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Answering The Challenges For Improving Gas And Condensate Production In Mature Field. Case Study: Wet Gas Limited Reservoir

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ANSWERING THE CHALLENGES FOR IMPROVING GAS AND CONDENSATE PRODUCTION IN MATURE FIELD. CASE STUDY: WET GAS LIMITED RESERVOIR

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Abstract

Strong hydrocarbon demand and rise in oil prices have challenged petroleum industry to increase production. Pertamina EP as a giant hydrocarbon producer in Indonesia was one amongst hundred that was challenged to improve production through the mature assets reactivation.

Anya Field is one of the mature fields operated by Pertamina EP Asset 2, located at 25 km North-West of Prabumulih, South Sumatera. It was discovered in March 1941 from Sandstone Talang Akar Formation (TAF) producing gas and condensate. Peak production was achieved in December 1984 with 3189 BOPD of condensates and 80 MMSCFD of gas from 28 production wells. Afterwards, production decline was continued until December 2016 with 17 BOPD from 1 production well. Currently 47 wells are idle in Anya Field.

The challenges were on the reservoir boundary and uncertainties, the absence of flow line installation due to suspended wells and no gas compressor installation at gathering station. Because of this, wellhead pressure must be within 400-450 psi that was higher than pipeline pressure.

Steps to attain production enhancement was including potential reserves by layer identification based on geological and reservoir study, well selection for workover candidates, data acquisition including welltest, hydrocarbon volume estimation using Material Balance Model, field life estimation and economic evaluation.

The study has positive outcome in production and economic aspects. Therefore, production line was installed from well to gas gathering station. Production and pressure monitoring were periodically performed to evaluate and update Material Balance Model. As the result, Anya Field production was increased by 537 BOPD and 7.5 MMSCFD from 6 production wells. In addition, new reservoir was discovered for future drilling opportunity.

Keywords : mature field, wet gas limited reservoir, improving production

1. Introduction

Pertamina EP is one of the oil and gas companies operating in Indonesia. Most of the *working areas* managed by Pertamina EP are old and mature fields that have been produced for decades. Many challenges are faced in the development of this mature fields in order to achieve the production target assigned on Pertamina EP every year. The biggest challenge is the reservoir condition which tends to have high watercut, this results in the oil gain obtained that below the target.

This challenges encourage the need for **new efforts** to achieve future production targets. One effort that can be done within short time was analyzing and evaluating opportunities to reactivate the mature suspended fields.

Anya Field is one of mature fields operated by Pertamina EP Asset 2, located about 25 km northwest of Prabumulih, South Sumatera. Anya Field was discovered in March 1941 with production of gas and condensate from sandstone reservoir in Talang Akar Formation (TAF). Anya hydrocarbon trap was formed by *Pendopo Anticlinorium* which extends from northeast to southwest. The graben structure formed from normal faults divided Anya Field into several compartments/blocks.

The peak production of Anya Field was achieved in Desember 1984 with 80 MMSCFD gas and 3189 barrel condensate per day. Afterwards, production continued to decline despite drilling up to 48 wells. The lowest production was in December 2016, when it only produced 17 bopd from 1 active well.

Based on subsurface evaluations (log, petrophysics, remaining reserve), production history and surface facility condition, Anya Field was chosen as the reactivation target. Many challenges must be faced in increasing Anya Field production:

1.1. Subsurface Aspects

Anya Field consists of 67 proven hydrocarbon layers, dominated by small reservoirs, About 65% of these layers can only produce hydrocarbon with cumulative of less than 2 BSCF, these reservoirs are statistically sufficient to be produced from only 1-2 wells. How long the production lifetime and how much cumulative production can be achieved from each well are the initial questions that must be answered to ensure that the investments made are of economic value.

1.2.Surface Facility Aspects

The suspended wells in Anya Field are no longer have flowlines, therefore producing the wells requires investment in installation of flowlines in the range of 3-5 km. In addition, to get commercial value, gas production from Anya Field must be able to enter the *SumBagSel* gas sales network with sales network pressure around 450-500 psig. Since there is no gas compressor in Anya Field gathering station, wells must produce from reservoir layers with high pressure.

