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Formation Evaluation and Economic Analysis of Gas Wells in Marginal Field, Onshore Niger Delta

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Abstract:

Formation Evaluation and Economic Analysis of Gas Wells from Marginal Field in Koko creek, Onshore Niger Delta, was carried out to analysis wells potentials in term of hydrocarbon driven gas and to forecast the cash flow. The study integrates reservoir information, production high forecast in formation evaluation and economic analysis of Gas wells in a marginal field. Petrophysical well logs were analyzed so that properties such as porosity, permeability and saturation can be used to understand the static and dynamic properties of the reservoir beds. This study used data obtained from a marginal field in the Niger Delta to evaluate gas production profitability using High Case Forecast scenario. The gas production some wells like well 002 with High case forecast shows a small production of 1863.2Mscf in 2023 with a steep slope rise in production one year later (2024), 69631Mscf. Standard price of gas used for calculation was $7.54/Mscf production in 2014 for marginal fields. Eight gas wells of interest gave the cash flow of over 65% from gas sales and revenues of $38,879,788.54. The Expenditure was above $3,359,625 which shows economical viableprospect for future investor especially by indigenous companies. Hence, some wells are prolific and optimal for gas production in the marginal field.

Key words-**Formation Evaluation, Economic Analysis, Petrophysics,Prolific.**

I. INTRODUCTION

Many people all over the world use gas energy for domestic and industrial uses. Gas can be sourced from conventional and unconventional gas well, with a positive cash flow on the mind of the investors. Due to current technological advancement, gas will be much relevant than oil in times to come, especially in developed countries. This is because of non-oil energy, solar energy, electric cars and other energy sources that environment friendly are on the verge of taking the lead. Therefore, the evaluation of gas wells for production and development cannot be over emphasized [1; 2].The aim is to evaluate the Formation and determine the economic potentials of some marginal gas wells in Niger Delta.

In the Niger Delta where the bulk of Nigeria's natural gas reserves exist, the region is split into geographical locations for production infrastructure. Therefore, gas resources exist in the East and West and between onshore and offshore basins. Natural gas resources exist in form of gas from oil fields (associated gas) or gas from fields that contain no oil (non-associated gas)[3]and[4]. Efficient development and operation of a natural gas reservoir depend on understanding the reservoir characteristics and the well performance. Predicting the future recovery of the reservoir and the producing wells is the most important part in the economic analysis on the field for further development and expenditures. To forecast the performance of a gas field and its existing production wells, sources of energy for producing the hydrocarbon system must be identified and their contributions to reservoir behavior must be evaluated to decipher its economic viability [5].

Most of the Oil and gas filed in the Niger Delta are marginal fields with fewer giant and large fields. The commercially viable gas field is a source of income to the multinational investor as well as the government. According to the Society of Petroleum Engineers, marginal fields are discoveries which have not been exploited for long, due to factors such as: very small sizes of reservoirs/reserves, lack of infrastructure in the vicinity, prohibitive development costs, unfavorable fiscal regimes and technological constraints.

However, it is now widely known that developing marginal fields has more to do with economics rather than reserves or production characteristics, [6]. Many oil and gas producing countries have therefore carried out reforms aimed at subsidizing the economic burden and making investment in marginal fields more viable.

[7] noted the major reasons for the interest of the Nigerian government in marginal fields development to include: reducing the rate of abandonment of once most investors account for the time value of money using present value calculations for mature fields, encouraging indigenous participation in the oil and gas industry to build competence and wealth and increasing government's take via royalty and taxes in non–producing fields.

II. GEOLOGIC SETTING OF THE STUDY AREA

The data used is a secondary data which was extracted from some wells in Kolo creek in Bayelsa state, Nigeria and has the follow areas within as Obia, Abua Odual and Opu Emeya located in latitudes 4°51'45"N and 4°54'0"N and longitudes 6°20'15"E and 5°24'0"E as shown in Fig. 1.

In terms of Geographical area, Niger Delta states includes: Rivers, Bayelsa, Delta Cross River and Akwa Ibom and covered an area of about 67,284 square kilometers and an estimated population of 16,331,000 persons. However, the actual Niger Delta states have undergone political adjustment Niger Delta in addition to Abia, Edo, Imo, and Ondo states, with a total area of 112,110 square kilometers of land as at 2006.The region represents about 12% of Nigeria's total surface area [8].

The Niger Delta basin was deposited in the Gulf of Guinea and extends throughout the Niger Delta Province as stated by [9]. From the Eocene to the recent, the delta has prograded south westwards, which gave rise to depobelts that represent the most active portion of the delta at each stage of its development according to [10].

