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Oil Production Value Chain Generation Using Petroleum System Modelling a Case Study of (Oka Field) Niger Delta

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ABSTRACT

There is a critical problem in understanding the cost and profit of each sector in oil production along the value chain and because each oil production field offers different challenging issues at different time due to location, geology and uncertainties. This research is aimed at applying a numerical simulation using petroleum system model for an oil production value chain, using Oka oil production field as a case study. The method used in this research was both efficient and effective through the application of software simulation integrated models, such as Excel for economics evaluation, GAP for generating VLP, PROSPER was applied to build the well model while Eclipse Model the reservoir. Hence the entire Petroleum asset can be assessed by daily production indices and information from the various nodes. In this research a decision support tool was developed. From the results obtained, the pressure was at 2600psig, the target RF was estimated =27%. The Minimum of 5 wells were initiated to drain the reservoir at estimated 40,000bbls per day for five years. The production profile was set to be evaluated for the period of 10 years. The BHFP is 1830psig; the averaged maintenance down time is 10 % for all the wells. The minimum economical rate for the field is 2000STB/D of oil. Maximum GOR =1500 scf/stb, Oil in place in the 113419255STB, filed water 402141787STB and the dissolved gas in the field 56823047Mscf. The maximum allowable water cut is 90%. This research surmises that Oka Field oil and gas value chain has been developed using petroleum system through the application software simulations, this can guide the petroleum industry on decision making to aid an effective value chain production.

Key Words: Reservoir, Value Chain, Prosper, Oil Production.

INTRODUCTION

The oil and natural gas supply chains can be complicated and sometimes obscure systems to many who rely on their products and services. API has created supply chain models for both oil and natural gas to communicate, in the simplest terms, how the industry works from the identification of resources to the end user. These models provide simple visual descriptions of these critical systems, their major components, and the critical customers and services which are dependent on this energy. Recognizing the critical components and their placement in the system provides the context to understand the diversity of the systems, the issues that can affect the various stages of development, production and distribution, and the resilience that is inherent throughout our Nation's energy infrastructure.

As an industry, we recognize that we produce the products that not only keep our homes warm in the winter and cool in the summer, but also the fuels that are essential to

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manufacturing, power generation and transportation. To achieve this, the industry is committed to: maintaining and wherever possible growing our commitment to safety, environmentally responsible operations onshore and offshore; maximizing industry resiliency and recovery to any incident; and continuing our partnerships with the public and government to ensure those operations are informed by the best information available. This all begins with a familiarity of the industry and how it works (Oil and Gas Publication-The Value Chain, 2021).

2.0 The Study Area - Niger Delta (Oka Oil Field)

The Niger Delta is situated in the Gulf of Guinea and extends throughout the Niger Delta Province as defined by (Asonye & Okolie, 2007). From the Eocene to the present, the delta has prograded southwestward, forming depobelts that represent the most active portion of the delta at each stage of its development (Amajor, L.C. 1997). These depobelts form one of the largest regressive deltas in the world with an area of some 300,000 km2 a sediment volume of 500,000 km^3 (Richard, S.K. 1999), and a sediment thickness of over 10 km in the basin depocenter (Oyekunle & Famakin 2005). Currently, most of this petroleum is in fields that are onshore or on the continental shelf in waters less than 200 meters deep, and occurs primarily in large, relatively simple structures.

