

Integrated Field Development Strategy for Offshore Mature Field - A Success Story from Bekapai Field

Benidiktus Gunung Massuka^{*1}, Saesarian Izwardy², Ahmad Anshariy³ and Pahala Richard Panjaitan⁴

^{1,2,3,4} PERTAMINA HULU MAHAKAM

* Email: benidiktus-gunung.massuka@pertamina.com

Abstract. This paper presents the results of the exploitation strategy in the development of an offshore mature field. For Bekapai offshore mature field, the integration of the geology, reservoir, production and surface had allowed to define new opportunities for drilling, baseline production optimization and then to establishing a holistic development strategy of Bekapai field.

Bekapai is a mature oil and gas field located in the offshore Mahakam Delta, Indonesia. Bekapai field was discovered in 1972, production commenced in July 1974 and the production peak was achieved in June 1978. The hydrocarbons are accumulated in a complex multilayered reservoir, where oil, gas and different reservoir pressure presence alternately. Reservoir heterogeneity, sand production from unconsolidated reservoirs, poor vertical lift performance (no artificial lift), increasing water cut, well integrity issue and ageing surface facilities are main challenges in Bekapai field.

Today's Bekapai development strategy therefore focuses on drilling projects, modification in several platforms for surface debottlenecking and gas lift compression project. Infill drilling activities which resumed recently give a very good result and contribute significantly to Bekapai field production. Next phase of drilling projects (conventional infill drilling, grid base drilling, deepening and step out drilling) and platform modification will be performed in 2022 and 2023 while gas lift compression project starts up expected in 2023. Tertiary oil recovery also considered as future development and long term project of Bekapai field. Other than future development projects, optimizing baseline production and well intervention contribution are important part to arrest the field production decline and prolong the life of the field. Improvement in exploitation strategy combine with synergy from multidisciplinary team have resulted in maintaining Bekapai field production decline and better realization of reserves replacement ratio, even after 50 years of production life.

The success of these improvement efforts illustrates an extensive review of the various aspects of mature field development which proved to be an effective approach in optimizing production from a mature oil and gas field.

Keyword(s): Mature Field; Development Project; Offshore Field; Infill Drilling.

1 Introduction

Bekapai is a mature oil and gas field located in the offshore Mahakam Delta, Indonesia. The field was discovered in 1972. Following the discovery, series of exploration and delineation wells were drilled to appraise the hydrocarbon extension. The hydrocarbons are accumulated in a faulted anticline structure with multilayered sandstone reservoirs, deposited in a fluvio-deltaic environment.

The field was divided in 3 panels based on structure which are West panel, Central panel and East panel. More than 80% hydrocarbons are accumulated in West panel. The Bekapai field consists of five stratigraphic intervals which are Deep zone, Lower, Upper, Main and Shallow zone. Shallow, Main and Upper zone are strong aquifer support while Lower and Deep zone are depletion drive. Geological context of Bekapai field is presented in Figure 1.

