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

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***Abstract*— There has been an increased pressure for fossil fuels divestment due to the carbon emissions from such fuels and this has a great impact on the investment in the fossil fuel sector, particularly, the gas-based industry. Due to the limited funds for investment in the industry, there is a need to make sure every investment count in terms of the quality of its return on investment to the stakeholders. Production is a direct contributor to the revenue from the fields, by virtue of this, there is a need to understand the production trends from the fields produced in the past comparing their forecasted and actual production values. The Que$tor tool was utilized for the modelling of field and generation of the forecasted values. It was observed that the actual production for the gas fields where higher than the forecast for the first 5years/45% of its lifespan and after that the reverse was the case, this implies that the tools generally are highly conservative for gas fields and there is minimum understanding of the fields at the pre-FID (final investment decision) stage. In addition, some production spikes were observed at the declining phase of the fields which aligned with the years the gas market prices increased.**

***Index Terms*—Production, Forecast, Gas, Energy Transition Norway.**

I. INTRODUCTION

The world seeks cleaner energy fuel and there has been a drive for renewable energy by several climate change institutions who seeks for means to reduce the carbon emissions from either energy production or consumption, to also ensure energy sustainability and limit pollutions in all forms [7]. Some other institutions are seeking for a balance to aid sustainability, get proper return on investment for the gas-based industries particularly in this time where there is a move for energy transition.

The United Nations has further stated that the future of gas will be greatly dependent on the policies adopted by the government and the markets mode of operation seeing that there is a social resistance to gas as it is considered a carbon-emitting fossil fuel. In the light of these and the limited investment available for the gas-based industry there is a need to understand the gas fields and how they fare in comparison to their forecasted/planned production figures as this will aid investment decisions. In this research the fields from Norway is considered following the availability of field data to the public

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II. NATURAL GAS AS A BRIDGE

Some discussions are ongoing for the purpose of utilizing natural gas for power generation at times where there is a drop in the wind availability or sun intensity, from the report by the Independent news on the 7th of September 2021, the UK fired up the Coal fired plant at the West Burton A station due to a significant reduction in the Wind energy availability and the need for economical balance the price of grid energy [4]. Gas is a low carbon emitting fuel (when compared to coal and Crude oil) and can be utilized as a bridge between fossil fuels and renewable energy. However, such will limit the use of gas fired generators for baseload operations as in this case they will serve more during the Peak periods.

Such decisions to reduce carbon emissions have an impact on the investments in the gas industry, as new infrastructures will be restricted and there will be more focus on the optimization of the existing infrastructure.

III. NATURAL GAS IN NORWAY

Norway has experienced an increasing Natural gas production since 1998 and started experiencing a consistent decline in 2018 [6] as seen in Figure 1.

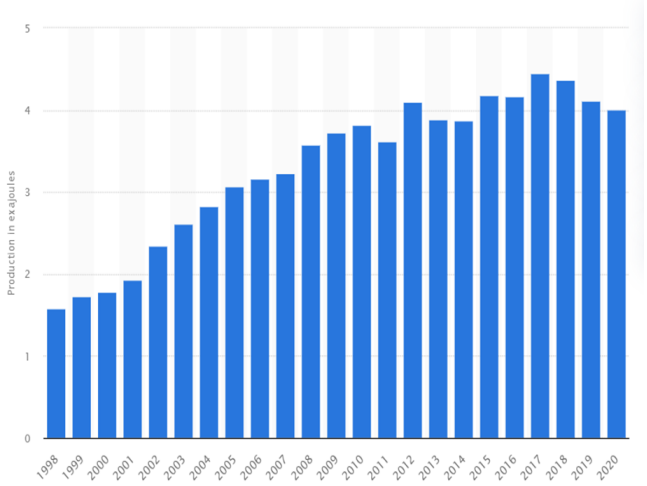

Figure 1: Norway Yearly Natural Gas Production (1998 –

2020) Source:[6]

IV. Investment in Natural Gas Fields

The natural gas industry presents some low profit margins and by implication results in longer time to recover the investment, therefore there is a need for certainty in the policies surrounding the industry to ensure it is attractive to investors [3] and also a need to understand the production trend for better prediction of the future. Many organizations have carried out analysis to indicate the amount of investment required in the sector up to year 2030, for example in the Asia Pacific region it is estimated that 2,243billion USD is required and 86% of the value required for the upstream sector.

This paper seeks to understand the general production trends from gas fields in Norway and the similarities amongst the fields to serve as a guide for investors. The concept from the research can then be replicated in other regions and a common similarity of the trends across the regions be considered and promulgated as a fact.

V. Production Trend

In the field development plan for a gas field, the forecasted production data from the field is of great importance as this has a direct relationship with the revenue to be derived from the field over its life. Several companies have sought ways, tool and software to ensure the accurate production forecast and modelling. Some companies like Schlumberger have been able to build the Eclipse simulator for this purpose practically utilizing the 3-Dimensional finite difference approach as its development principle [5], some other tools and researchers have applied other principles which includes Neural Network, Fuzzy Logic as applied by Zellou and Ouenes [8] and also the use of an algebraic multigrid approach [1].

VI. Methodology

In this research we will be utilizing the Que$tor tool, this is a production and cost forecast/estimation tool and the aim is to forecast the gas production from some selected fields from Norway and compare them with the Actual production from the fields. In addition, we will see the general trends and observations from the fields. The source of the data is from the Norwegian Petroleum Directorate (NPD) Website (https://factpages.npd.no/en/field). The methodology workflow can be seen in Figure 2.

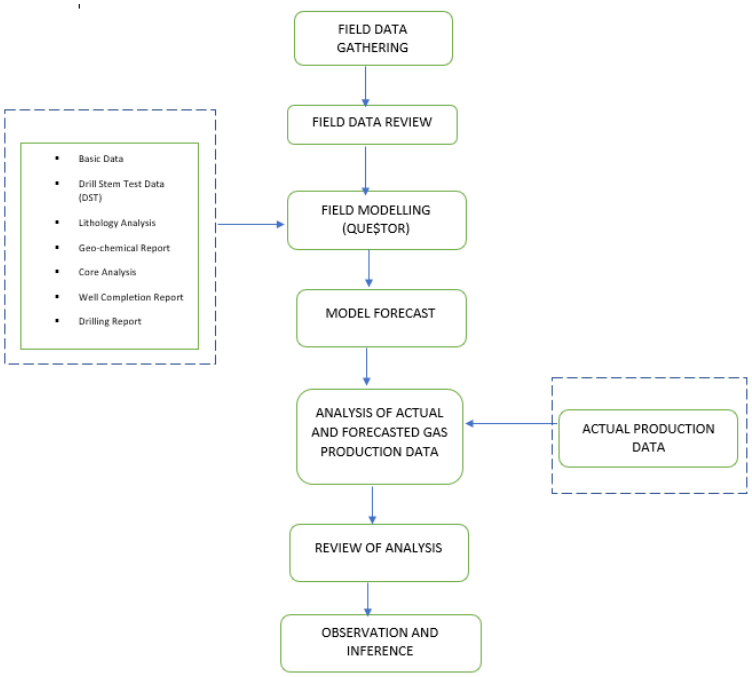

Figure 2: Methodology Workflow

VII. Field Choice

For the sake of this research the fields chosen are fields classified to have been shutdown by the Norwegian Petroleum Directorate (NPD). The list of the fields reviewed are: ALBUSKJELL, COD, FRIGG, HULDRA, LILLE FRIGG, NORDOST FRIGG, ODIN, TOMMELITEN GAMMA, VEST EKOFISK, YTTERGRYTA, a total of 10 gas fields. Their actual production dates ranges from 1977 to 2014 for the different fields with water depths ranging from 70m to 300m and reservoir depth ranging from 1900m to 3900m.

Table 1: Brief information on the Reviewed Fields (source: Norwegian Petroleum Directorate (NPD) Website (https://factpages.npd.no/en/field).

Field	Reservoir Depth (m)	Water depth (m)	Investment (mill NOK nominal values)	Original Recoverable Oil (mill Sm3)	Original Recoverable Gas (bill Sm3)
FRIGG	1900	100	8605	0	116.2
NORDØST FRIGG	1950	110	1816	0	11.6
ODIN	2000	100	2612	0	27.3
YTTERGRYTA	2500	300	1450	0.29	2.22
COD	3000	75	1003	2.88	7.28
ALBUSKJELL	3200	70	2752	7.35	15.53
VEST EKOFISK	3200	70	943	12.15	25.97
TOMMELITEN GAMMA	3500	75	2369	3.87	9.68
LILLE-FRIGG	3650	110	3921	1.33	2.19
HULDRA	3900	125	7554	5.21	17.34

Table 2: Showing the First Gas Year and Abandonment Year

Field	First Gas Year	Abandonment Year
FRIGG	1977	2004
NORDØST FRIGG	1983	1993
ODIN	1984	1994
YTTERGRYTA	2009	2013
COD	1977	1998
ALBUSKJELL	1979	1998
VEST EKOFISK	1977	1998
TOMMELITEN GAMMA	1988	1998
LILLE-FRIGG	1994	1999
HULDRA	2001	2014

VIII. Field Modelling

The Que$tor tool was utilized for the modelling of the gas fields and the exploration data from the fields was studied to generate the right information to be inputted into the Que$tor tool. Such data includes Drill Stem data, lithology analysis, Geochemical reports, core analysis, Drilling and Well completion report and some field general information.

IX. Actual Production and Modelled Production Comparison

The field modelled values were plotted side by side with the actual gas production from the various fields under review.

The graphs can be seen in Figure 3 to Figure 12.

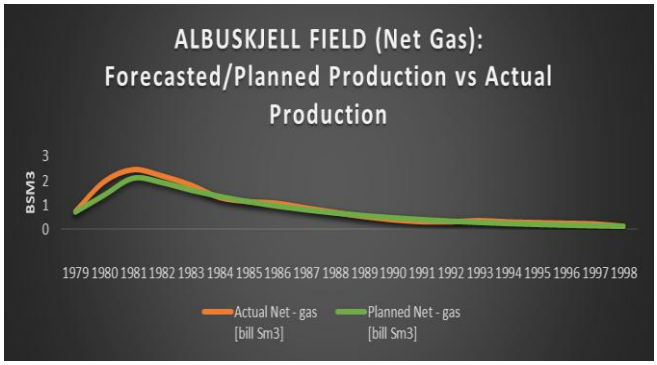

Figure 3: Showing the Modelled vs Actual Gas Production for the ALBUSKJELL Field Offshore Norway

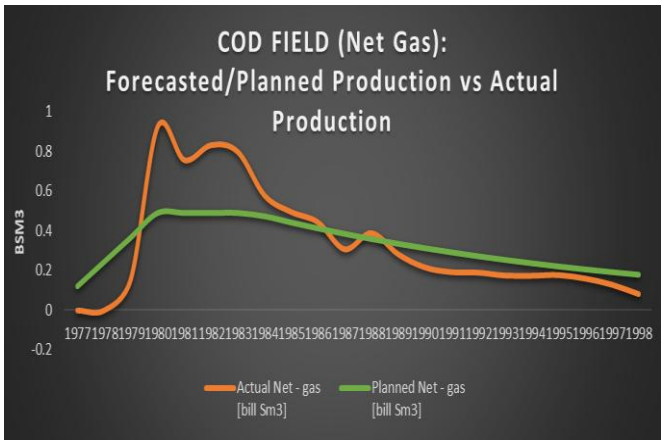

Figure 4: Showing the Modelled vs Actual Gas Production for the COD Field Offshore Norway

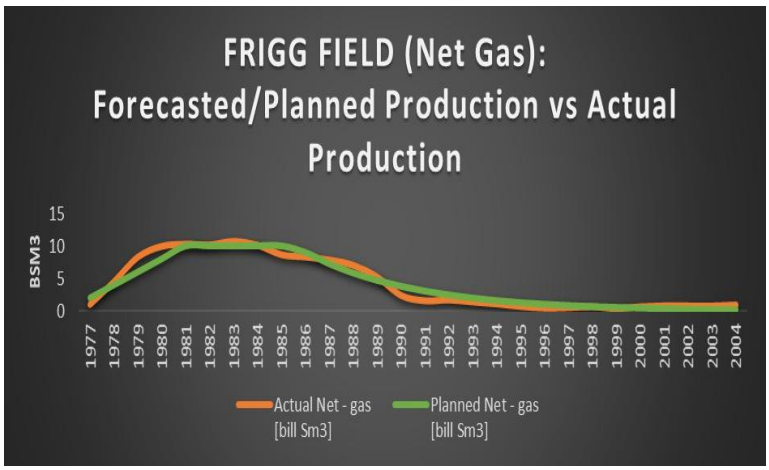

Figure 5: Showing the Modelled vs Actual Gas Production for the FRIGG Field Offshore Norway

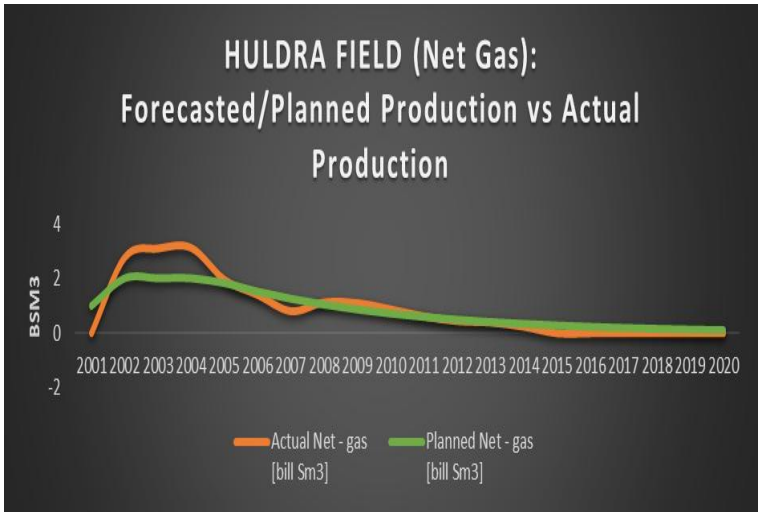

Figure 6: Showing the Modelled vs Actual Gas Production for the HULDRA Field Offshore Norway

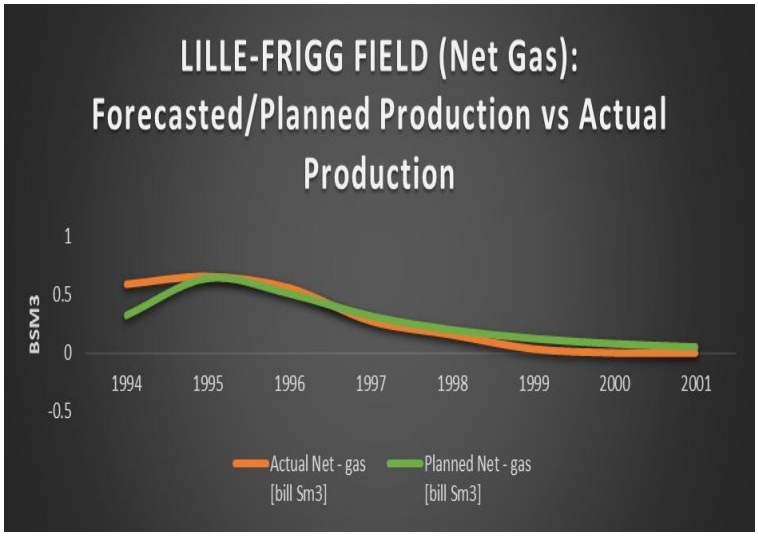

Figure 7: Showing the Modelled vs Actual Gas Production for the LILLE_FRIGG Field Offshore Norway

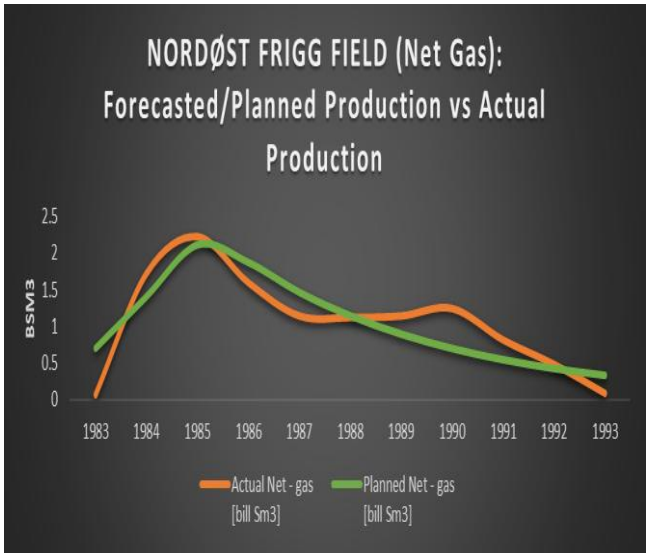

Figure 8: Showing the Modelled vs Actual Gas Production for the NORDOST FRIGG Field Offshore Norway

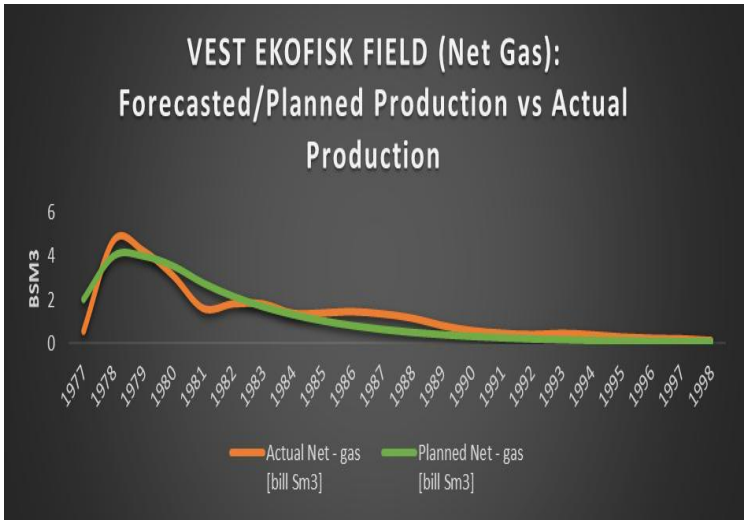

Figure 11: Showing the Modelled vs Actual Gas Production for the VEST EKOFISK Field Offshore Norway

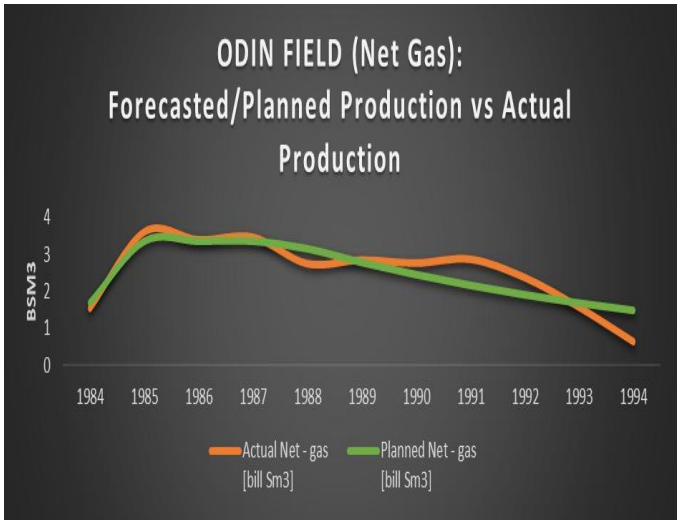

Figure 9: Showing the Modelled vs Actual Gas Production for the ODIN Field Offshore Norway

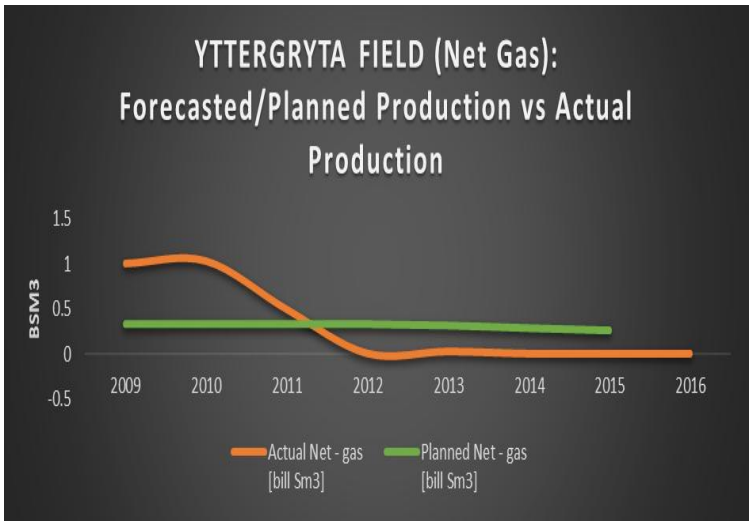

Figure 12: Showing the Modelled vs Actual Gas Production for the YTTERGRYTA Field Offshore Norway

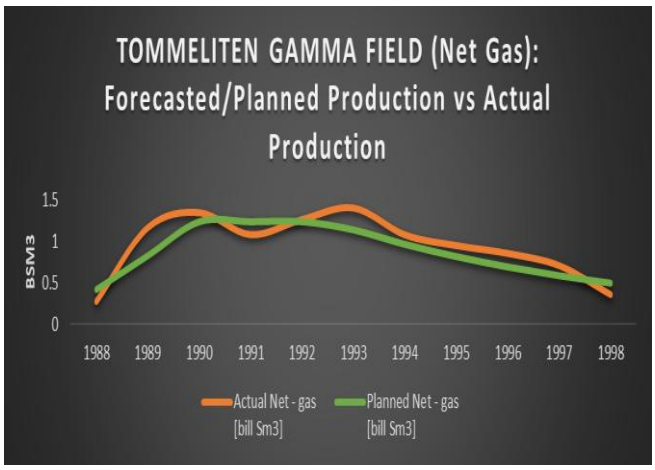

Figure 10: Showing the Modelled vs Actual Gas Production for the TOMMELITEN GAMMA Field Offshore Norway

X. RESULTS

From the comparison between the model values and the actual production values, it was observed for most of the fields that the actual production from the fields in the first 5years was higher than the forecasted values. In addition, for most of the fields, after approximately 45% of the field life, the reverse was the case as the actual production was observed to be lower than the forecasted production from the fields. For all the Shutdown fields reviewed apart from the FRIGG field, the actual total gas produced from the field was more than the declared original recoverable Gas, a percentage that ranged from 1.6% in ODIN field to as high as 15.81% in YTTERGRYTA field. During the life of the field in the decline phase there were some spikes that aligned with the

increase in the market Gas price in Year 1989-1993, 2000-2005.

XI. DISCUSSION

It is known that the uncertainty in a field is reduced as the field is produced, the longer the production of the field the better the understanding of the field. The observed increase in actual production in the gas field as compared to the planned production can be drawn from the minimum understanding of gas fields Pre-FID (Final Investment Decision) and the high conservative nature of the forecasting tools particularly for gas field modelling. As seen in the research by [2] the reverse is the case in the early years of production from the oil fields. Another possible cause is the desire of the operators to quickly recover the reserves to meet up with their obligations. This was also seen with the production spikes at the declining phase of the field which aligned with the years the gas market prices increased. The variance between the modelled values and the actual values after 45% of the Fields lifespan can be attributed to pressure management issues in the field due to the maximized production in the first 5years of the gas fields.

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