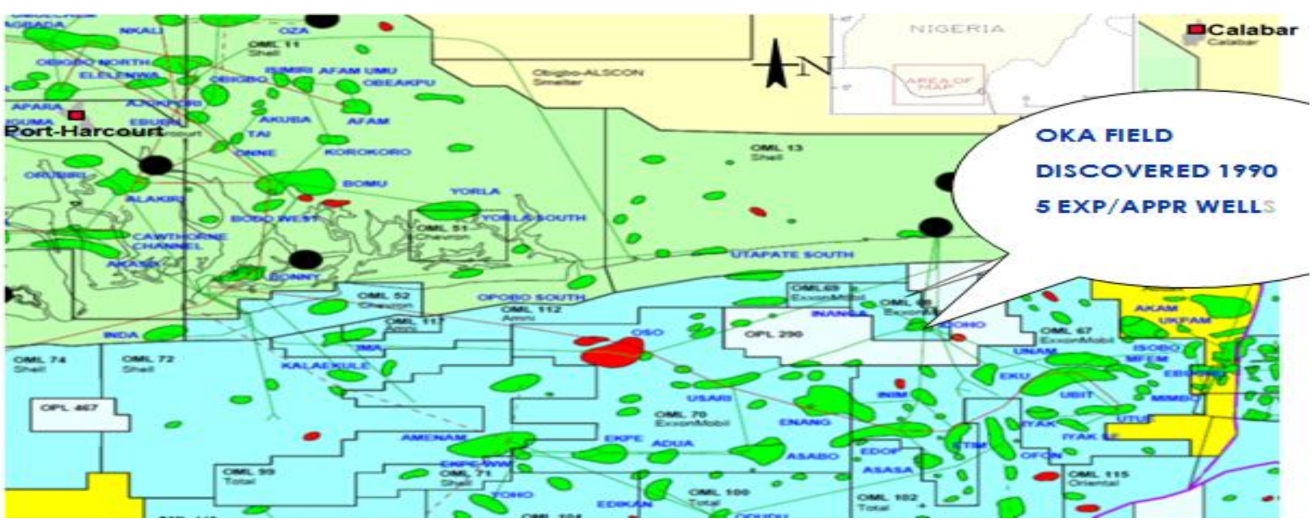

Figure 1: Oka Filed

2.1 Case Scenario-Oka Field

Location of OKA Field in the concession map of the Niger Delta, The OKA Field is located

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offshore in OML 68 in the central part of the Eastern Niger Delta in water depth of about 45 feet. The field is surrounded by IBU LTD-operated blocks (at the southern part of the field is Abanga while Adoho field lies beside the field). The field was discovered in 1990 with the drilling of Pw1. Pw1 encountered 3 hydrocarbon-bearing zones, and four appraisal wells were subsequently drilled. Most of these reservoirs are aerially extensive, but relatively thin. The OKA field is located within the geological setting of the Niger Delta Petroleum Province. This province was formed along the failed arm of a triple junction system, which was created during the breakup of the South American and African plates in the late Jurassic. The Tertiary section of the Niger Delta is divided into three diachronous lithostratigraphic units - the ***Akata, Agbada and Benin*** Formations. Akata Formation is the oldest –marine shales- source rock. Agbada Formation-Reservoir. The Benin Formation is the youngest in age grits, claystone and streaks of lignite. Table 1 is the initial reservoir properties of the Oka filed. With the Initial reservoir Pressure (Pi) 3990 psig, Temperature (T) 166 ^{0} C, Gas Oil Ratio 500.89, Saturation Pressure (Psat) 1800psig, Bo @ Psat 1.24468 rb/stb, and finally the thickness of 17.7ft

Table 1: Initial Reservoir Properties of Oka FIeld

Initial reservoir Pressure (Pi)	3990 psig
Temperature (T)	166 ^{0} C
GOR	500.89
Saturation Pressure (Psat)	1800psig
Bo @ Psat	1.24468 rb/stb
thickness	17.7 ft

3.0 Natural Gas Transportation and Storage in the Value Chain

Natural gas may be stored underground in a variety of methods, most commonly in depleted reservoirs, aquifers or salt caverns. The transport options for gas depend on its physical state. Natural gas liquids can be transported either by pipeline or tanker truck, but dry gas (methane) can only be transported by pipeline, yet not across the seabed of deep oceans, which

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severely limits the ability to trade natural gas between different regions of the world (clearly the costs for such pipelines might also be prohibitively expensive). An option for long-distance gas exports is liquefied natural gas (LNG), which will be described in more detail below. Piped gas has to be transported all the way from the production site to the final customer (power stations, industry, domestic and commercial uses etc.), using multiple types of pipelines and pipeline networks along the way.

4.0 Refining and Marketing Value Chain

Crude oil almost always needs to be refined into oil products prior to consumption, with the main product categories being fuel oil, gas oil, jet/kerosene, gasoline, naphtha and liquefied petroleum gases (LPG). Gasoil and jet/kerosene are often described as middle distillates‖, gasoline and naphtha are light distillates‖. The three main energy-related uses for oil are transportation, power generation and heating. There is also non-energy or process use, for example as feedstock for the petrochemicals industry. The different end uses differ markedly in their vulnerability to fuel substitution. The transportation and non-energy markets have a low vulnerability, making them relatively captive markets for oil. For power generation and heating, however, the markets can easily switch between fuels, especially between gas, coal and oil, so their price elasticity tends to be higher (UBS 2000). Oil refining is the process of separating the hydrocarbon molecules present in crude oil and converting them into more valuable finished petroleum products. Refineries can consist of a number of different process units that undertake separation, conversion and treatment of oil. The initial stage of a refinery run involves the heating and separation of crude into its constituent parts in a distillation column.

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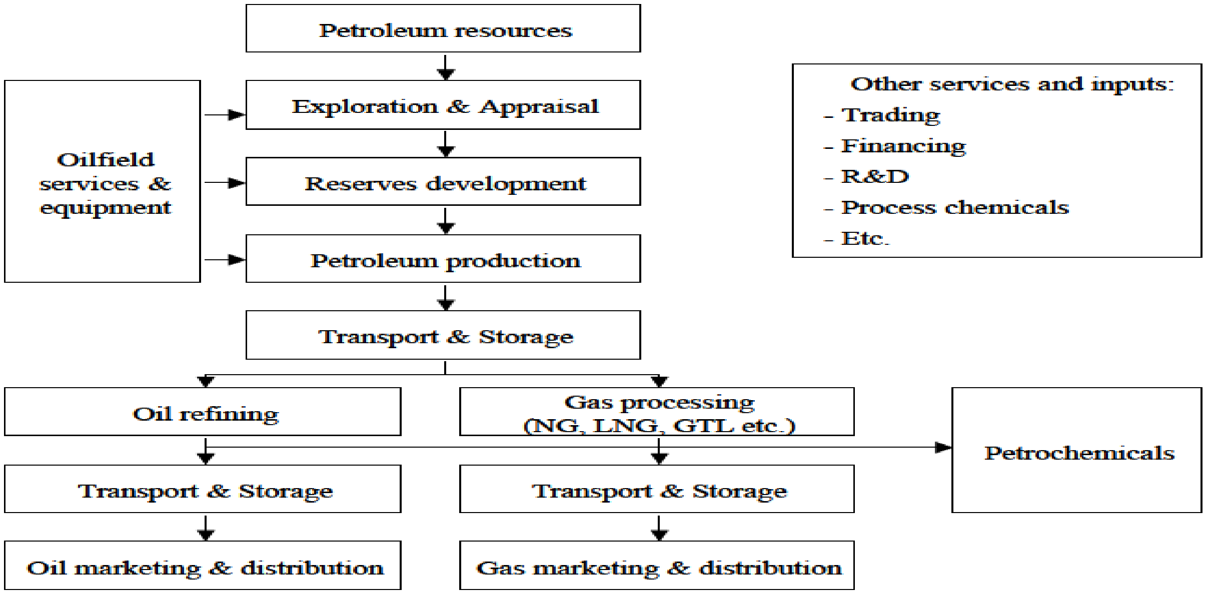

Figure 2: Petroleum Value Chains

Source: World bank bulletin (2013).

