the producing wells is being underestimated for the Roncador field, and as a result, the amount of royalties paid to the Brazilian government is lower than it would be if the proposed methodology were applied.

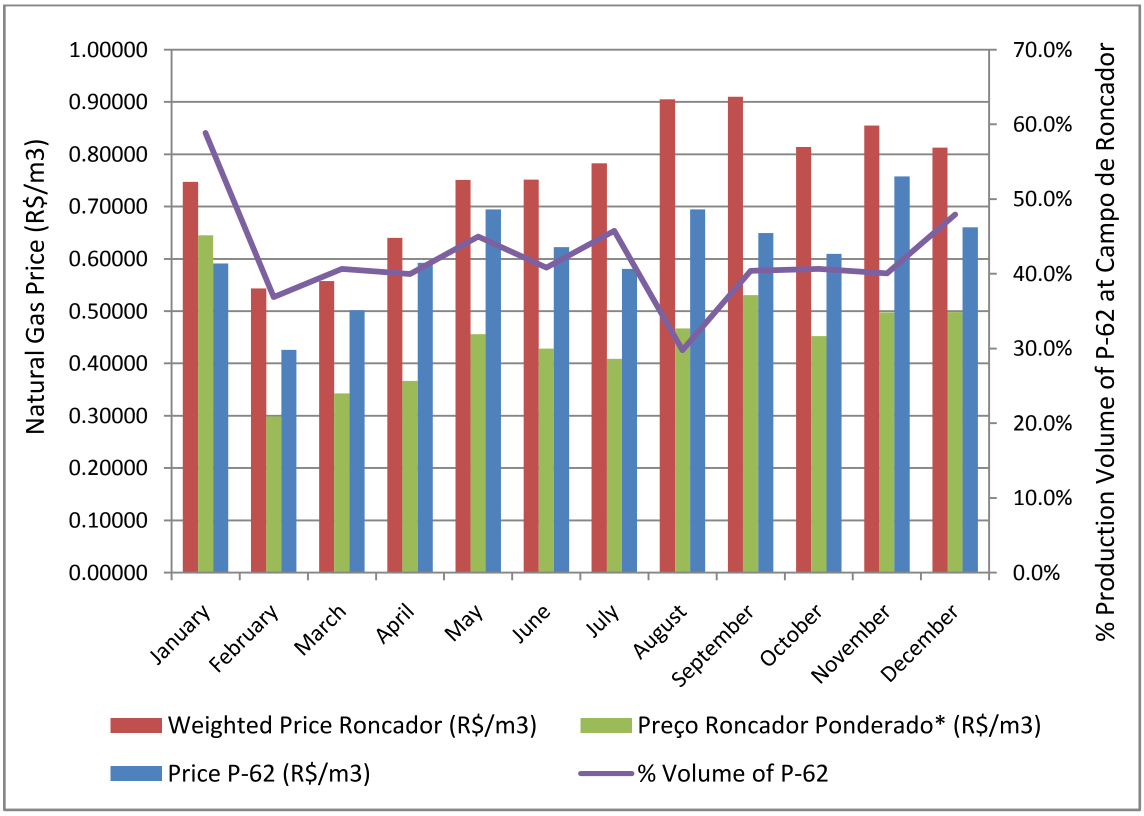
The findings do not necessarily indicate that the results can be positive for all Brazilian fields, that is, that companies are always using natural gas poorer in components with higher added value than they are in effect producing. In fact, there is a regulatory vacuum in the definition of natural gas that will actually be used to price production.

As the reference price of the natural gas produced is not only used for royalties calculation, but also for special participation, the loss that may be happening to the Brazilian State is significant for the case studied, in the Roncador field in 2018.

III.V - Influence of P-52 on the Roncador Field Reference Price

In the Roncador field itself, if there had been a month with production stop on platform P-52, which has the highest price of natural gas among the four platforms that produce the field, the weighted price, calculated with the methodology proposed methodology, would be reduced compared to the value calculated with the production performed.

Figure 12 shows the result of the application of the methodology, removing the production of the P-52 platform in the whole period, and the percentage of participation of the P-62 in the production of the field during the year under these circumstances.



Source: Prepared by the authors based on ANP data.

Figure 12 - Price of Natural Gas according to the Proposed Methodology without the production of P-52.