2. Mapping of Hydrocarbon Potential and Candicates Selection for Workover

Based on subsurface and surface consideration, hydrocarbon produced from Anya Field need to be from high pressure reservoirs with reserves that are still economically sufficient for the investments incurred. Therefore, selected reservoirs for production need to be virgin reservoirs or reservoirs with very small drainage radius.

The first step was to take inventory of all hydrocarbon potentials from each well using petrophysic analysis and geological correlation. All layers with resistivity >10 ohm.m and porosity >7% were categorized as hydrocarbon potential. Layers which had been produced/perforated based on well history and production data were marked, leaving the layers with hydrocarbon potential but never been produced (virgin reservoirs).

The net sand map was marked with wells that previously produced and the ones with hydrocarbon potential but never been produced. This map shows the distribution of production wells in each layer, layers with very small drainage, and wells that would be used as workover candidates to maximize their drainage. The drainage radius of a layer was considered very small when it produced from only 1-2 wells, with the distance between candidate well to the production well at least 500 m.

Based on analysis above, nine virgin layers were found in Anya Field: L1a and L1 in block A, F0, G1, S3, S2, and P4 in block B, E3 and P2a in block D, and another five layers have very small drainage radius: M1, E, L1a and J3 in block D and K4 in block B. These layers are relatively thin with average thickness of 3 m and resistivity of 50 ohm.m. The reservoir properties were poorer compared to layers that had been produced, which was the reason these layers were marginalized.

Workover candidates can be seen in **Table 1**.

3. Workover Campaign: A Case Study

3.1. Workover Candidates Execution

The selected workover candidates were then executed with the following scope of work:

- Squeeze cementing of the existing layer
- Perforating the target layer with casing gun (4.5 inch 5 spf standard penetration). As for the G1 layer at ANY-09, fracturing job was added due to tight formation.
- Swab well until it flows naturally and conduct production test with mobile test unit (due to lack of flowline to gathering station).

Workovers were executed using small rig with work duration around 2-3 weeks per well.

3.2. WellTest Data Acquisition and Analysis

There have been seven workover wells executed in Anya Field with six wells succeeded producing gas and condensate after swab jobs: ANY-45 (layer L1a), ANY-36 (L1a), ANY-08 (S2), ANY-30 (S3), ANY-23 (M1) and ANY-42 (F0).

The one well that was not succeeded was ANY-09, showed hydrocarbon potential after swab from layer G1, indicated by increase in wellhead pressure to 1300 psi after the 12 hours shut in. The gas flow was intermittent and took several hours for the wellhead pressure to build up. Layer G1 is still under evaluation and will be proposed to be produced from other wells with better petrophyisic properties. Layer P2a of ANY-09 did not show the presence of hydrocarbon, with 100% watercut fluid recovered from swab job. This was confirmed by static bottomhole pressure gradient which also showed the water gradient in the wellbore.

Welltests were conducted on each producing well to determine the size and capacity of each layer so the gas deliverability and reserves can be calculated. This process was important as a justification for flowline installation from well to gathering station.

The types of welltests conducted were MIT (Modified Isochronal Test) and PBU (Pressure Build-Up) with a duration of four hours for each flowing and shut in stage, eight hours of extended flow, and 48 hours of pressure build-up. During MIT, the shut in stage did not need to wait for the reservoir pressure to be stable therefore welltests time were faster. Test duration consideration was important due to safety issues in high pressure gas flaring at the site.

The choke sizes used during the test were 20/64", 24/64", 28/64", and 32/64". The smallest choke selected was 20/64" because smaller choke size could cause higher pressure difference that leads to ice formed along the line from wellhead to separator test, which was not a recommended condition. As for wells with medium pressure, the choke combination used could be larger.

Complete results of welltests can be seen in **Table 2**. Producing layers in Anya Field has various CGR (condensate gas ratio), where five layers are HP (High Pressure) gas with WHP (Wellhead Presure) of 1400-1800 psi using 20/64” choke size and layer F0 produces MP (Medium Pressure) gas with WHP range from 200-300 psi.

Plots of derivative logs in PBU analysis indicate that these reservoirs are small with a reservoir radius ranging from 400-500 m.