Petroleum system modeling is used to calculate the comparative percentage and volumetric contribution of gas through heavy oil from each source rock at reservoir, interval, and basin scales. This identifies the primary source rocks and their relative contributions through time at accumulation to province scales. Mature basins allow better evaluations and calibrations of models by comparing the calculated volumes to known volumes of in-place and recoverable oil and gas and estimates of undiscovered resources. This type of analysis is both for training purposes and for later use of the models as analogs for other basins or reservoirs.

5.0 MATERIALS AND METHOD

5.1 MATERIALS

The materials that were used for the successful completion of this work, oil production value chain generation using petroleum system modeling. First consideration was the Oka field, which was our field of interest for the oil and gas filed development, the second was collection reservoir core sample for laboratory analysis to determine if the Oka field reservoir contain oil and gas in commercial quantity. Laboratory equipment for the analysis of initial reservoir properties, examples Pressure, Temperature, Gas Oil Ratio, Saturation, Bo, the thickness, volume, porosity, permeability and hydrocarbon saturation Pressure, the application of five deferent computer aided engineering software which are (1) Eclipse-Reveal for the reservoir Model (2) PROSPER for the Well

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Model and gathering network (3) GAP was used for the gathering network, (4) HYSYS for the surface gathering and flow-station process and finally (5) Excel for the economic investment and sale consideration. Mathematical formulation based on deferent sets of corresponding equations were some of the tools applied.

5.2 METHODS

The step-by-step approach that was considered as method in accomplishing the work was a series of data completion ranging from the reservoir Core and laboratory analysis of the Core to obtain adequate information if the reservoir holds abundant of hydrocarbon. A computer based mathematical formulation and software numerical simulation application for a multi-period and multiproduct oil and gas field, the mathematical model was used for optimizing the upstream and midstream segments of crude oil supply chain simultaneously. The used computer software application model includes all entities and their connections from oil wells to product depots. Also, several decisions including oil field development, transformation, transportation, and distribution are considered in the model of the petroleum modeling system.

The Eclipse-Reveal was employed and used to run numerical simulation for the reservoir Model in order to obtain adequate information to generate the reservoir model for the oil and gas value chain of the petroleum modelling system. The Petroleum engineering PROSPER simulation tool for the Well Model and gathering network application enhance our knowledge of decision making of initially considering five wells for the model formulation. The GAP computer aided engineering simulation tool was used for the gathering network while Process engineering simulation software Hysys was applied for the surface gathering and flow-station process and Excel for the economic investment and sale consideration. Furthermore, Equations and relevant mathematical models was initiated to facilitate the calculation and numerical simulations fractions of total depreciable capital ($FTDC_t$) and net earnings; in regards to the salvage value of capital with the period and entire expected life time of the petroleum asset.

6.0 RESULT AND DISCUSSION

Phase 1 is dedicated to the **discovery and evaluation of prospect**. This aspect is essentially the Exploration Process of the petroleum system model value chain and Oka field as shown in figure 3.1 below has been identified and assessed as a petroleum field with opportunities investors to be advice based

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on the outcome result of a developed value chain model to either invest or not invest.

6.1 The Eclipse-Reveal Simulation

From the Initial Reservoir Properties obtained from the laboratory analysis, the result was used as an input data for the Eclipse-Reveal simulation which was employed and used to run numerical simulation for the reservoir Model in order to obtain adequate information to generate the reservoir model for the oil and gas value chain of the petroleum modeling system. Figure 3 is the Eclipse-Reveal simulation of the Oka field reservoir.