The value of the weighted price without the participation of the P-52 is lower than the weighted price calculated with its participation, and the higher the participation in the production of the Roncador field has the P-62, the closer the weighted price with the participation is. price of natural gas only from P-62.

This fact is very consistent and connected with reality, since the natural gas produced by P-52 is the one with the highest added value, without it, the weighted natural gas price in the field must be reduced and get closer to the price of natural gas produced on P-62.

III.VI - Scope of the Methodology Proposed

As demonstrated, the methodology proposed makes it more effective the valuation of natural gas actually produced by a natural gas producing field and has a quick response to variations in the composition of natural gas pricing.

Even if the application of this methodology was carried out in another period of time, for example, with 2019 and 2020 data, there would be no change in the findings, because likewise, the natural gas resulting from the application of the methodology that would be priced would maintain adherence with the natural gas actually produced, that is, that natural gas that came from the producing wells, and not only from the natural gas made available to the consumer market.

Thus, the methodology can be applied in any field producing natural gas, regardless of the production environment and the classification of the natural gas stream either as a mixed or a simple one. Considering a simple current, the methodology can also be applied even if it is single or multiple, since it immediately captures the variation in the composition of the natural gas produced, at different points of the primary processing plant, in the production facilities.

IV - CONCLUSIONS

The situation demonstrated for the Roncador field in Brazil can occur in any oil-producing field in a country that does not clearly establish which natural gas stream should be priced to pay government stakes.

Another aspect to be observed is the country's deliberate choice to price the natural gas made available at the delivery point since this current is not in fact the natural gas from the producing wells. Normally, due to primary processing, the natural gas available at delivery points has in its composition fractions of lower added value in a higher percentage, that is, it is a stream of natural gas with a higher percentage of C_1 and C_2.

The methodology proposed showed a faster response in the reference price of the natural gas produced, concerning a variation in its composition in platforms and the Roncador field. In other words, the methodology proposed was able to make a correlation between the reference price of the natural gas produced and the composition of the gas actually produced, i.e. the natural gas from the producing wells.

The application of the methodology for the year 2018 does not present any restrictions for the considerations and conclusions made, since the methodology applied by the ANP so far is the same. The differential of the proposal is that it connects the composition of the natural gas actually produced, from the producing wells, with the reference price that will be calculated, regardless of the volumes produced by the different reservoirs, processed and totaled in different places, with different compositions.

In conclusion, the objective of the methodology proposed is to guarantee the best pricing of natural gas and the fairest compensation, through the payment of government stakes, for the State holding the finite natural resource. The quick response to the reference price of natural gas calculated by the methodology will represent a better remuneration for the country that holds the natural resource, due to its extraction, to better remunerate the society that will not have such natural resources available in the future.

REFERENCES

[1]. Alessandra Aloise de Seabra, Alla Khosrovyan, T. Angel Del Valls, Marcus Polette, 2015, Management of pre-salt oil royalties: Wealth or poverty for Brazilian coastal zones as a result?, Resources Policy, http://dx.doi.org/10.1016/j.resourpol.2015.03.006.

[2]. ANP. Resolução ANP nº 40, de 14 de dezembro de 2009. Estabelece os critérios de fixação do preço de referência do gás natural na hipótese prevista no §4° do art. 8° do Decreto n° 2.705/1998.. Resolução. Disponível em: http://legislacao.anp.gov.br/?path=legislacao-anp/resol-anp/2009/dezembro&item=ranp-40-2009&export=pdf#:~:text=1%C2%BA%20Ficam%20estabelecidos%2C%20atrav%C3%A9s%20desta,06%20de%20agosto%20de%201997%2C. Accessed in: 20 de outubro de 2020.

[3]. ARGENTINA. Ministerio de Justicia y Derechos Humanos, http://servicios.infoleg.gob.ar/infolegInternet/anexos/15000-19999/16078/norma.htm. Accessed in 12 de outubro de 2020.

[4]. BRASIL. Low nº 9.478, de 06 de agosto de 1997. Provides for national energy policy, activities related to the oil monopoly, establishes the National Energy Policy Council and the National Petroleum Agency and takes other measures. Low. Available in: http://www.planalto.gov.br/ccivil_03/leis/l9478.htm. Acesso em: 20 de outubro de 2020.