3.3. Calculation of Reserves and Economic Analysis

Gas deliverability and reserves of layer L1a, S2, S3, and M1 that produce HP gas from five wells were then calculated to ensure that the gas produced is economically feasible for the investment incurred. Meanwhile, layer F0 in ANY-42 temporarily will not be produced until the gas compressor for LP gas is available at the gathering station.

Calculation of reserves that can be produced from the reservoirs was done using Material Balance simulation. The reservoir model used was a single tank model without an aquifer (volumetric reservoir).

Because the simulated reservoir still did not have production data, IGIP (Initial Gas In Place) were included as an input in the model. IGIP values were obtained from volumetric calculation using the reservoir radius from pressure build-up analysis. This IGIP value, surely, were updated as new reservoir pressure and production data were obtained. Data from wellhead pressure matching were used when no reservoir pressure data available.

IPR model were generated by using C & n method, where C & n value obtained from MIT analysis. Whereas to generate THP (Tubing Head Pressure) curve, matching of flowing gradient in wellbore must be performed to get the correct vertical lift correlation.

After that, VLP (Vertical Lift Performance) table was generated with three sensitivity parameters, namely water-gas ratio, condensate-gas ratio and wellhead pressure.

The constraints used in Material Balance simulation were WHP with a minimum pressure of 600 psi (accomodating gas sales network pressure) and maximum gas rate in accordance with the test results using 20/64 choke. With small choke sizes, the production plateau time was expected to be longer.

Simulation results in **Table 3**, in general, shows good production performance, where in average a layer can be produced with plateau rate 2 MMCFD for more than one year with a total of 5.7 BSCF cumulative gas produced.

To ensure this project economically feasible, the economic calculations were done by including rig costs and investments in flowline installation. Economic evaluation is carried out in the span of one year using IRR (Internal Rate of Return) and NPV (Net Present Value) indicators. The results show that investment in each well gives an IRR> 11% and positive NPV values, which gives justification to install flowline from each well to the gathering station. The flowline installation process takes about 1-2 months.

3.4. Result

With increasing production from these layers, Anya Field production slowly increased from only 17 bopd in March 2017 to 537 bopd and 7.5 mmscfd in early September 2018. The number of active production wells increased from one well to six wells.

Moreover, this project also successfully adds proven reserves in Anya Field.

3.5 Forward plan

For the next step, it is necessary to monitor reservoir parameters periodically, at least 2 times a year, so that the Material Balance model can be updated. As has been done in layer L1a in block A, the updated production and pressure data adjust the IGIP value using Material Balance model from 1.8 BSCF to 3.5 BSCF.

The success in reactivating Anya Field has encourage us to conduct an integrated GGRE (Geology, Geophysics, Reservoir Engineering) study to find new drilling potentials, both infill and step-out. The study will be outlined in Anya field POD which is currently under discussion with SKK Migas.

4. Conclusion

With good planning and engineering processes, challenges in reactivating Anya Field were overcame properly and increases gas and condensate production from this field.

5. Recommendation

Acquiring new subsurface data, such as cased-hole logs, will be useful in order to increase success ratio of workover in Anya Field. Installing Medium Pressure compressor can also help to optimize gas production.

6. Acknowledgement

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7. References

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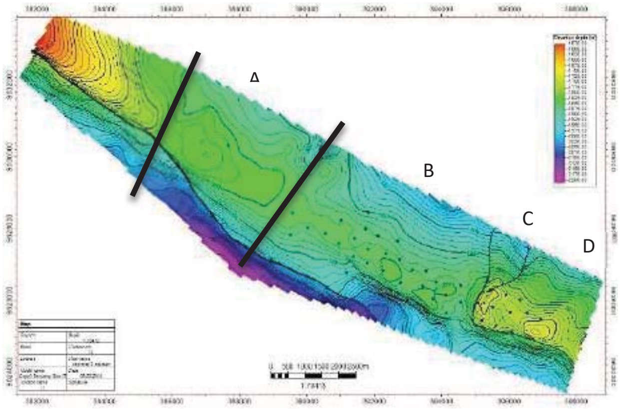