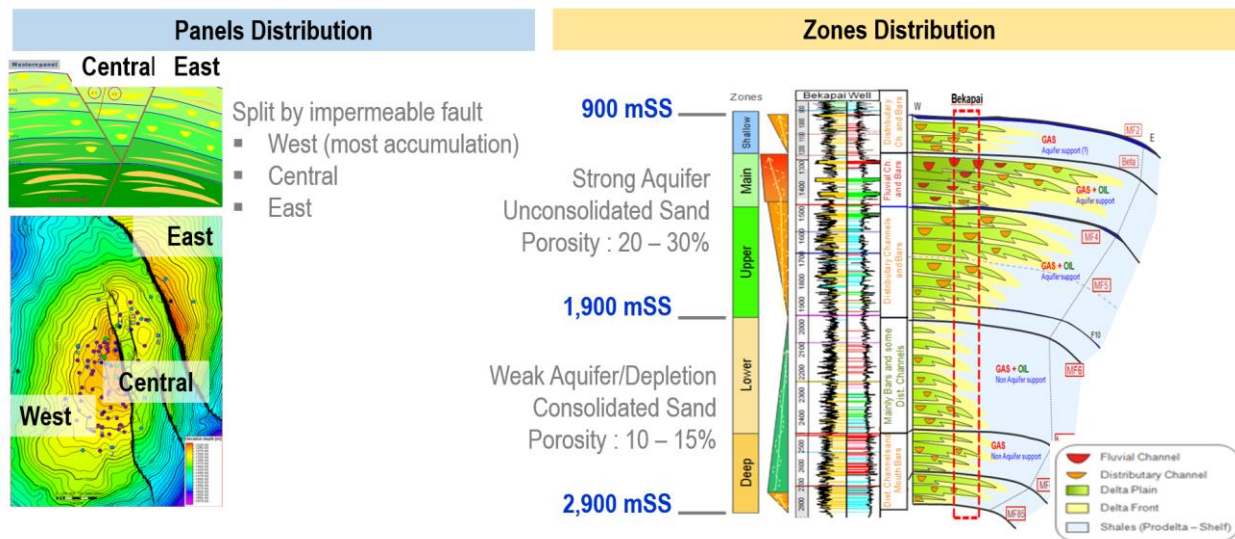


Figure 1. Bekapai Geological Context

1.1 Bekapai Complexity & Challenges

The hydrocarbons are accumulated in a complex multilayered reservoir, where oil, gas and different reservoir pressure presence alternately. It's difficult to optimize the production while optimizing the recovery in such environment since they have to produce in commingles to achieve the production target. Auto gas lift by producing oil and gas reservoirs in commingle is default lifting methodology to produce oil potential. This methodology is already proven to lift our oil potential together with the gas potential but will not optimally drained the oil accumulation.

Reservoir heterogeneity, sand production from unconsolidated reservoirs, poor vertical lift performance (no artificial lift), increasing water cut, well integrity issue and ageing surface facilities are main challenges in Bekapai field (Figure2).

Unconsolidated Sand Pressure Depletion Issue Typical Well Configuration

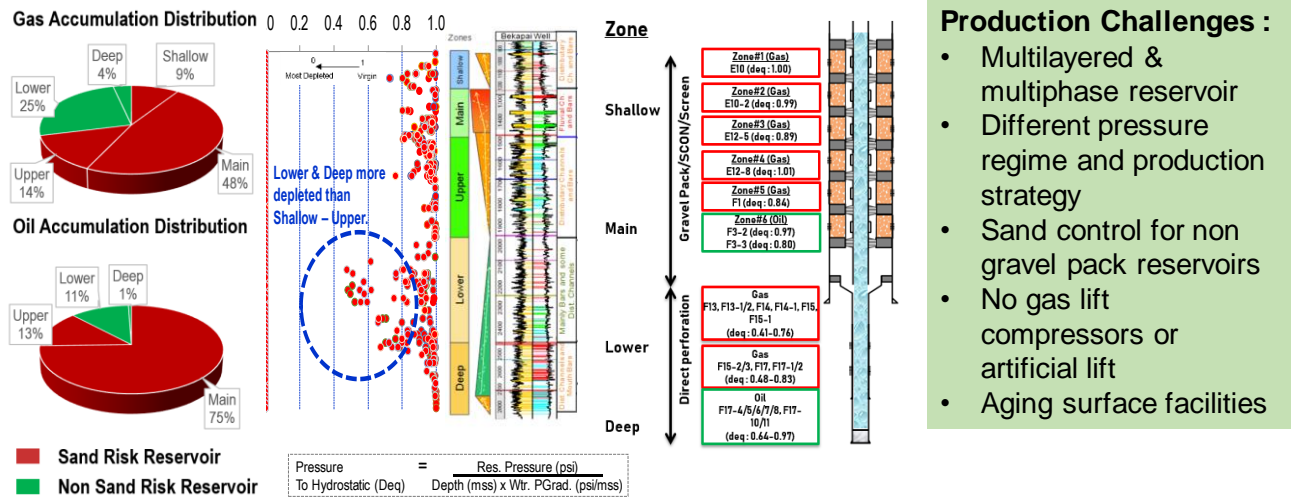


Figure 2. Bekapai Complexity & Challenges

1.2 *Bekapai Development History – First Revival Project*

The initial development from 1972 to 2007 drilled 85 wells and reached a peak production in 1978 (60,000 BOPD). A field re-development project was initiated in 2008. By the end of 2013, the field was able to produce 10,000 BOPD and 46 MMSCFD. Following this successful project, a further development plan, so-called Phase 2, was proposed and a new 3D OBC seismic was acquired to support the re-development plan. Phase 1 was targeting hydrocarbon in Lower zone and by-passed oil in Main and Upper zone. Phase 2 was targeting attic oil in Main and Upper zone, gas cap blowdown, Lower zone and also targeting Central panel (Muhazir et al, 2015).