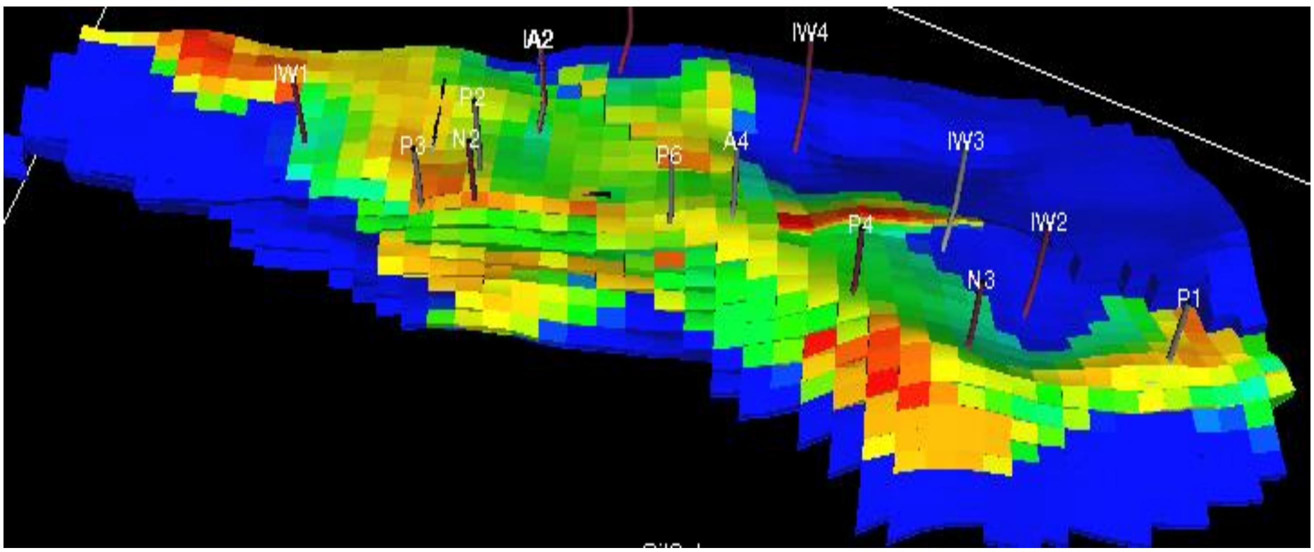

Figure 3 Eclipse-Reveal Simulation of the Oka Field Reservoir.

6.2 Reservoir Model -Eclipse

Model the reservoir, the propose development plan that would maximize total HC production, investigate the production capacity of the reservoir (%RF), Optimize number of wells and well placement, Optimize production scheme (natural depletion, water injection, gas injection, WAG) OKA Field Value Chain. Each scenario was implemented in the numerical reservoir model. In natural depletion, the model was run until 1400 psig (BHP). Investigation was done to give the best number of wells. For secondary production: We optimized the injectors to meet the target production. The water injection scenario was selected based on technical criteria and economic parameters that were compared. 40,000bbls per day for five years Production plateau should be maintained for 5years Production profiles to be evaluated over 10 years. The minimum bottom hole flowing pressure (BHFP) is 1830psig. The averaged maintenance down time is 10 % for all the wells. Due to surface facilities on platforms, the maximum allowable GORi 1500

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scf/cf and the maximum allowable water cut is 90 %. The minimum economical rate for any well is 200 STB/D of oil. The minimum economical rate for the field is 2000STB/D of oil.

Phase 2 and **3** are basically the decision-making period and the **Development Planning** phases, when many professionals and where many teams of experts execute the feasibility studies in order to characterize the most advantageous development plan for the oil and gas field, consisting costs, schedule and project economics analysis in order to obtain a Final Investment Decision (FID).

6.3 Well Model and Surface Network- PROSPER, GAP & Economics –Excel

The well models were built in PROSPER, VLP Generation, GAP was used to generate the VLP, GAP uses PROSPER to generate and save the lift curve for any number of wells in batch mode. The variables (GOR, WHFP and Water Cut) were chosen in such a manner that the host application will reasonably interpolate between them to find a solution, thereby avoiding extrapolation. Based on Material Balance calculation, estimate of number of wells that would produce the well effluent was estimated. A minimum of five wells were estimated to be able to drain the reservoir.

