Proven Development Strategies to Revitalize Brownfield Lifetime: A Success Story from Semberah Field Sanga-Sanga Block, Indonesia

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Abstract.
Semberah Field, one of fields which operated by PT Pertamina Hulu Sanga-Sanga, is located in Sanga-Sanga PSC, Kutai Basin, East Kalimantan Indonesia. This field consists of numerous complex-stacked sand of deltaic environment. It has been explored in 1974 and produced since 1990. It has been producing mixed oil and gas from existing and newly discovered reservoirs. In the meantime, the production is very challenging with decline rate of almost 60% yearly combined with increasing production cost and fluctuating oil prices. Addressing the challenge, integrated development program needs to be considered to revitalize the mature field and deliver optimum production.

This paper presents an integrated approach to revitalize this field and to address this reality by focusing on three key areas. They are:

1) Infill well drilling by implementing new geological understanding and concept to develop the crestal area and to add take-off points on spare area which has been implemented and has proven to open up additional reserve.
2) Smart rigless workover program in existing wells to access the potential zones by diverse completion types.
3) Production enhancement in base production, particularly hydraulic fracturing program in dual monobore completion, deliquification method and surface debottleneck optimization.

These revitalization approaches must be combined with a fully integrated solution, from planning, simulation and design, to field implementation. In addition, collaboration and integration of multi-disciplinary within subsurface, production, surface facility, field operation, drilling and well intervention team are fully required.

The strategy has been successfully applied in the last 5 years in Semberah Field. These initiatives have already been shown to deliver big improvement in production by more than 200% in 2023. This paper will focus on describing in detail how the aforementioned programs have successfully to extend the economic life of a mature producing field.

Keywords: integrated development, infill drilling, rigless, production enhancement

1. Introduction

The Sanga-Sanga working area is located in East Kalimantan Province, specifically in the delta system of the Mahakam River. (Please see figure 1) Sanga-Sanga is part of the Kutai Basin, which has proven to contain significant oil and gas reserves. The production intervals at each Sanga-Sanga field range from 1,000 to 13,000 feet. Oil and gas production comes from stacked pay reservoirs with an average thickness of 1,000 feet. These reservoirs are detailed as multi-layered reservoirs with varying properties and sizes. To date, more than 4,600 reservoirs have been modeled with varying driving mechanisms. The Semberah field is one of the fields within the Sanga-Sanga working area. Semberah field is located in the northernmost part of the Sanga-Sanga working area. It was discovered in 1991. The field has 672 gas reservoirs, 83 oil reservoirs, and 49 gas-oil reservoirs. There are 182 wells that have been drilled in this field with a cumulative production of 707 BCF, 59 MMSTB of oil, and 88 MMSTB of condensate. Currently, the production from the Semberah field is about 33 MMscfd and 2,300 BOPD.

Geological Environment

The geological environment of the Semberah field is deposited in a distal complex deltaic environment. Its lithology consists of sandstone, shale, coal, and minor limestone. The average thickness of the sandstone is about 20 feet. The sandstones in this field are mostly distributary channel and mouth bar facies. Regionally, the trending anticline is NE-SW with a major fault located in the western part. Structurally, the dip on the western flank is steeper compared to the eastern flank. Reservoirs in the Semberah field range from depths of 4,000 to 11,000 feet, from layers C to J. The quality of the reservoir deteriorates with depth, with decreasing permeability. Porosity ranges from 6-25%, and permeability ranges from 1-450 md. Reservoir thickness varies between 1-150 feet. The driving mechanisms in this field include depletion drive, water drive, and a combination of water and gas cap drive (please see figure 2).

Completion Evolution

Dual Completion

PHSS initially used dual completion until the early 1990s. This dual completion involves using dual tubing to produce each layer through separate tubing. This setup was used when the number of reservoir layers intersected by the well was limited. For this completion type, workover operations are relatively straightforward because there is less equipment in the wellbore, and the completion is simpler.

Dual Selective Completion

After 1990, as new wells increased and field development became more massive, more reservoirs were intersected in a single well. Consequently, PHSS transitioned to dual selective completion, where reservoirs are produced selectively using SSD (Selective Sliding Door). This type of completion still utilized rig-based operations for recompletion or workover tasks.

Single Monobore

In 1997, PHSS initiated the use of a single monobore completion with a 4-1/2-inch diameter. The primary goal was to simplify the completion due to geological factors and reduce drilling, completion, and workover costs. With monobore completion, operations could be carried out without a rig. Additionally, the rigless approach allowed for faster, more effective, and efficient completion and workover operations.

Dual Monobore

In 2005, the single monobore completion was upgraded to dual monobore to provide higher flexibility, bottom-up perforation, and maximize reserves and production. It also aimed to prevent liquid loading using 3-1/2-inch tubing. Please see figure 3 below to describe PHSS well completion evolution.