- **1974-1986 Initial Development:** targeting oil and gas in Main zone, appraisal well also performed to confirm oil and gas potential in Lower and Deep zone.
- **2006-2011 Phase 1 Development:** targeting oil and gas in Lower, Main & Upper Zone.
- **2012-2019 Phase 2A & 2B Development:** targeting by-passed oil in Main zone, oil in Lower and Deep zone, Lower zone gas cap blow down and continue development of Central Panel.

2 **Bekapai Integrated Depletion Plan – Second Revival Projects**

Integrated study then performed to define the next development projects of Bekapai field. Based on this study, Bekapai development strategy focuses on drilling projects, modification in several platforms for surface debottlenecking and gas lift compression project. Infill drilling activities which resumed recently give a very good result and contribute significantly to Bekapai field production.

Next phase of drilling projects (conventional infill drilling, grid base drilling, deepening and step out drilling) and platform modification will be performed in 2022 and 2023 while gas lift compression project starts up expected in 2023. Tertiary oil recovery also considered as future development and long term project of Bekapai field. Other than future development projects, optimizing baseline production and well

intervention contributions are important part to arrest the field production decline and prolong the life of the field. Figure 3 illustrates the comprehensive depletion plan of Bekapai field. This depletion plan consists of several projects and studies, not only short term but mid-term and long term projects. These projects show continuous improvements and efforts to maintain and increase production of Bekapai field.

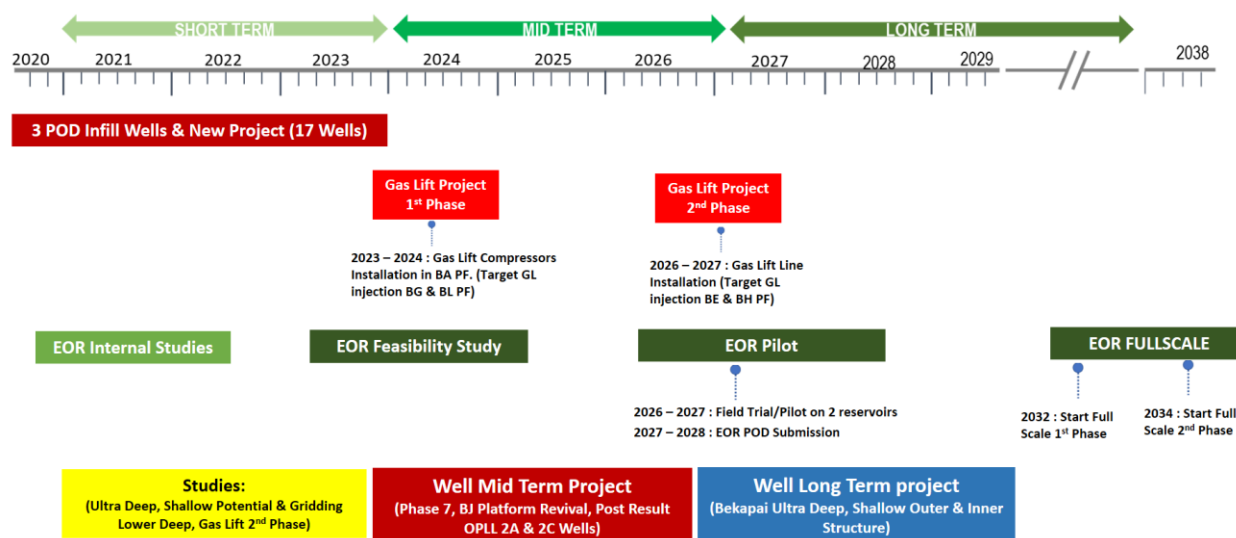


Figure 3. Bekapai Integrated Depletion Plan

2.1 Bekapai Short & Mid Term Development Projects

2.1.1 Bekapai Aggressive Drilling Project

First stage of this drilling project was performed in 2020, 4 wells were drilled with very good result (Figure 4). Next phase of drilling projects (conventional infill drilling, grid base drilling, deepening and step out drilling) and platform modification will be performed in 2022 and 2023. Table 1 summarize the drilling phase and well number of Bekapai short term drilling projects. In the history of Bekapai field, this drilling campaign is the most aggressive ever performed. Following are the main challenges of this project.

- Limited drilling slots in the existing platform.
 - Major modification in the existing platform is challenging, both surface and economical.
 - Sidetrack option from existing slots is not always easy. Readiness of the well slots, well integrity and well abandonment is challenging.
- Marginal stakes. Economic evaluation of this project could be challenging as reserves of our wells are become less and less. Efforts from multidisciplinary team is mandatory to deliver this project successfully.

Table 1. Bekapai Drilling Project Summary

Drilling Phase	Well Number	Execution Plan	Surface Scope
Phase 3	5	2022-2023	Major modification
Phase 4	4	Done	Well connection
Phase 5	5	2022-2023	Well connection
Phase 6	7	2022-2023	Well connection
Phase 7	8	2023+	Well Connection & Minor modification

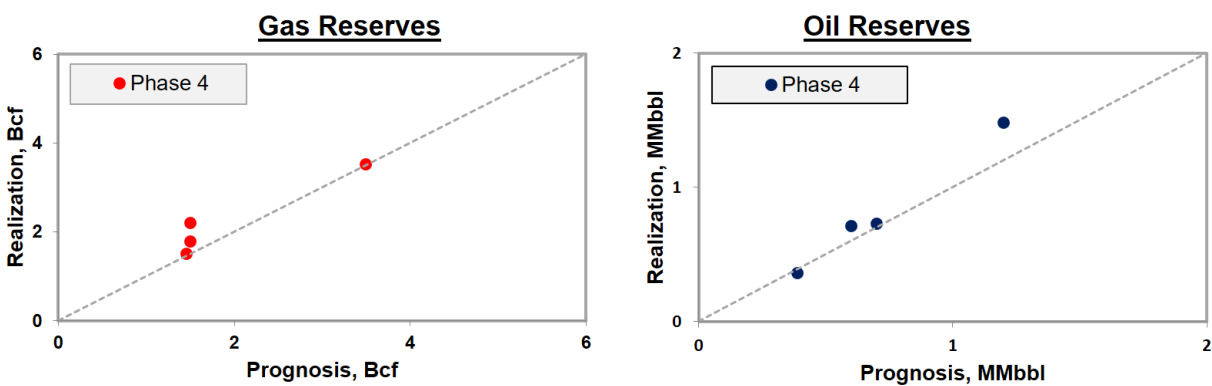


Figure 4. Bekapai Phase 4 Drilling Result

2.1.2 Bekapai Artificial Lift Project

Artificial lift is required as a solution to increase oil recovery in Bekapai field. Compared to current oil lifting practice, this system will provide more optimum oil lifting. Based on subsurface study, field environment and characteristic, closed gas lift system is recommended to be implemented in Bekapai. Since we will have continuous gas lift source with stable and higher pressure gas lift injection, this system will give higher oil recovery compared to current practice. Following figure illustrates the scope of Bekapai gas lift project first phase.