6.3.1 Well Determination and Placement

Estimated Ultimate Recovery (EUR) -- Using 30% OOIIP

Assuming 17% of Estimated Ultimate Recovery per year:

Q0 = 0.17 * EUR

PI = Q/ (Pres-Pbhp)

$$\boldsymbol{Average\ oil\ withdrawal} = \frac{\text{OOIP.EUR,(\% reserves)}}{365\ day}$$

$$\boldsymbol{Production\ Plateau = PImean\ X\ DD}$$

$$\boldsymbol{Number\ of\ wells} = \frac{\text{average oil withdrawal}}{production\ plateau}$$

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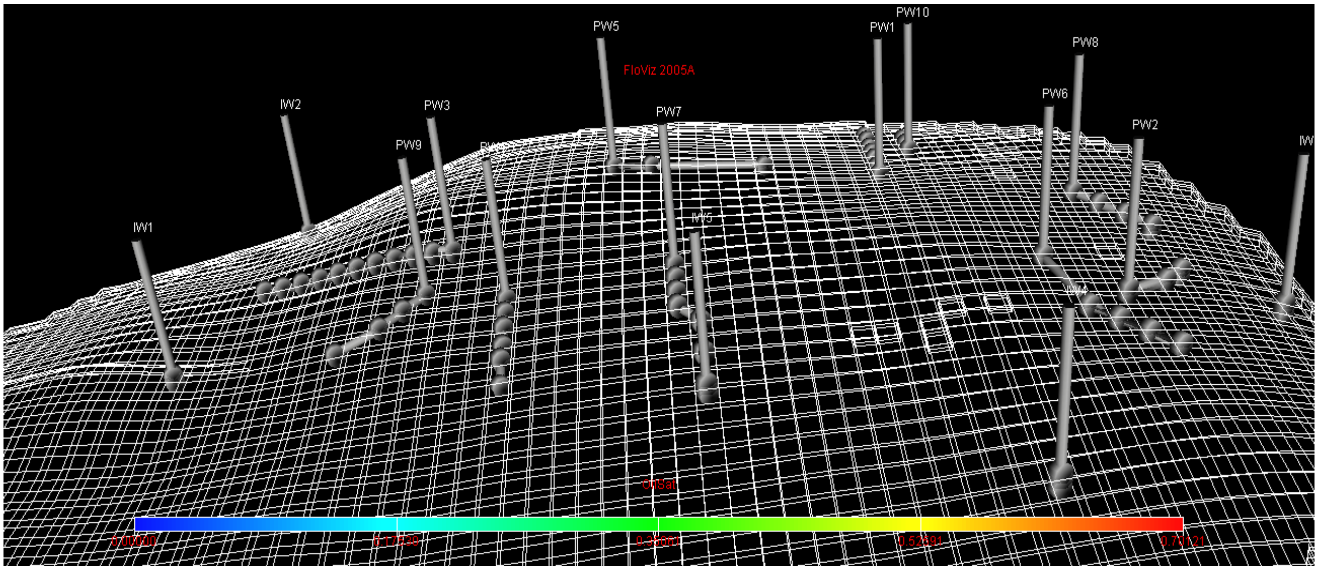

Figure 3: A software simulation the wells to maximize hydrocarbon recovery.

Figure 3 is a software simulation that was used to optimize the wells to maximize hydrocarbon recovery, a minimum of three wells was first test run to ascertain if it is adequate to produce and drain the reservoir hence the performance was inadequate and five wells were also initiated and estimated.