Figure 1. Structural Map of Anya Field

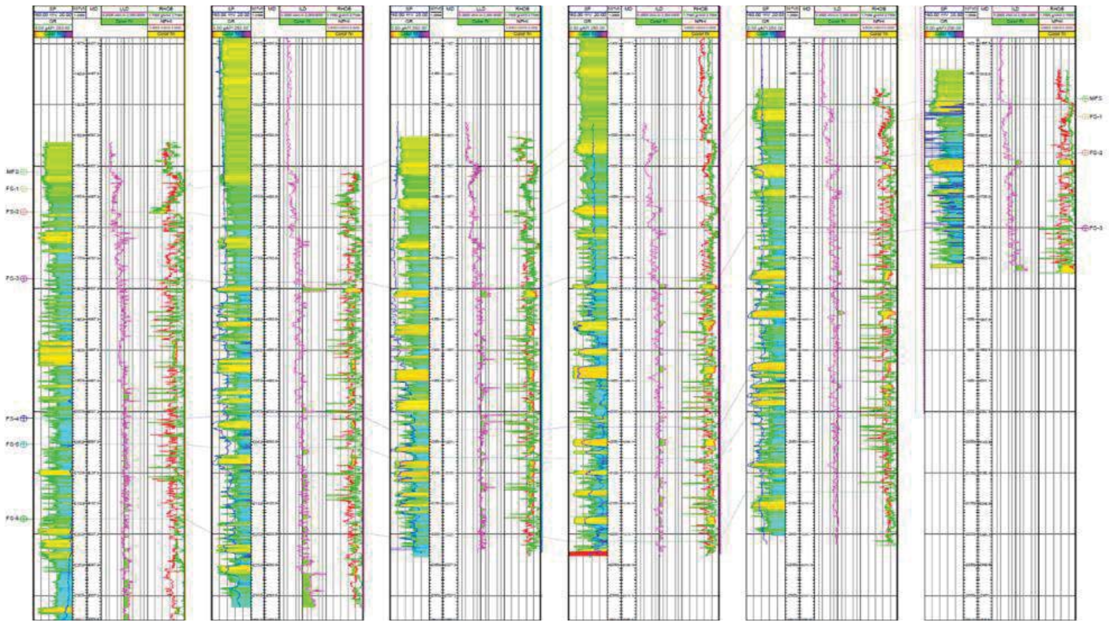

Figure 2. Anya Field Correlation

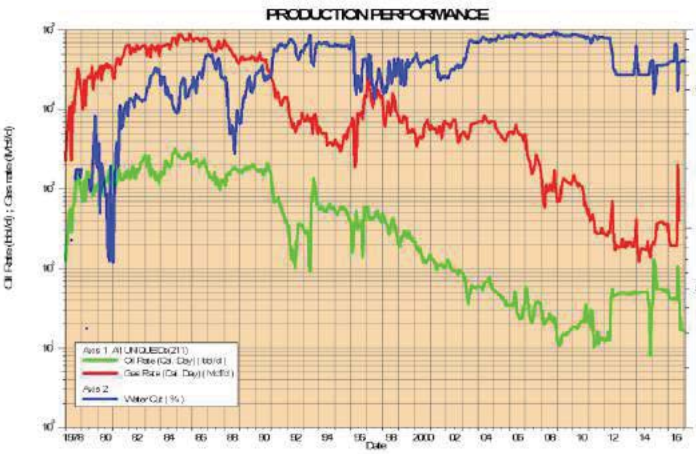

Figure 3. Anya Field Production Performance

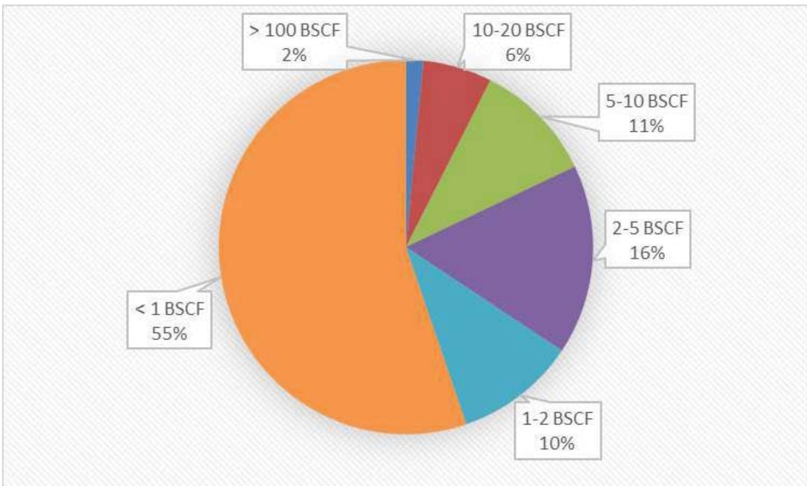

Figure 4. EUR distribution

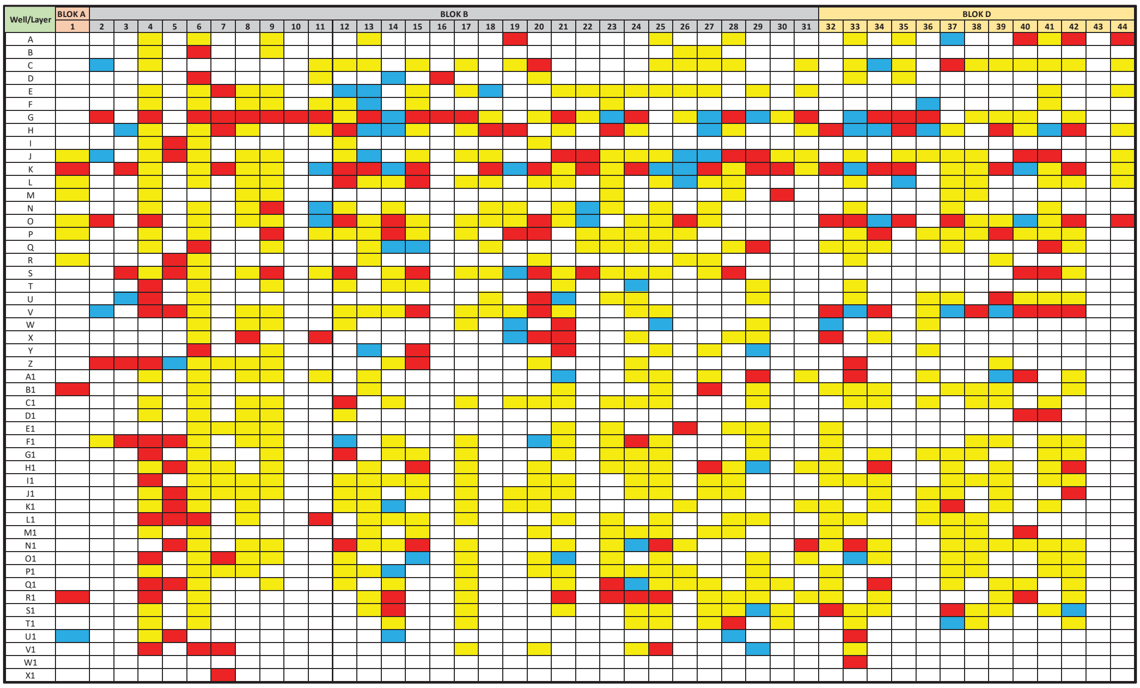

Figure 5. Tabulation of inventory of potential hydrocarbons

(Yellow : hydrocarbon potential, red: gas, blue : water)

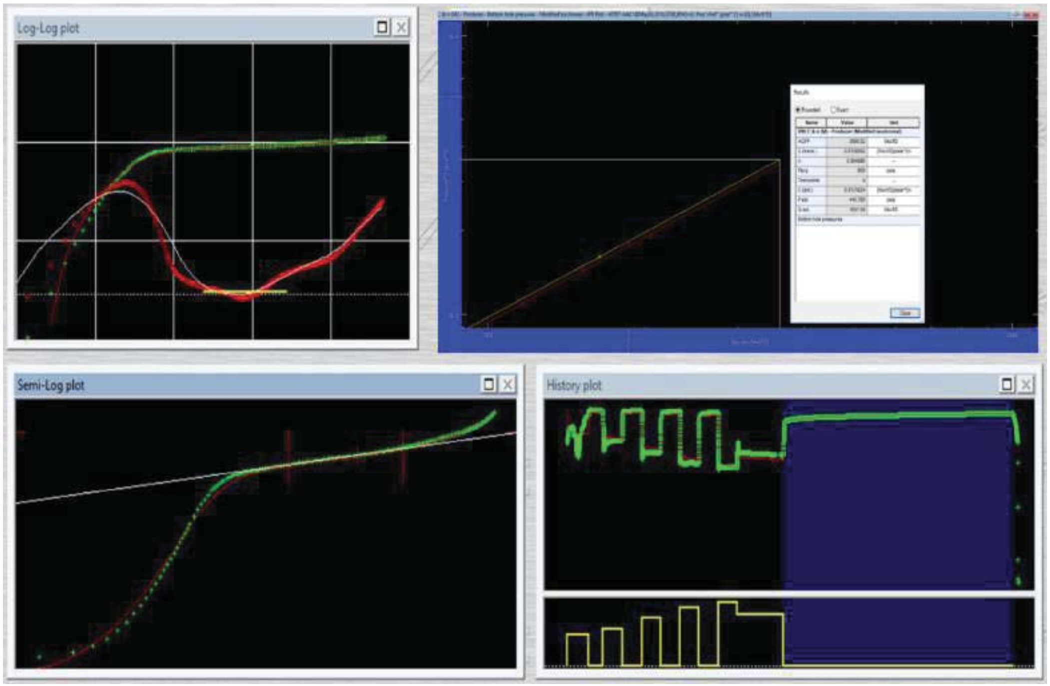

Figure 6. Example of Welltest Analysis

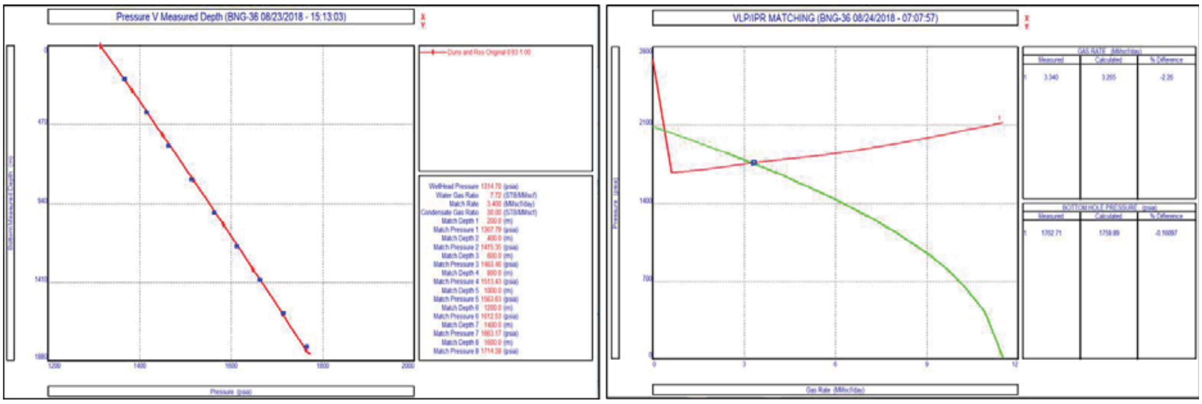

Figure 7. VLP/IPR Matching

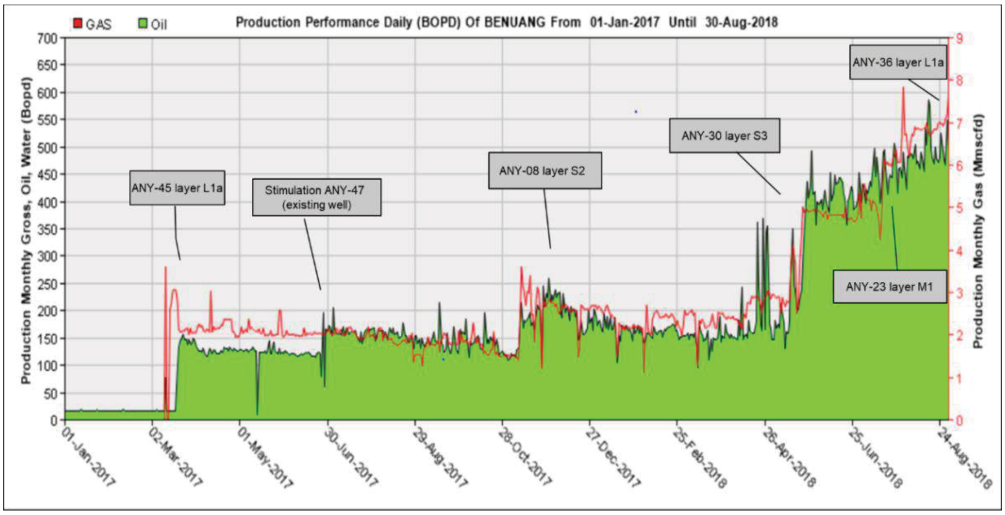

Figure 8. Anya Field Production Performance

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Table 1. Workover Candidates

Layer	Blok	Well	h, m	Ø	Rt, ohmm	Note
L1a	A	ANY-45	2	0.16	70	Virgin reservoir
L1	A	ANY-45	1	0.12	60	Virgin reservoir
F0	B	ANY-42	2.5	0.2	80	Virgin reservoir
G1	B	ANY-09	3	0.12	20	Virgin reservoir
S3	B	ANY-30	10	0.13	15	Virgin reservoir
S2	B	ANY-08	5	0.14	30	Virgin reservoir
P2a	D	ANY-23	4	0.13	80	Virgin reservoir
E3	D	ANY-41	2	0.13	30	Virgin reservoir
M1	D	ANY-23	3	0.2	60	Small drainage
L1a	D	ANY-36	3	0.13	80	Small drainage
J3	D	ANY-41	2.5	0.16	80	Small drainage
K4	B	ANY-09	2.5	0.23	43	Small drainage
E	D	ANY-36	2	0.18	60	Small drainage

Table 2. Welltest Analysis

Layer	Blok	Well	Bean	Production Test	WHP, Psia	AOFP, MMSCFD	Boundary model	Boundary, m
L1a	A	ANY-45	20/64"	150 BCPD/2 MMSCFD/ 0% WC	1577	14.3	Closed reservoir	Re = 407
F0	B	ANY-42	32/64"	30 BCPD/2 MMSCFD/ 33 % WC	234	3.6	Closed reservoir	N=57, E=150, S=400, W= 60
S3	B	ANY-30	20/64"	188 BCPD/2.3 MMSCFD/ 7 % WC	1830	6.8	Channel reservoir	L1=150, L2=150, L3=400
S2	B	ANY-08	20/64"	46 BCPD/0.88 MMSCFD/ 0 % WC	1508	2.57	Closed reservoir	Re=488
M1	D	ANY-23	20/64"	79 BCPD/1.98 MMSCFD/ 11 % WC	1450	11.8	Closed reservoir	Re=430
L1a	D	ANY-36	20/64"	63 BCPD/2.2 MMSCFd/ 3 % WC	1420	10.6	Intersecting fault	L1=341, L2=150

Table 3. Reserves Estimation

Layer	Blok	Well	IGIP, MMSCF	Production Rate	Plateu	EUR, MMSCF
L1a	A	ANY-45	1816	2 MMSCFD/150 BCPD	16 month	1207
S3	B	ANY-30	2200	2.3 MMSCFD/188 BCPD	20 month	1540
S2	B	ANY-08	743	0.88 MMSCFD/46 BCPD	15 month	440
M1	D	ANY-23	1757	2 MMSCFD/79 BCPD	15 month	1340
L1a	D	ANY-36	2154	2.2 MMSCFD/63 BCPD	16 month	1136

Table 4. Economic Analysis

Layer	Blok	Well	IRR	NPV, MUSD
L1a	A	ANY-45	153%	1076
S3	B	ANY-30	241%	1325
S2	B	ANY-08	175%	522
M1	D	ANY-23	129%	884
L1a	D	ANY-36	123%	840