- First Phase Project: Gas lift compressors installation and network revamping. Targeting production wells in BG & BL Platform. Expected start up by 2023
- Second Phase Project: Gas lift pipeline installation. Targeting BE & BH Platform. Expected start up by 2026

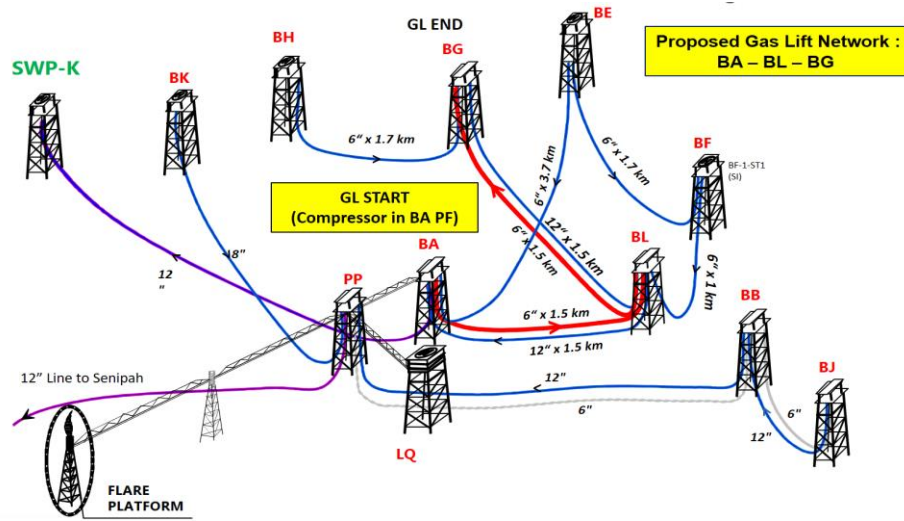


Figure 5. Bekapai Gas Lift Project – First Phase

2.2 Bekapai Long Term Development Project: EOR

Tertiary oil recovery also considered as future development and long term project of Bekapai field. This project currently under study and very challenging. Based on preliminary screening study (literature and PertaEOR software), CO₂ injection and CEOR are the most suitable EOR method for Bekapai field. As can be seen in the table 2, cost magnitude and economical aspect of this of EOR project will be challenging. Considering several aspects (subsurface, cost, economical aspect and surface facilities), Chemical Enhanced Oil Recovery (CEOR) is the selected method for Bekapai tertiary recovery. This project will be further evaluated in the next couple of years.

Table 2. EOR Method Comparison

Metode	Surface Consideration	Surface Facility Requirement
Miscible Gas Inj.: Carbon Dioxide (CO ₂)	<ul style="list-style-type: none"> There is no CO₂ source in Bekapai (Bekapai CO₂ < 5%). 	CO ₂ Multistage Compressor at Bontang, CO ₂ Separation-Dehydration at Bontang, CO ₂ Multistage Compressor at Senipah, CO ₂ Pipeline Bontang – Senipah, CO ₂ Pipeline Senipah - Bekapai, 2 Offshore Platform (CO ₂ Injection Wells), Utilities, Power Generation & Distribution
Miscible Gas Inj.: Hydrocarbon Gas (HC)	<ul style="list-style-type: none"> Loss of opportunity to produce Gas. Gas Lift Compressor Feeding. 	2 Multistage Compressor, 2 Offshore Platform, Gas Dehydration, Gas Injection Wells, Gas Injection Network, Power Generation.
Enh. Water Flooding: Polymer / Surfactant/ ASP	<ul style="list-style-type: none"> There is no existing water system facility (water injection/water flood). 	2 Offshore Platform, Feed Water Treatment & Pumping, Water Injection Wells, Water Injection Network, Power Generation, Polymer & Surfactant Injection Facility.
Imiscible Gas Inj.: Nitrogen / Flue Gas	<ul style="list-style-type: none"> There is no Nitrogen source in Bekapai. 	2 Offshore Platform, Nitrogen Plant, 2 Multistage Compressor, Injection Wells, Injection Network, Power Generation.

3 Conclusion

Improvement in exploitation strategy combine with synergy from multidisciplinary team have resulted in maintaining Bekapai field production decline and better realization of reserves replacement ratio, even after 50 years of production life.

In the last four years, Bekapai production stable at level 4,000 - 5,000 BOPD and above 30 MMscfd. Several important projects also sanctioned and executed to maintain short term, mid-term and long term production of this field. Reserves replacement ratio of Bekapai field always above 100% in the last four years.

The success of these improvement efforts illustrates an extensive review of the various aspects of mature field development which proved to be an effective approach in optimizing production from a mature oil and gas field.

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