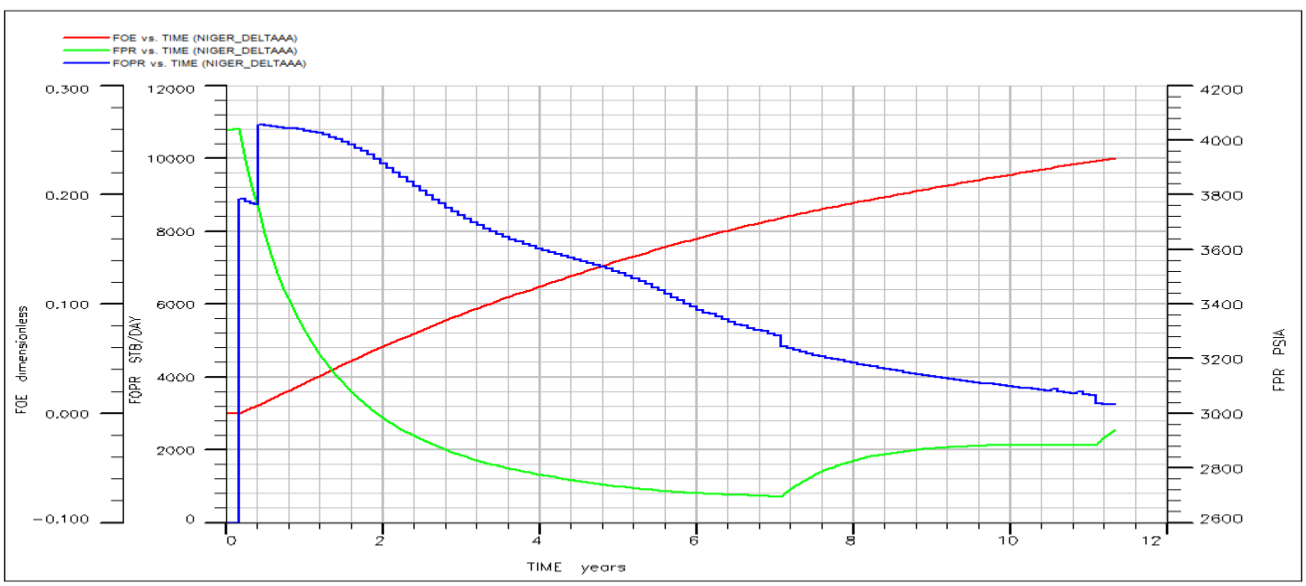

Figure 4: Graph of the Derivation from initial Development Plan.

The derivation from initial development of the five wells indicates that the number of wells is inadequate to drain the reservoir, the pressure is still very high at 2600psig, there is good aquifer support, the plateau production cannot be sustained by the aquifer strength, early water

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injection is required to achieve the target, and the Rf estimated = 27%.

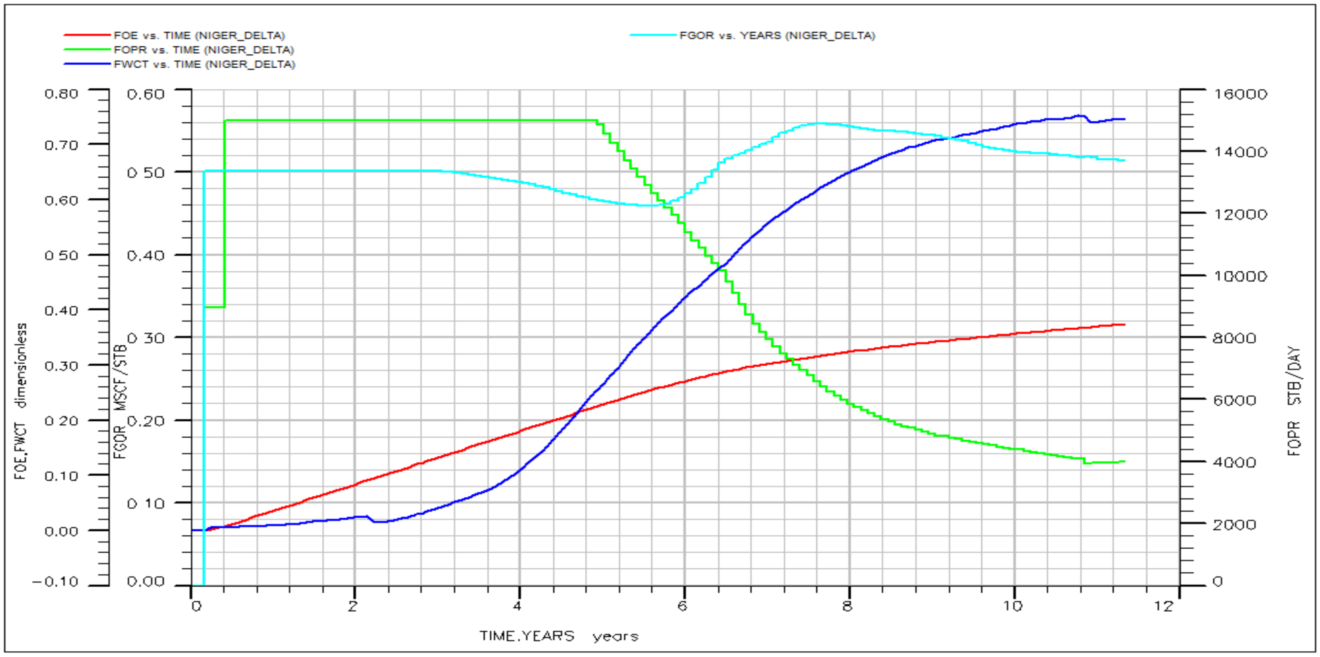

Figure 5: Graph of Well Performance.

From the figure 3.6 graph of the well performance, the performance is high (RF=37.5%), high GOR expected, FOPR FOE, FWCUT. Also, from the graph through the numerical simulation result a total 40,000bbls per day for five years can be recovered. Production plateau should be maintained for 5 years. Production profiles to be evaluated over 10 years. The minimum bottom hole flowing pressure (BHFP) is 1830psig. The averaged maintenance down time is 10 % for all the wells. Due to surface facilities on platforms, the maximum allowable GOR is 1500 scf/cf and the maximum allowable water cut is 90 %. The minimum economical rate for any well is 200 STB/D of oil. The minimum economical rate for the field is 2000STB/D of oil.

Phase 4 is the **Execution of the Development Plan** and now that it is believed that the field holds oil and gas in abundant and the FID is made, phase four, which is the Execution of the Development Plan, is essentially the Field Construction period) takes place oil and gas production platforms are installed. Over and over again, the various disciplines in the petroleum production value chain strive to achieve multiple conflicting goals when operating a field. Several existing optimization methods are used to address this problem based on company objectives and operational standard. Through this example, this study demonstrated that an integrated Production system modelling can help decision makers identify the best trade-offs. The method is both efficient and robust

6.4: Result of the Value Chain Model and Discussion

The integrated model generates dynamically, the productions from the field into Excel for economics evaluation. It also provides open server application network. Hence the entire asset team can assess the daily production indices and information from the various nodes in any location under a secured network

It also offers:

- increased HC production,
- increased flow assurance monitoring
- operational flexibility and control and
- It can help decision makers identify the best trade-offs

Results obtained demonstrated the effectiveness of the approach. The method is both efficient and robust,

this is a feasible oil and gas development opportunity that would maximize the value this asset.

7.0 CONCLUSION

The integrated model generates dynamically, the productions from the field into Excel for economics evaluation. It also provides open server application network. Hence the entire asset team can assess the daily production indices and information from the various nodes in any location under a secured network. It also offers increased HC production, increased flow assurance monitoring operational flexibility and control and It can help decision makers identify the best trade-offs Results obtained demonstrated the effectiveness of the approach. The method is both efficient and robust.

Design and assess the potential of an integrated approach as a decision support tool for development and management of an oil/gas asset, tthrough a field case; build an integrated model that will dynamically analyse the behaviour of the petroleum field under different production and injection conditions, the components of a petroleum system is tightly connected and the development of the value chain cannot be optimized by managing the various nodes independently because of the dynamism of the petroleum system; the physics of fluid dynamics, Saturation, Relative permeability, Capillary pressure and viscosity, Which changes continue to alter the application of existing operational and development strategies. A silo approach ensures that at no time in the life of the asset will the value chain be optimized operationally and economically.

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