The Niger Delta is one of the largest regressive deltas in the world that covered about 300,000km^2[9; 11], with a sediment volume of 500,000 km^3[12].

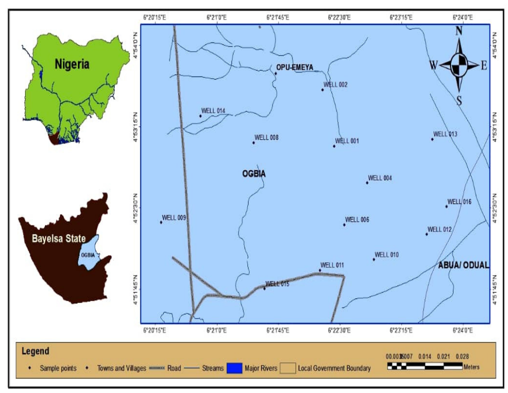

Fig. 1Location map of the study area

III. METHODOLOGY

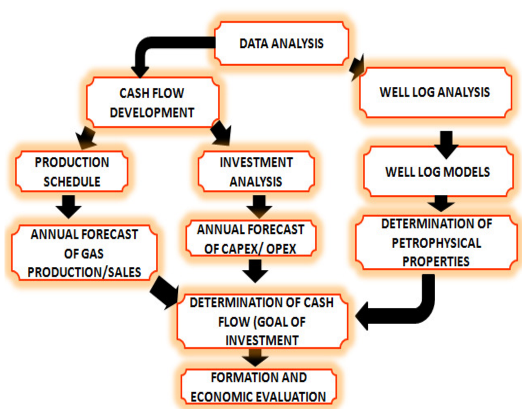

Fig.2A technical work flow of the steps taking in this research.

A. Methodology of Gas Flow Rate Determination

The available data as obtained for existing wells with the study area will be used in the next chapter to determine production vis-à-vis the decline rate for gas flow in Niger Delta Marginal fields since they display common pressure from the upstream.The high case production forecast from an onshore producing well in Niger Delta operated by Shell Nigeria. The data cover a period of 8 – 20 years on the average from different wells in a field.

B. Production Decline

According to [13], a typical life time of a well can be classified into different periods buildup, the plateau, and the decline periods as shown in Fig. 3.

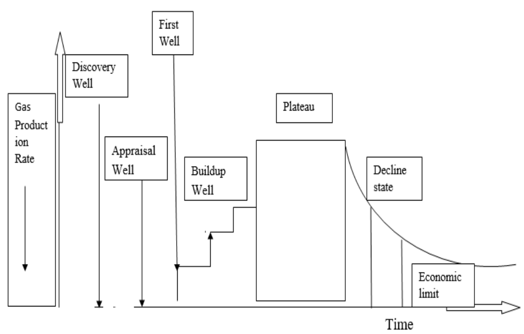

Fig. 3 Theoretical production curve as drawn from [13].

C. Petrophysical Formulae Used

Oil accumulation for reservoir A and B of stock tank oil originally in place (STOIIP) was estimated using standard estimation formula.

$N=7758Ah\phi(1-S_w)/B_{oi}$

Where:

N=STOIIP (stb)

7758=Conversion factor in acre-ft to bbl

A=Area of reservoir (acres) obtained from map and model

h= Reservoir pay thickness (ft)

ϕ= Reservoir porosity

S_w= Water saturation

B_{oi}= Formation volume factor taken as 1.00bbl/stb

Stb= Stock tank barrel

IV. RESULTS AND ANALYSIS

A. Interpretation of Well Log Data

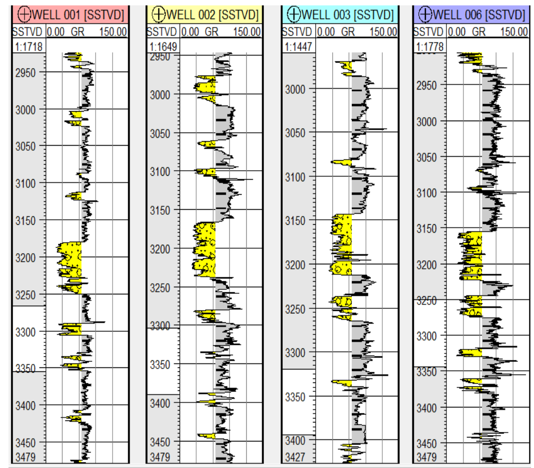

Fig. 4 Lithologic models produced from Gamma Ray log signatures.

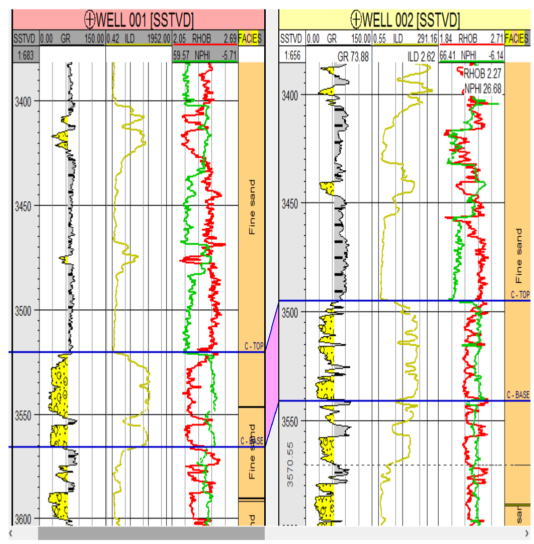

Fig. 5 Reservoir evaluation vis-à-vis well log response of well 001 and 002.

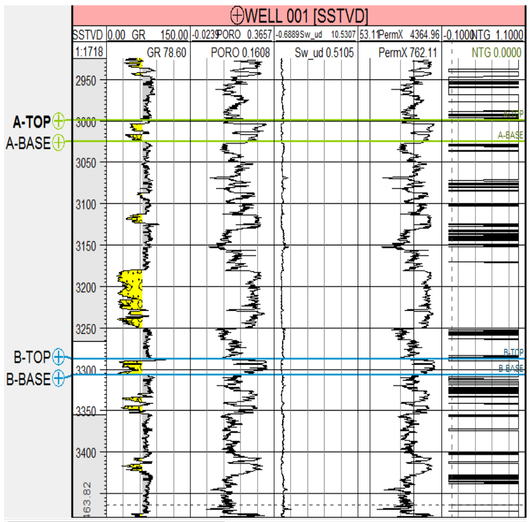

Fig. 6 Petrophysical logs used for the description of reservoir properties.

The study integrates reservoir information and production forecast in formation evaluation and economic analysis of Gas wells in a marginal field, Onshore Niger Delta. Petrophysical well logs were analyzed so that properties such as porosity, permeability and saturation can be used to understand the static and dynamic properties of the reservoir beds. However, subsurface well information was used to demonstrate graphical illustration of production in some gas wells using parameters from a marginal gas field, Niger Delta.

The well log model is a model that depicts a conceptual 2D and 3D construction of reservoir sand bodies in relation to shale intercalations within an oil/gas field. However, several models resulting from the drilling and logging processes of this field led to the geologic evaluation of the subsurface formation. The evaluation involves a detailed analysis of the petrophysical properties of the reservoir sands which involves porosity, permeability, saturation, net-to-gross ratio, etc.

Fig. 4 of well 001, 002, 003 and 006 show lithologic models produced from Gamma Ray log signatures. The log signatures which are formed due to changes in the geologic formation as depth increases. The Gamma Ray log responses depict alternation of sand and shale sequences due to the presence of radioactive material present within the shales and less amount of radioactive content present within the sands.

Thus, the resistivity log, density, neutron porosity hydrogen index logs were used to complement the Gamma Ray log for an efficient geological and petrophysical interpretation of the reservoir formation as depth increases (Fig.5). The resistivity log was used in the interpretation to show areas of fluid content (gas and oil) present within the reservoir sands as shown in Fig. 5.

The density log was used to show areas of density response of the hydrocarbon fluids within the reservoir [14], while, the neutron log was used to show the amount of hydrogen atom index present in the formation in relation to the percentage absorption of these atomic nuclei in the formation. In this case, the density and the neutron porosity hydrogen index logs were combined after reversing the neutron log to form a gas-balloon structure for delineating gas-oil-contact (GOC) and oil-water-contact (OWC) within the reservoir sands.

Fig. 6 is a model showing various petrophysical logs derived from the reservoir formation using certain petrophysical properties as shown above. These formulae were imputed into the Petrel Software for generating and delineating various petrophysical properties within the reservoir formation (i.e., of reservoir A and B).

B. Economic Evaluation

In well 001, the production of 41235Mscf in 2026 forecast with a peak of 74103Mscf in 2028 remains nearly constant for three years when the production declined to zero prediction. Thus, Years 2026 to 2033 is the forecasted economic viability.

The gas production in well 002, using High case forecast shows that a small production of 1863.2Mscf in 2023 with a steep slope rise in production one year later (2024), 69631Mscf. However, the maximum forecast of the gas well was recorded in 2027 with 138501Mscf after which is expected to decline to zero production in 2031.

Although, well 002 forecasts are for a period of 8 years unlike the other low period high forecast. The profitability of the gas wells is sure based on Net Present Value is NPV > 0 [15], with good Internal Rate Return IRR and a positive cash flow particularly for selected wells like 002, 005 and 006.

For well 003, it is expected from the plot and table (Fig. 6) that forecast for the period 2025 to 2031 would be economically viable or plateau period after which it will suffer minor down time in 2037 to the point of economic limit in nearest time.

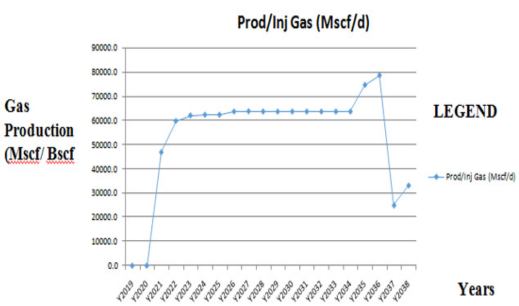

Fig. 7 High case forecast for well 006.

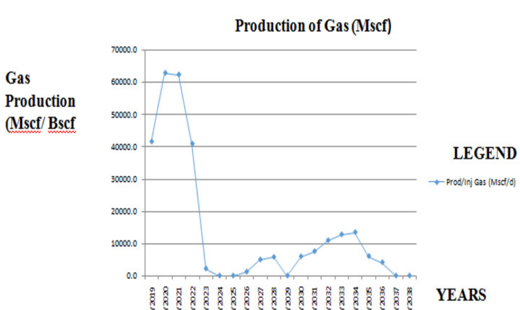

Fig. 8 Production pattern from 2020-2038 in well 001.

Table1

Well 001 revenue calculation between 2025 and 2033

YEAR(S)	Sales/produced Gas (Mscf)	Nigerian current price ($7.54)	Gas Revenue in Millions ($)
2025	40654	7.54	306531.2
2026	47661	7.54	359,364
2027	73201	7.54	551,935.5
2028	73212	7.54	552,018.5
2029	73280	7.54	552,531.2
2030	64294	7.54	484,776.8
2031	18487	7.54	139,392
TOTAL			2,946,549.2

Table 2

Well 002 gas revenue over time

YEAR(S)	Sales/produced Gas (Mscf)	Nigerian current price ($7.54)	Gas Revenue in Millions ($)
2022	1787.4	7.54	13477
2023	68463	7.54	516211.
2024	71061	7.54	535799.9
2025	77395	7.54	583,558.3
2026	136536	7.54	1,029,481.4
2027	111021	7.54	837,098.3
2028	83539	7.54	629884.1
2029	36508.7	7.54	275,275
TOTAL			4,420,785

V.DISCUSSION

Although Nigeria has a global reputation as a major oil producing nation, with recoverable reserves estimated at 35 billion barrels of crude oil and daily production trends of 2.5 million barrels per day, her real energy potential lies in natural gas with estimate of about 185 trillion standard cubic feet, which outstretches its endowment in crude oil.

Predicting the future recovery of the reservoir of producing wells is the most important part in the economic analysis of Gas fields for further development and expenditures. To forecast the performance of a gas field and its existing production wells, sources of energy for producing the hydrocarbon system must be identified and their contributions to reservoir behavior evaluated.

To carry out the formation evaluation of reservoir sand bodies across the wells in the field. The study was carried out with the following objectives, to predict conventional gas field performance vis-à-vis current price of gas globally with the view to understanding the economic viability of the wells, to evaluate the production scale of the gas wells alongside appropriate forecast during long term investments, to encourage small indigenous players in marginal fields in profitable investments.

The Gamma Ray log responses depict alternation of sand and shale sequences due to the presence of radioactive material present within the shales and less amount of radioactive content present within the sands. The Revenues from gas sales was $38,879,788.54, while the Expenditure was above $3,359,625 which shows economical viable prospect for future investor especially indigenous companies.

From Gas production forecast of nine wells in consideration, a good revenue was evaluated to the tune of $38,879,788.54 which should NPV> 0 when compared with the expenditure value in range of above $3million. The marginal field recorded positive cash flow which shows the economic boom in petroleum sector. The cash flow is about $ 1,314,841,844. Wells 005 and 006 are viable and prolific well to invest into for optimal gas production in the marginal field.

VI.CONCLUSION

The profitability of the gas wells is sure based on Net Present Value is NPV > 0, with good Internal Rate Return IRR and a positive cash flow particularly for selected wells like 002, 005 and 006.

From Gas production forecast of nine wells in consideration, good revenue was evaluated to the tune of $38,879,788.54 with good cash flow which should give NPV> 0 when compared with the expenditure value in range of above $3million. The marginal field recorded positive cash flow which shows the economic boom in petroleum sector.

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