[5]. BRASIL. Low nº 12.351, de 22 de dezembro de 2010. Provides for the exploration and production of oil, natural gas and other fluid hydrocarbons, under the production sharing regime, in pre-salt areas and strategic areas; creates the Social Fund - FS and deals with its structure and sources of funds; changes provisions of Law nº. 9,478, of August 6, 1997; and makes other arrangements. Low. Available in: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/L12351.htm. Accessed in: 20 de outubro de 2020.

[6]. CAMPOS, Adriana Fiorotti, SILVA, Neilton Fidelis da, PEREIRA, Marcio Giannini, FREITAS, Marcos Aurélio Vasconcelos, 2016. A review of Brazilian natural gas industry: Challenges and strategies, Renewable and Sustainable Energy Reviews, http://dx.doi.org/10.1016/j.rser.2016.11.104.

[7]. CJ Castaneda, 2013, Historical Overview of the Natural Gas Industry, Encyclopedia of the Anthropocene, https://doi.org/10.1016/B978-0-12-809665-9.09034-0.

[8]. GOMES, Jorge Salgado; ALVES, Fernando Barata. O Universo da Indústria do Petróleo: Da Pesquisa à Refinação. Lisboa: Fundação Calouste Gulbenkian, 2007.

[9]. INTERNATIONAL ENERGY AGENCY. World Energy Outlook 2020. Paris, 2020. Disponível em: https://www.iea.org/reports/world-energy-outlook-2020/outlook-for-energy-demand#abstract. Accessed in: 16 de outubro de 2020.

[10]. Jin Ho Park, Mohd Shariq Khan, Riezqa Andika, Mesfin Getu, Alireza Bahadori, Moonyong Lee, 2014, Techno-economic evaluation of a novel NGL recovery scheme with nine patented scheme for offshore applications, Journal of Natural Gas Science and Engineering, http://dx.doi.org/10.1016/j.jngse.2014.12.023.

[11]. Joseph Sarkis, Maurie J. Cohen, Paul Dewick, Patrick Schröder, 2020, A brave new world: Lessons from the COVID-19 pandemic for transitioning to sustainable supply and production, Resources, Conservation & Recycling, https://doi.org/10.1016/j.resconrec.2020.104894.

[12]. LIMA, P. C. R.. A Compensação Financeira pela Exploração Mineral no Brasil e no Mundo. Brasília: Câmara Dos Deputados, 2007.

[13]. Luo Dongkun, Yan Na, 2010, 37(6): 756–762, Assessment of fiscal terms of international petroleum contracts, Petroleum Exploration and Development.

[14]. Norwegian Petroleum Directorade, NPD, Regulations for determining the norm price, https://www.npd.no/en/regulations/regulations/regulations-for-determining-the-norm-price/#C-2. Acessado em 12 de outubro de 2020.

[15]. POSTALI, Fernando Antonio Slaibe, 2009, Petroleum roaylties and regional develpment in Brazil: The economic growth of recipient towns, Resources Policy, doi:10.1016/j.resourpol.2009.03.002.

[16]. Ribwar K. Abdulrahman, Mohammed H. S. Zangana, Immanuel. M. Sebastine, 2015, Optimal NGL recovery from natural gas using turboexpander: a case study and simulation, DOI 10.1007/s10553-015-0636-3.

[17]. S.A. Al-Sobhi, A. Elkamel, 2015, Simulation and optimization of natural gas processing and production network consisting of LGN, GTL, and metanol facilities, Journal of Natural Gas Science and Engineering, http://dx.doi.org/10.1016/j.jngse.2015.02.023.

[18]. Sindy SanJuan-Reyes, Leobardo Manuel Gómez-Oliván, 2020, COVID-19 in the environment, Chemosphere, https://doi.org/10.1016/j.chemosphere.2020.127973.

[19]. Wang Jianlianga, Bentley Yongmei, 2020, Modelling world natural gas production, EnergyReports, https://doi.org/10.1016/j.egyr.2020.05.018.

[20]. WATT NETO, Artur. Petróleo, Gás Natural e Biocombustíveis - Doutrina, Jurisprudência e Legislação. São Paulo: Saraiva, 2014. 460 p.