Challenge in Semberah Field

More than 70% of the reservoir facies in the Semberah field are bar-type, with relatively small reservoir sizes, leading to a shorter production life. As a result, the production decline trend at Semberah is quite steep. Without intervention and production optimization efforts, the annual decline rate can be as high as approximately 50% for gas and 60% for oil. Massive and effective efforts are required to mitigate this decline. Rapid and extensive production optimization is necessary to stabilize production. Therefore, a field development strategy is needed to maximize revenue for the company. Three strategies that have been applied and successfully optimized production over the past five years in the Semberah field are:

1. Infill Well Drilling
2. Smart Rigless Program
3. Production Enhancement

2. Data and Methodology

Infill Well Drilling
The infill drilling method used to determine new well locations in potential areas is based on studies and a combination of subsurface data. Data utilized includes HCPV (Hydrocarbon Pore Volume), filling ratio, CWT (Completion Well Testing), and statistics. The offset well-based method has been the most widely applied over the past five years, where filtering is performed on existing reservoirs or wells with the best performance. Please see figure 4 to describe offset well basis method which applied in Semberah field.

Smart Rigless Program
In the Semberah field, the most common completion type is currently dual monobore. Workover and recompletion operations are carried out rigless. Rigless activities include perforation through tubing (Extreme UB, UB, OB, or Balance condition), isolation through tubing (mechanical and chemical), coiled tubing operations (unload dry/flow, sand cleanout, squeeze cement, cement packer, cement plug), and slickline operations (PT survey, MPLT, prework tubing clear, etc.). With the rigless program, the execution of workover and recompletion programs for layer switching can be completed quickly. Layer switching can be accomplished in just 1-2 days, allowing for faster hydrocarbon monetization and better economic efficiency.

Production Enhancement
The application of technology and production optimization is implemented in the Semberah field to control the high rate of decline. Several optimizations and technologies that have been applied in the Semberah field include:

1. Capillary string
   Surfactant (foamer) fluid injection to help reduce surface tension and fluid density in the tubing.
2. Plunger lift
   The intermittent artificial lift method that uses the reservoir's own energy to lift liquid in the tubing, utilizing a plunger as a "free-falling" piston.
3. Velocity string & Gas Lift Gas
   Reducing the tubing size for fluid flow to lower the "critical rate" while considering the tubing restriction.
4. Coil tubing gas lift
   The artificial lift method where gas is injected into the production tubing using coiled tubing.
5. Very low Compression System
   Flowing the well into the production system at very low pressure to restore the well’s ability to flow fluid.
   Wellhead Compressor (WHC)
   A compressor is installed at the wellhead with very low suction pressure to restore the well’s ability to flow fluids.
   Liquid Unloading
   The method to remove liquid accumulation from the bottom of the well by flowing it to the atmospheric system. This method effectively prevents liquid loading and avoids critical conditions in gas wells.
6. Hydraulic Fracturing
   The method of pumping proppant at high pressure to fracture the reservoir.

3. Results and Discussion

a) Infill Drilling
   Since 2018, 35 new development wells have been drilled, yielding a total incremental reserve of 32 BCF and 4.2 MMBO. The total net pay reservoir achieved is 2,034 feet. On average, the incremental reserve per well from drilling over the past 5 years is 0.91 BCF of gas and 0.12 MMBO of oil. The results from this massive infill drilling program demonstrate that continuing new well development in the Semberah field remains promising and has potential for obtaining good reserves.

b) Rigless program
Since 2018, 209 rigless workover jobs have been executed, achieving a total initial oil rate of 3,728 BOPD and a total initial gas rate of 53.1 MMscfd, with an incremental reserve of 10.74 Bcf equivalent. The rigless program includes layer switching perforation and installation of artificial lift using coiled tubing gas lift on existing wells. Figure 5 & 6 describe rigless workover performance since 2018.

c) Production Enhancement
Capillary string, wellhead compressor, very low compression system, velocity string, gas lift gas, coiled tubing gas lift, and plunger lift have all been applied in the Semberah field. For instance, hydraulic fracturing conducted in SEM A and B in 2023 with dual monobore completion achieved a production gain of 333 BOPD from these two wells. Figure 7-12 shows success story of each production technology which has been applied in Semberah field.

4. Conclusions

The infill drilling of new wells, rigless workover on existing wells, and production optimization efforts using technology have successfully stabilized the production decline at the Semberah field and even improved production levels. As of August 2024, the gas production at the Semberah field is approximately 41 MMscfd, representing more than a 100% increase from the 20 MMscfd production level in 2018. Oil production at the Semberah field is currently around 2,400 BOPD, which is a 63% increase from the 1,474 BOPD production level in 2018. