World Journal of Innovative Research (WJIR)
ISSN: 2454-8236, Volume-11, Issue-2, August 2021 Pages 50-56

An Analysis of the Forecasted and Actual Crude Oil Production: A Case Study of Fields in the North Sea Norway

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***Abstract*— Norway has shown some developmental strides within the offshore Oil and Gas industry and the accessibility to data through the Norwegian Petroleum Directorate (NPD) has aided research in the sector. Several policies have affected the Oil and Gas industry and limited funding for development poses more risk to the survival of the sector. There is a need to fully understand the production reality of the Sector. In this research, eleven (11) Oil fields were selected which have been fully produced and abandoned, the Pre-FID (Final Investment Decision) data was gathered and reviewed to generate a Pre-FID production forecast. The forecast was generated using the Que$tor tool and the values compared with the actual production from the field to understand the trends across fields. It was observed that for fields with life span less than 20years, the cumulative actual production was averagely 5% less than the Original recoverable oil and for fields with life span greater than 20years, the cumulative actual production was averagely 5% more than the Original recoverable oil. For the first 3-5years of the fields, the actual production was observed to be more than the forecasted production and the reverse is the case after 5years. The variations within 3-5years can be attributed to project schedule delays and after 5years pressure on the companies to meet up their production targets and loan obligations. A trend of increased production was observed with reactions to the periods of Oil price increase.**

***Index Terms*—Production, Forecast, Norway.**

I. INTRODUCTION

Norway is a country with significant strides in the oil industry, particularly offshore [2] and they have been able to enforce laws in the industry within the shores of the country. Most importantly, the transparency in information sharing through its website (https://www.npd.no/en/), the Norwegian Petroleum Directorate (NPD) is key as this has aided research in various dimensions.

The NPD in 1993 once stated that the resources within the purview of the country could last for as long as 200years in gas production and 40years in crude oil production [2] and at that time according to [4] Norway was showing some good position amongst the top crude oil producers in the world. As at 2020 by the data from the U.S. Energy Information Administration Norway ranks the 12th based on the crude oil production in Year 2020 [15]. This clearly points to the statement by some industry professionals, that there will be a consistent decline in the available identified resources unless there is a conscious effort to increase the drive for discoveries and exploration activities. Norway as a country has experienced some declines in new investments in the petroleum industry [2].

In 2021, the NPD has stated that, Norway has barely produced half of its recoverable resources, this clearly indicates that there's more to be produced. However, from the trend as seen in figure 1, there has been a steady decline in the crude oil daily production in Norway.

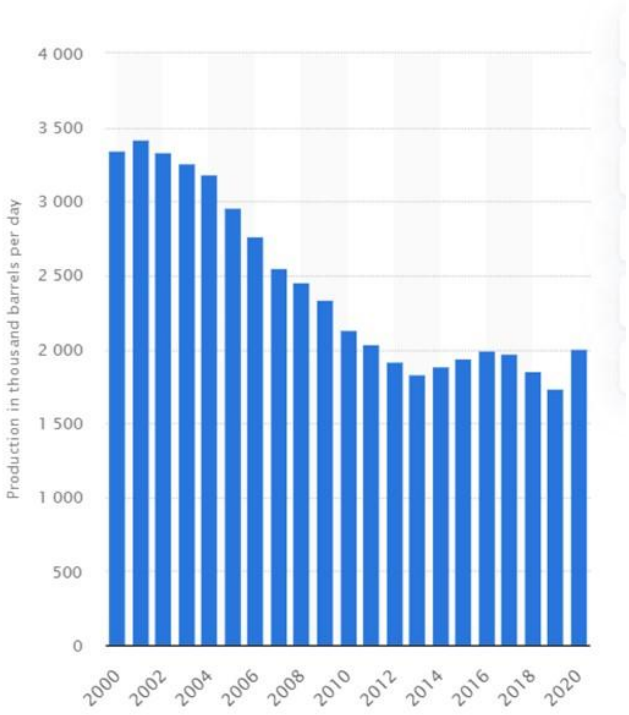

Figure 1: Norway Oil Production (2000 – 2020) Source:[12]

A. INVESTMENTS IN THE OIL INDUSTRY

There have been some limitations in addressing the actual investments in the oil and gas industry due to the challenges with getting accurate data publicly for such analysis [8]. Investors generally have divergent views from the industry players, and this could be determined by various factors which includes growth, economic environment, scale of investment, climate change, carbon footprints etc. [10]. A major threat to investments within the industry has been

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climate change, however there are speculations that the demand for gas which is considered as a much cleaner energy will be on the increase and therefore there will be need for investments to guarantee the discoveries.

The fossil fuel industry has experienced some changing policies, regulations, and investment direction in the recent years with the key institutions reducing their investment support for the industry and putting some stringent conditions to assessing the funds. Several reports have been made by several researchers with output indicating that the taxes gained from the fossil fuel companies is less than the impact on the environment when quantified [7].

Considering the changes in the regulations and the limitations in financing, there is a need to ensure that every fossil fuel project financed brings the maximum value to the investors.

B. NORWAY AND ENVIRONMENTAL SUSTAINABILITY

Norway has taken active steps to ensure its environmental sustainability and has been classified as the most sustainable country in the world by Acciona [14], in addition, the Norwegian parliament approved a proposal to achieve carbon neutrality by 2030 [5].

C. PRODUCTION FORECAST

Considering the importance of oil to the economy and its implications in planning and potential revenue, forecasting has been an area of interest for researchers, significant efforts has been spent generating process and models to accurately forecast crude oil.[3]. There are several methods and tools that exist for the forecasting of crude oil, a popular tool utilized in the industry is ECLIPSE a Schlumberger tool [13] and it uses an implicit three- dimensional finite difference approach in order to solve material balance equations, other methods are numerical models including the Multi-layered neural network and Multi-Valued Neurons, [1] which was applied to an oilfield asset in the coastal swamps of the Gulf of Mexico. Some new methods are being proposed by other researchers and professionals like the Sam-Oil method [11]. In this research the tool utilized is the IHS Que$tor 2015 which serves as an Oil and Gas Production and cost estimation software [9]. The Que$tor tool possess several modules including modules for simulating production, expenditure, development scheduling, concept selections to aid Engineering and Finance professionals.

II. METHODOLOGY

The fields under study are the Norwegian fields that have been produced, shutdown and with the available data on the Norwegian Petroleum Directorate (NPD) portal. A total of nine (11) oil fields is considered for the analysis which includes: BRYNHILD, EDDA, FROY, GAUPE, GYDA, JETTE, JOTUN, MIME, OSELVAR AND VARG. The workflow utilized can be seed in Figure 2. The reviewed data of the fields includes: Some General information about the fields, drill stem tests, lithology analysis, Geo-chemical reports, Core Analysis, Well completion reports, Drilling reports etc. The information gathered from all the reports is inputted in the Que$tor software to forecast the oil production in line with the declared Original recoverable oil.

The forecasted oil production is then analysed against the actual production from the fields and the trend over the years from the various fields is observed. The purpose is to know the consistent behaviour from the fields which is also expected to tell the usual oil production experiences not minding the operating company in the Norwegian North Sea. The same concept can be replicated in other regions and this inference will aid the crude oil production forecast for the future. In addition, this same process can be replicated in other regions to understand the production reality within such regions, after which it can then be determined that the findings are consistent with the reality of the industry.

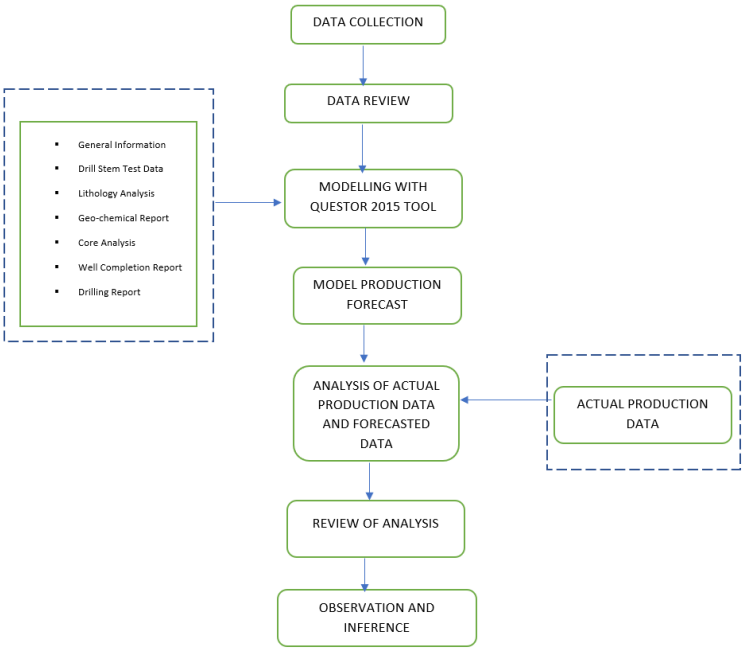

Figure 2: Methodology Utilized for the Forecasted vs Actual Production Analysis

III. FIELD REVIEW

The fields under review have its production ranging from 1979 to 2020 and the fields have been fully produced and abandoned. This presents them as good candidates for the review. All the fields are offshore with water depth ranging from 70m to 127m and with Reservoir Depth from 2150m to 4200m. The Data can be confirmed from the Norwegian Petroleum Directorate (NPD).

Table 1: Basic Information of the Reviewed Fields

Field	Reservoir Depth (m)	Water depth (m)	Investment (mill NOK nominal values)	Original Recoverable Oil (mill Sm3)	Original Recoverable Gas (bill Sm3)
GLITNE	2150	110	2988	8.88	0
JETTE	2200	127	3562	0.43	0.01
VARG	2700	85	8923	16.33	0.3
GAUPE	3000	90	2321	0.23	0.46
EDDA	3100	70	2157	4.82	1.98
OSELVAR	3250	70	4433	0.68	0.4
FROY	3300	120	5551	5.55	1.61
BRYNHILD	3382	80	8060	0.49	0
MIME	4200	80	323	0.37	0.08
JOTUN	2000	125	9554	23.14	0.88
GYDA	4000	65	13263	36.27	6.2

Table 2: Production Start Year and Abandonment Year for the Reviewed Fields

Field	First Oil Year	Abandonment Year
GLITNE	2001	2013
JETTE	2013	2017
VARG	1998	2016
GAUPE	2012	2018
EDDA	1979	1998
OSELVAR	2012	2019
FROY	1995	2001
BRYNHILD	2014	2018
MIME	1990	1993
GYDA	1990	2020
JOTUN	1999	2017

IV. FORECASTED VS ACTUAL PRODUCTION ANALYSIS

The forecasted production and actual production values were placed side by side for observation and the graphs can be seen in Figure 3 to Figure 13.

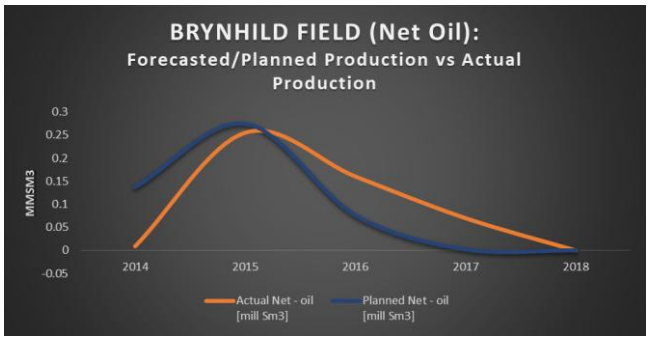

Figure 3: BRYNHILD FIELD: Forecasted vs Actual Production Graph

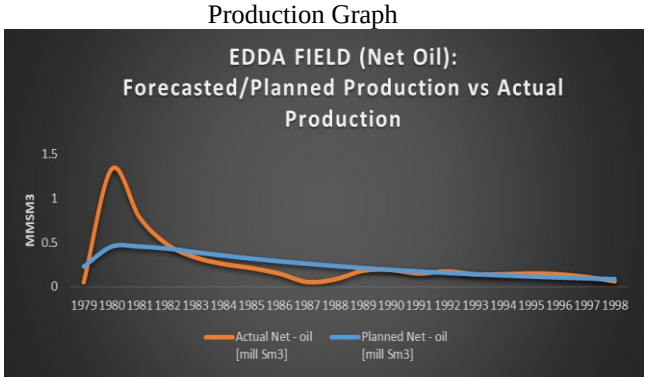

Figure 4: EDDA FIELD: Forecasted vs Actual Production Graph

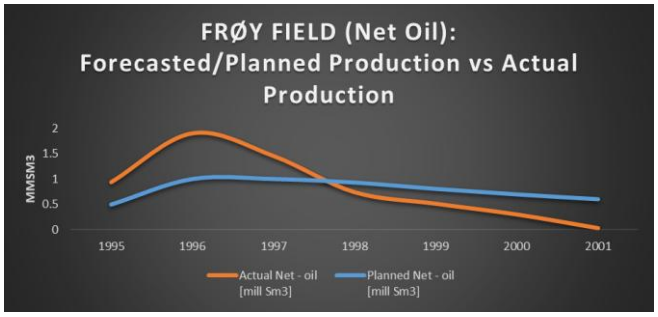

Figure 5: FROY FIELD: Forecasted vs Actual Production Graph

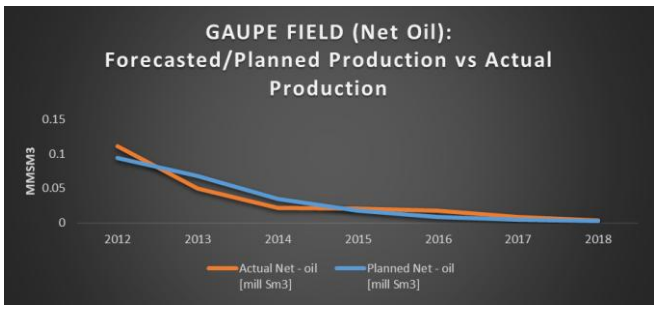

Figure 6: GAUPE FIELD: Forecasted vs Actual Production Graph

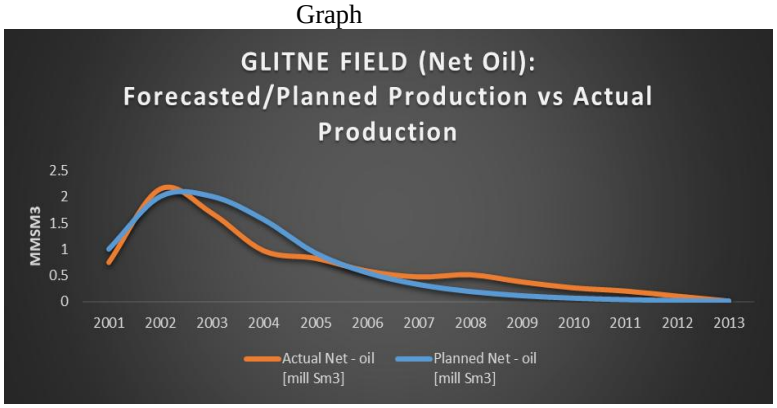

Figure 7: GLITNE FIELD: Forecasted vs Actual Production Graph

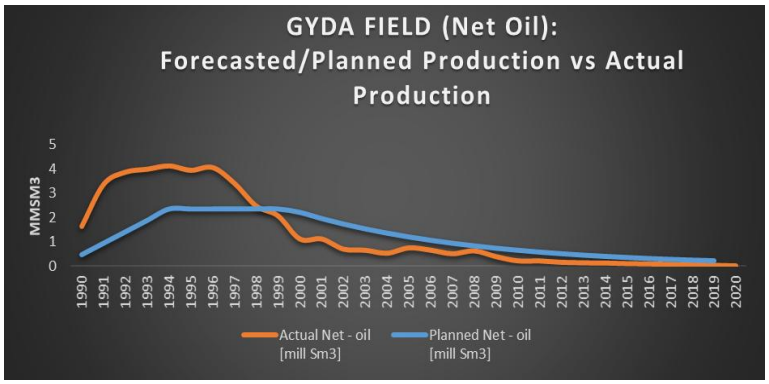

Figure 8: GYDA FIELD: Forecasted vs Actual Production Graph

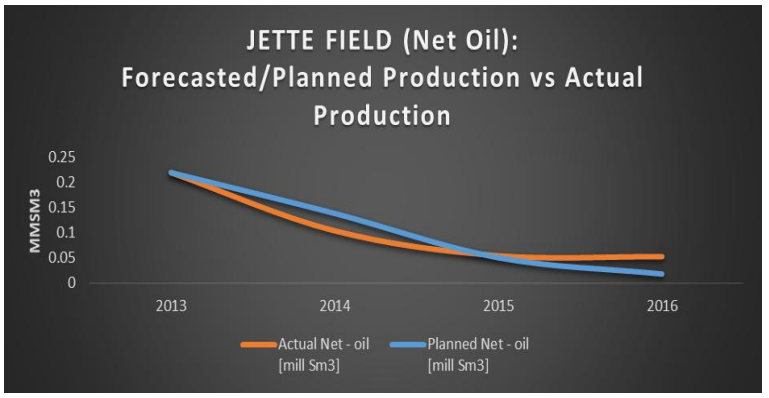

Figure 9: JETTE FIELD: Forecasted vs Actual Production Graph

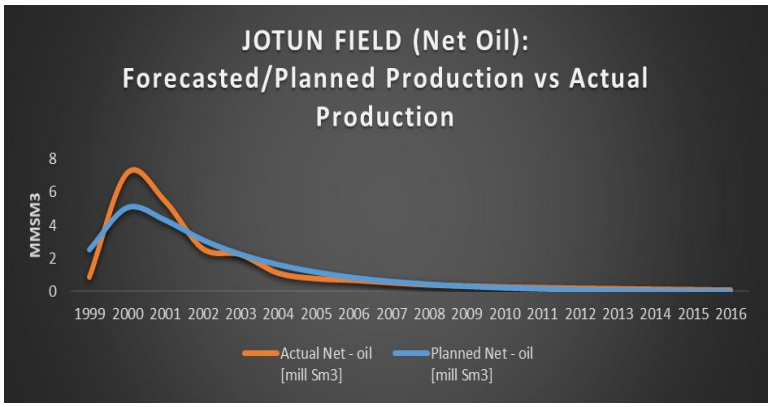

Figure 10: JOTUN FIELD: Forecasted vs Actual Production Graph

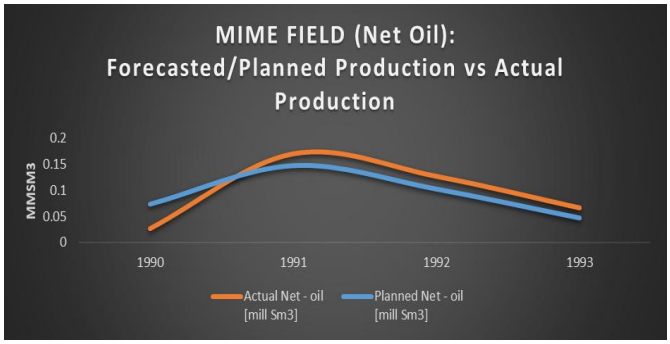

Figure 11: MIME FIELD: Forecasted vs Actual Production Graph

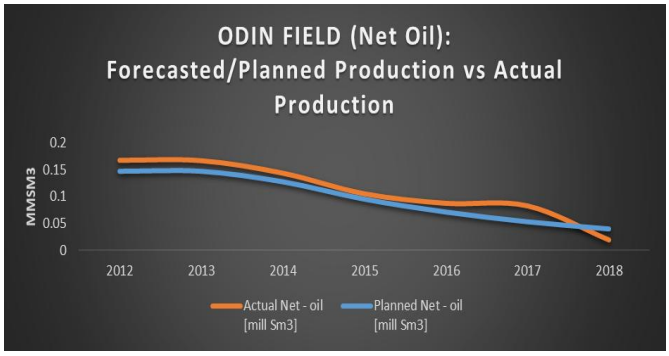

Figure 12: ODIN FIELD: Forecasted vs Actual Production Graph

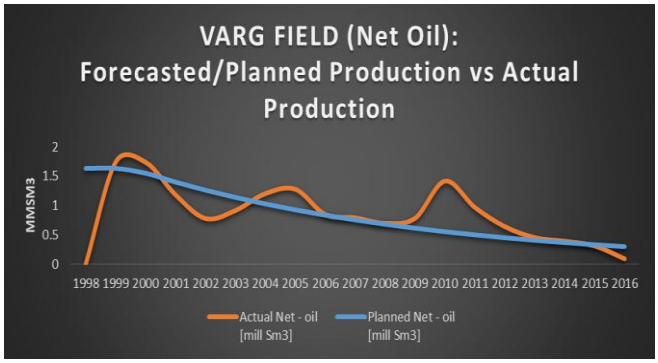

Figure 13: VARG FIELD: Forecasted vs Actual Production Graph

V. VARIANCE

The variance from the analysis was studied to observe the average consistency across the fields to serve as a guide for companies' carrying out economic analysis of fields for Final Investment Decisions (FID).

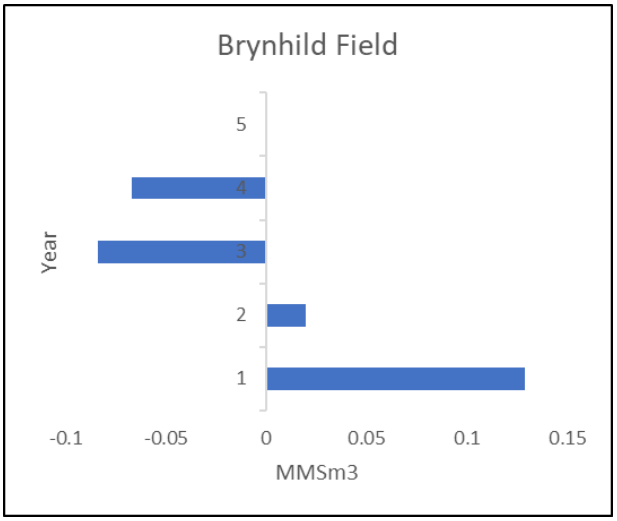

Figure 14: BRYNHILD FIELD: Forecasted vs Actual Production Variance

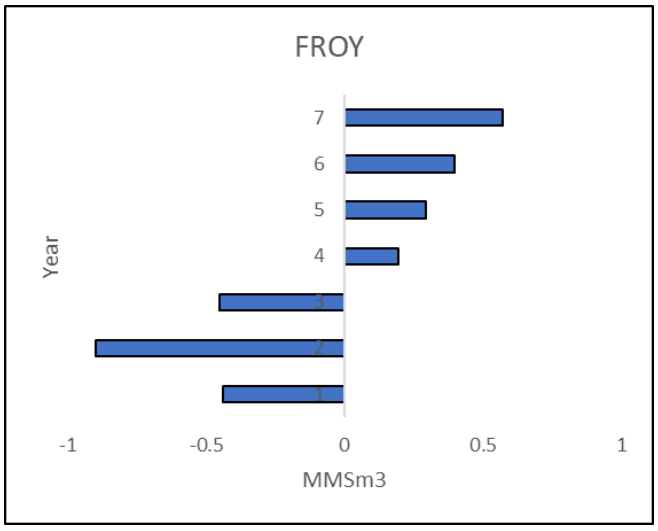

Figure 15: FROY FIELD: Forecasted vs Actual Production Variance

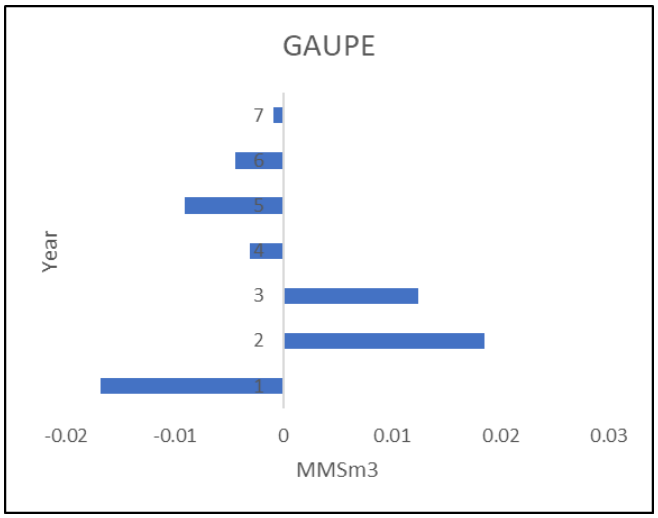

Figure 16: GAUPE FIELD: Forecasted vs Actual Production Variance

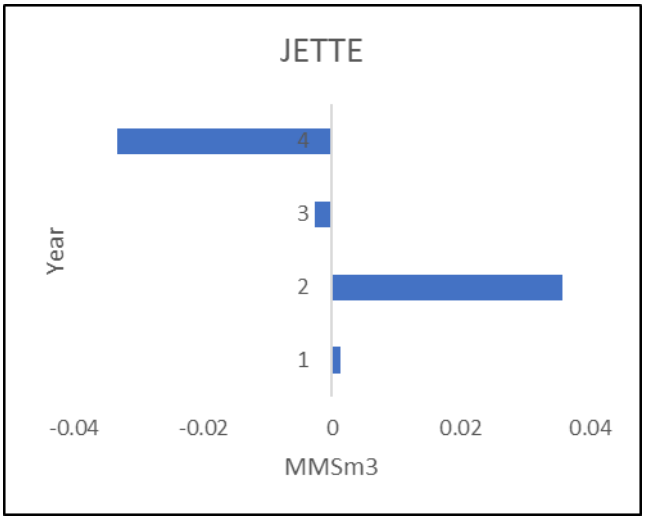

Figure 17: JETTE FIELD: Forecasted vs Actual Production Variance

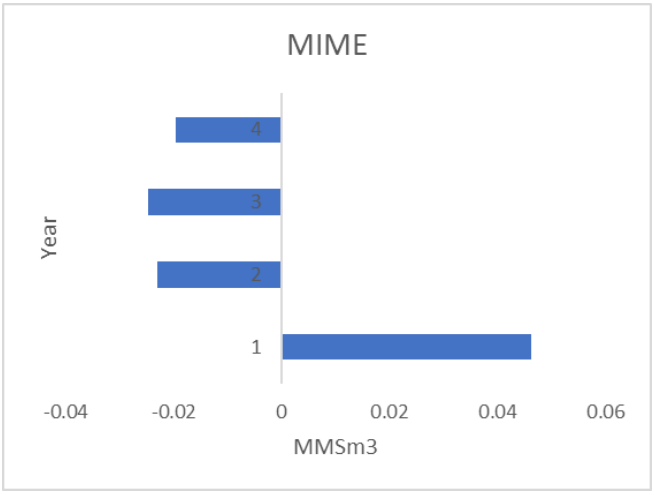

Figure 18: MIME FIELD: Forecasted vs Actual Production Variance

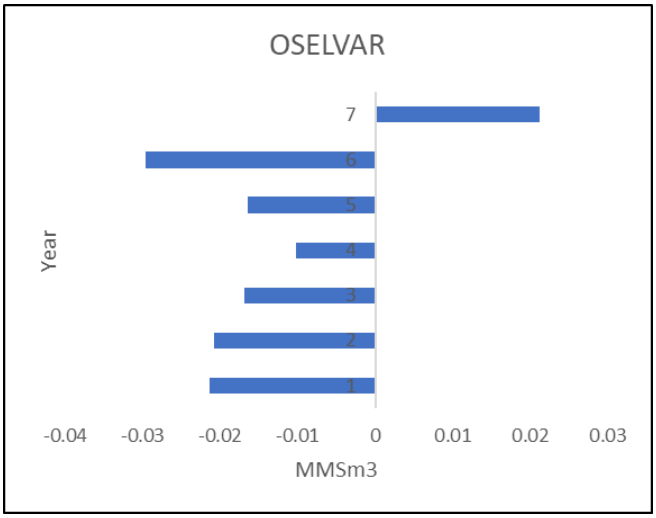

Figure 19: OSELVAR FIELD: Forecasted vs Actual Production Variance

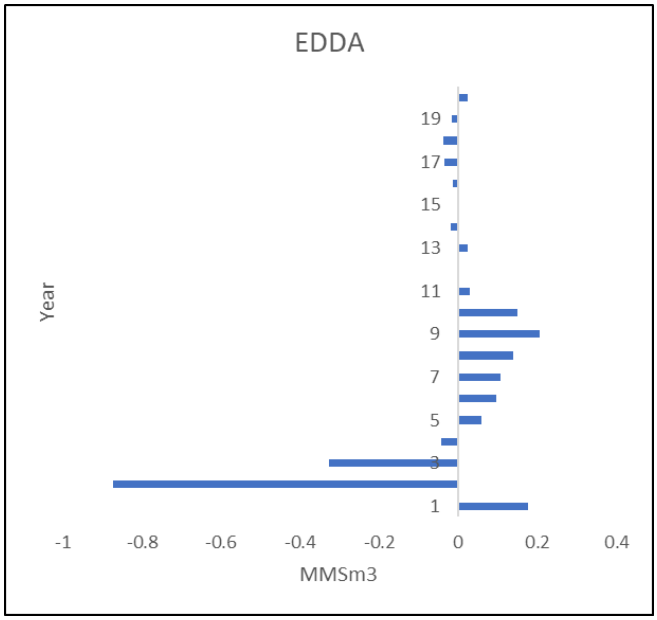

Figure 20: EDDA FIELD: Forecasted vs Actual Production Variance

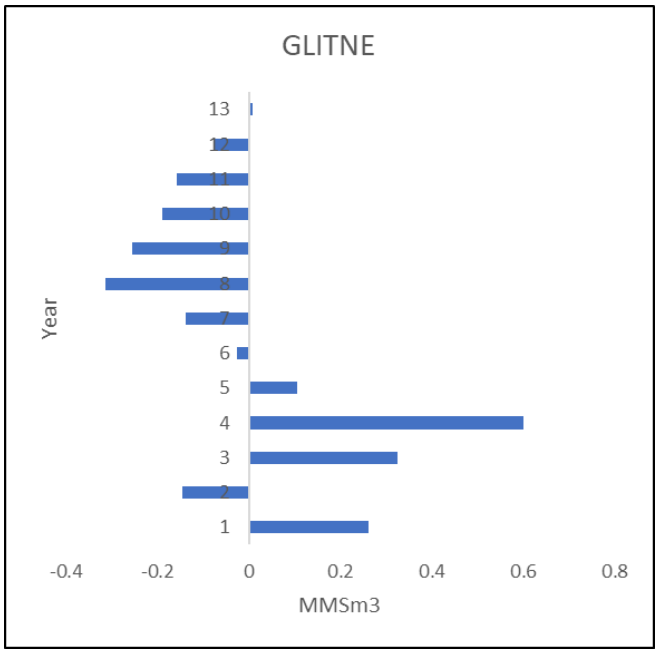

Figure 21: GLITNE FIELD: Forecasted vs Actual Production Variance

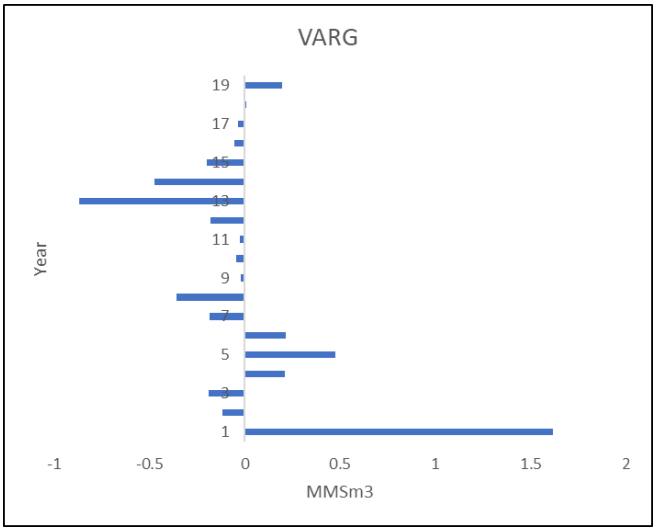

Figure 22: VARG FIELD: Forecasted vs Actual Production Variance

VI. RESULTS

From the data and the variance analysis of the forecasted and actual production values, the following was observed, the forecasted Oil values for the fields were usually higher than the actual Oil produced within 3 – 5 years of producing the field. Also, for fields with field life above 20years, the actual production was observed to be averagely 5% greater than the original recoverable oil Pre-FID. In addition, for most of the fields with life span less than 20years, the actual production was observed to be 5% less than the original recoverable oil, while in some fields the actual production was less than the original recoverable oil.

Also, towards the end of the field there is limited deviation between the planned and actual production values. After the period (3 -5 years of Production) the actual production becomes more than the forecasted production values. For some fields the increase crude oil price led to an increase in oil production, and this was pronounced in VARG.

VII. DISCUSSION

A possible cause of the negative variation in the actual production from the planned production at the early life of the field can be related to field development delay and this will corroborate the Chris Hinkin position as stated in his book An Introduction to Petroleum Economics [6]. The possible reasons for the field development delay could include funding challenges, variation in the development schedule. The positive variation between the actual and planned production data after 5years of the first oil could be as a result of the following: pressure on the companies to meet up the production target for the life of the field, pressure on the companies to meet up their loan obligations, also, there could be pressure to produce more due to oil price surge as 2004 – 2005 & 2010 -2011 showed some signs as some fields produced more despite the fact that most of the fields considered where in their decline phase.

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