Open Journal of Yangtze Oil and Gas, 2025, 10(4), 111-119
https://www.scirp.org/journal/ojogas
ISSN Online: 2473-1900
ISSN Print: 2473-1889

Analysis of Production Decline Rate to Predict the Life Span of Mnazibay Gas Field

Lazaro Isaac, Christina Ndunguru, Paul T. Nsulangi

Department of Marine Engineering, Dar es Salaam Maritime Institute, Dar es Salaam, Tanzania
Email: lazaroisaac36@gmail.com

How to cite this paper: Isaac, L., Ndunguru, C. and Nsulangi, P.T. (2025) Analysis of Production Decline Rate to Predict the Life Span of Mnazibay Gas Field. *Open Journal of Yangtze Oil and Gas*, **10**, 111-119.
https://doi.org/10.4236/ojogas.2025.104006

Received: September 9, 2025
Accepted: October 20, 2025
Published: October 23, 2025

Abstract

This research aims to analyze production decline rate and estimating a lifespan of the MnaziBay natural gas field under different reserve scenarios. The research employed Arp's decline rate equations together with statistical analysis to evaluate production trend. Research also involves the use of historical production data from the beginning of the field 2007 to 2024 as an actual production data and forecasted production data from 2025 to 2043. The analysis was conducted for three scenarios 1P (proved reserve), 2P (proved plus probable reserve) and 3P (proved plus probable pus possible reserve). The research was successful in establishing different decline rate based on scenarios as well as field abandonment timeline for all three reserve scenarios (1P, 2P and 3P), the analysis found a varying production decline rate across reserve classification. The research discovered that 3P is the scenario that has a longest span with lowest decline rate followed by 2P and 1P respectively.

Keywords

DCA, Lifespan, MnaziBay Gas Field, Reserve, Production Rate, Decline Rate

1. Introduction

The MnaziBay concession is located at approximately 10˚ 19' south and 40˚ 23' east, on the southeastern coast of Tanzania, just north of the border with Mozambique. The MnaziBay development and production license (MnaziBay) is located primarily onshore in southern Tanzania, approximately 410 km from Dar es Salaam [1]. MnaziBay has a cover area of 756 km^2 and comprises the MnaziBay and Msimbati gas fields, which have been on-stream since January 2007. Maurel & Prom (60%) and Tanzania Petroleum Development Corporation (TPDC) (40%) operate MnaziBay as joint venture partners. It is the sole onshore production agreement (PSA) in Tanzania in which TPDC is a partner. MnaziBay gas field was discovered in 1982 by AGIP [2]. The first well, MnaziBay well 1 (MB-1), tested gas from the Miocene formation at a rate of 13 MM Scf/day. After testing, the well was suspended by AGIP due to a lack of viable gas monetization options at the time. In 2005 the MnaziBay well 1 (MB-1) as re-entered, and three subsequent gas discoveries were made: MnaziBay well 2 (MB-2), MnaziBay well 3 (MB-3), and Msimbati 1 exploration (MS-1X). Currently, the MnaziBay gas field produces from a total of five wells: the MB-1 well, MB-2 well, MB-3 well, MB-4 well and MS-1X well. The field began production in January 2007, producing 2.5 MMscf/d to the Mtwara power station. In October 2015 [3], the Madimba gas processing plant was completed and commissioned, allowing production to be ramped up to 44 MMscf/d in 2016 and 50 MMscf/d in 2017. 2018 production averaged 83.2 MMscf/d and 70 MMscf/day in 2019, 65.5 MMscf/d in 2020, 75 MMscf/d, 90 MMscf/d and 118 MMscf/d in 2021, 2022 and 2023 respectively, and current production is 120 MMscf/day. The MnaziBay Gas field is located in the northern part of the Ruvuma Basin, which straddles the border between Tanzania and Mozambique. It is one of numerous basins along the east coast of Africa, formed when the Paleo continent of Gondwana drifted apart during the Permian, Triassic and early Jurassic [1]. The depositional environment is dominantly clastic with the exception of some mid-Jurassic carbonates. The MnaziBay reservoirs have been penetrated by five wells as shown in **Figure 1**.

MnaziBay well 1 (MB-1) drilled by AGIP in 1982, total depth 3489 m. MnaziBay well 2 (MB-2) drilled by Artumas in 2006, total depth 2012 m. MnaziBay well 3 (MB-3) drilled by Artumas in 2006, total depth 2749 m.

Msimbati well 1 (MS-1X) drilled by Artumas in 2007, total depth 2003. MnaziBay well 4 (MB-4) drilled by Maurel et Prom in 2015.

MnaziBay gas field is a significance natural gas field in Tanzania; it plays a crucial role in Tanzania energy sector and industry development by supplying a natural gas to major clients like Tanzania Electric Supply Company Limited (TANESCO) direct to Mtwara region and through GASCO (TPDC subsidiary) to TANESCO Kinyerezi 1 power plant, TANESCO Kinyerezi 2 power plant and Ubungo 3 power plant, and other client include Dangote cement industry, Goodwill Ceramic Company, Lodhia steel industry, KNAUF industry and RADDY fiber manufacturing Tanzania Limited. It contributes about 48% of the country's total gas output.

Production decline rate refers to the yield change rate or yield decline percentage in unit time. Decline curve analysis is a traditional method for identifying well performance, well production problems and life based on measured gas well production. DCA is the most important section in any field since it will enable knowing the trend at which the gas production will follow till the time of decommissioning. DCA enable to estimate the life span of the field. Worldwide, the gas production profiles differ considerably.

When a field starts production, it builds up to a plateau stage; every operator will want to remain at this stage, but in reality, it is not possible because at a point in the life of the field, the production rate will eventually decline to a point at which it no longer produces profitable amounts of natural gas.

Well abandonment can be either temporary or permanent. Temporary abandonment, also referred to as long-term suspension, may last from a few days to several years, depending on regulatory requirements and operational circumstances [4].

The review explains about three types of decline curve that are produced from three different equations as proposed by Arps [5] [6] (1945), the curvature in the production rate versus time curve can be expressed mathematically by a member of the hyperbolic family of equations.

- Exponential decline curve;
- Harmonic decline curve;
- Hyperbolic decline curve.

Exponential decline curve type of decline curve which result to a straight-line relationship when the flow rate versus time is plotted on a semi-log scale and also when the flow rate against cumulative production is plotted on a Cartesian scale as shown in **Figure 2** [7].

where $q = q_1 e^{-Dit}$;

q = Gas flow rate at current time (scf/d);

q_1 = Initial gas production rate (scf/d);

Di = Nominal initial decline (per day or per month or per year);

t = Time (year or month).

The use of exponential decline curve in this research influenced by the characteristics of the forecasted production data for three scenarios and single-phase flow of the reservoir fluid. The forecasted data show the constant decline rate.

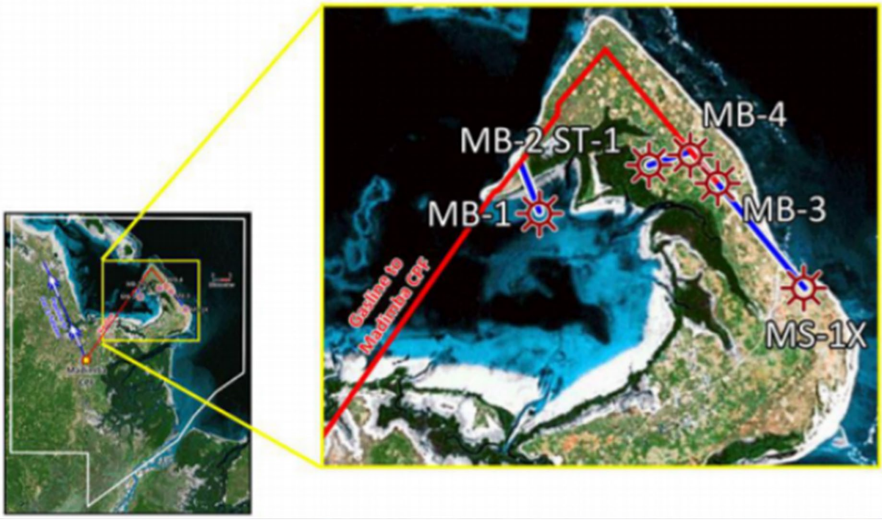

Figure 1. Five wells of MnaziBay field [1].

Hyperbolic decline curve

For a reservoir or a well whose production follows the hyperbolic decline behavior are given by equation

$$q_t = \frac{q_1}{(1+bDit)^{1/b}}$$

where,

b = Hyperbolic exponent factor;

Harmonic decline curve

For a reservoir or a well whose production follows the harmonic decline behavior are given by equation.

$$q_t = \frac{q_1}{(1+Dit)}$$

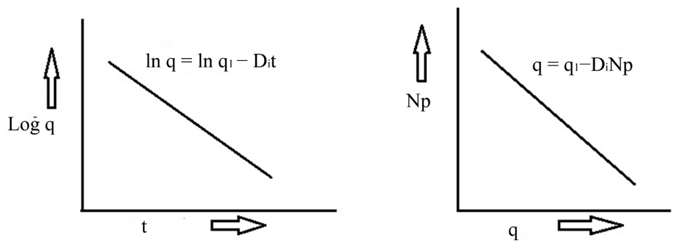

Figure 2. Curves for exponential decline rate.

2. Material and Method

2.1. Material Balance

Current MnaziBay natural gas field use material balance as a method of estimating GIIP, Material balance mostly applied when the field meets peak production or plateau period as it effectively captures the relationship between pressure and production, but as production continue, field will experience a transition of production rate from a constant rate to decline rate, and during decline period a DCA become suitable for estimating reserve and forecasting production.

Material balance use cumulative production and reserve to estimate plateau duration (**Table 1**).

$$t_{Plateau} = \frac{Gp}{q} \times RF$$

where,

$t_{plateau}$ = plateau duration time (year);

Gp = recoverable reserve (Bscf);

q = current production rate (MMscf);

RF = Recovery factor (%).

Table 1. Plateau duration.

Case	GIIP (Bscf)	RF (%)	q (MMscf)	$t_{plateau}$
1P	489	0.85	82.5	14 (2013-2027)
2P	733	0.81	92.5	16 (2013-2029)
3P	1036	0.82	130	15 (2013-2028)

2.2. Decline Rate Estimation

1P

q = 6 MMscf/d;

q_1 = 64 MMscf/d.

= Nominal or continuous or initial decline (per day or per month or per year).

= 2037 − 2028 = 9 years.

$$q = q_1 e^{-Dit}$$

$$\frac{6}{64} = e^{-Di9}$$

$$9D = \ln\frac{64}{6} = 0.26/\text{year}$$

t = 2039 − 2030 = 9;

q = 4 MMscf/d;

q_1= 40 MMscf/d.

$$D = \frac{2.30}{9} = 0.26/\text{year}$$

Decline rate D from the slopes of the graph (Figure 3)

$$\text{slope} = \frac{\Delta \ln q}{\Delta t}$$

$$\text{slope} = \frac{2.30}{9} = 0.26/\text{year}$$

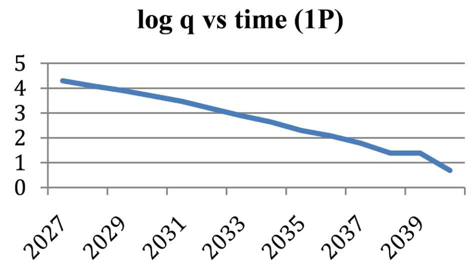

Figure 3. Best fit for 1P.

2P

t = 2039 − 2030 = 9 years;

q = 16 MMscf/d;

q_1 = 76 MMscf/d.

$$q = q_1 e^{-Dit}$$

$$9D = \ln\frac{76}{16} = 0.17/\text{year}$$

t = 2042 − 2032 = 10 years;

q = 10 MMscf/d;

q_1 = 56 MMscf/d.

$$q = q_1 e^{-Dit}$$

$$10D = \ln \frac{56}{10} = 0.17/\text{year}$$

Decline rate D from the slopes of the graph (**Figure 4**)

$$\text{slope} = \frac{\Delta \ln q}{\Delta t}$$

$$\text{slope} = \frac{1.16}{7} = 0.17/\text{year}$$

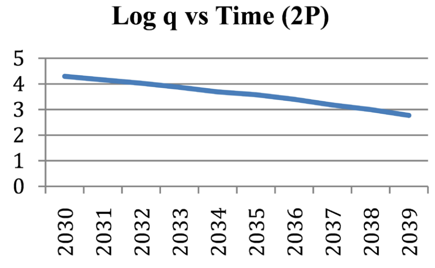

Figure 4. Best fit for 2P.

3P

$t = 2039 - 2029 = 10$ years

$$q = q_1 e^{-Dit}$$

$$\frac{36}{116} = e^{-Di10}$$

$$10D = \ln \frac{116}{36} = 0.12/\text{year}$$

$t = 2042 - 2034 = 8$ years

$$24 = 62 \times e^{-Di8}$$

$$8D = \ln \frac{62}{24} = 0.12/\text{year}$$

Decline rate D from the slopes of the graph (**Figure 5**)

$$\text{slope} = \frac{\Delta \ln q}{\Delta t}$$

$$\text{Slope} = \frac{0.92}{8} = 0.12/\text{year}$$

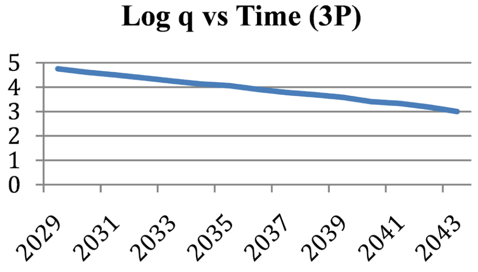

Figure 5. Best fit for 3P.

Abandonment time

$$t = \frac{\ln\left(q_i/q\right)}{D}$$

1P Estimation

q_1 = 82 MMscf/d

q = 5 MMscf/d;

D = 0.26/year.

$$t = \frac{\ln\left(16.40\right)}{0.26/\text{year}} = 10.76 \text{ year}$$

2P Estimation

q_1 = 92.5 MMscf/d;

q = 5 MMscf/d;

D = 0.17/year.

$$t = \frac{\ln\left(18.50\right)}{0.17/\text{year}} = 17.16 \text{ year}$$

3P Estimation

q_1= 130 MMscf/d;

q = 8 MMscf/d;

D = 0.12/year.

$$t = \frac{\ln\left(16.25\right)}{0.12/\text{year}} = 23.23 \text{ year}$$

3. Result

The MnaziBay gas field is currently in a plateau period, making it difficult to use DCA until the plateau period is estimated. The field will have 14 years of constant production from 2013 to 2027, with the decline rate of 0.26/year and the economic limit will be reached at 2038 equal to 11 years from first decline, this will happen if the MnaziBay gas field will produce only proven reserve (1P), and the field will have 16 years of plateau production from 2013 to 2029, reaching an economic limit at 2046 with the 0.17/year decline rate if the production base on 2P,

Table 2. Decline result and abandonment result.

	Scenarios		
	1P	2P	3P
Plateau duration (years)	14	16	15
Decline rate (from production rate (/year))	0.26	0.17	0.12
Decline rate from slope (/year)	0.26	0.17	0.12
First decline estimation	2027	2029	2028
Lifespan (from estimated first decline) (years)	11	17	23
Abandonment time	2038	2046	2051

if proven, probable and possible reserve (3P) are produced, the plateau will last 15 years followed by 23 years of decline until 2051 with the 0.12/year decline rate, (**Table 2**).

4. Conclusions

The research analyzed three scenario 1P, 2P and 3P of production rate based on sale outlook provided by Maurel and Prom, and result into the following decline rate, 0.26/year with plateau duration of 14 years and life span of 11 years, 0.17/year with 16 plateau duration and life span of 17 years and 0.12/year with plateau duration of 15 years and life span of 23 years respectively (**Figure 6**). This research assumes constant operational condition and one factor that will result to decline in production rate, that is sales outlook, for pressure and number of well are kept constant. Not only market demand, pressure and number of wells will result in field abandonment when field reach to its economic limit but also environmental and regulatory changes could impact actual abandonment decisions as MnaziBay field is located near reserved Marine Park. Other factors include well location, well total depth, well's mechanical condition, weather, price fluctuation and planning.

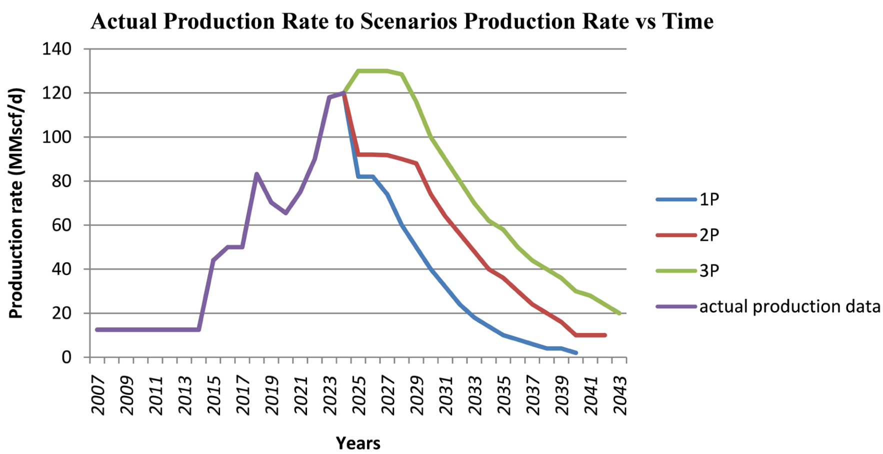

Figure 6. MnaziBay actual production (2007-2024) and predicted reserve production.

The research encounter limitation that must be considered, the analysis is conducted based on current and predicted data that may require updates as field matures, this is due to the fact that as field matures the degree of uncertainty tend to decrease and more accurate prediction can be attained through advanced methods such as application of machine learning approaches for production forecasting, conducting integrated reservoir to surface modeling to validate decline predictions.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Weatherill, B. (2019) MnaziBay Resources Evaluation. RPS Energy Consultants Ltd.

[2] Summary of Deep Wells Drilled in Tanzania. https://tpdc.co.tz/wp-content/uploads/2022/06/SUMMARY-OF-DEEP-WELLS-DRILLED-IN-TANZANIA.pdf

[3] RPS Energy Canada Limited (2018) MnaziBay Reserves and MnaziBay and Mozambique Prospective Resources. Wentworth Resources Limited.

[4] Mahmoud, K. and Arild, S. (2020) Introduction to Permanent Plug and Abandonment of Wells. *Ocean Engineering & Oceanography*, **12**, 1-2. https://doi.org/10.1007/978-3-030-39970-2_1

[5] Alfitouri, J. and Mohamed, A. (2015) Decline Curve Analysis in East Almabrouk field. *International Journal of Scientific & Technology*, **4**, Article 73.

[6] Abdulrahaman, R.K. and Sebastine, I.M. (2012) Natural Gas Sweetening Simulation and Optimization. *WIT Transactions on Engineering Science Engineering*, **81**, 37-46.

[7] Okotie, S. and Ikporo, B. (2019) Reservoir Engineering: Fundamentals and Applications. Springer. https://doi.org/10.1007/978-3-030-02393-5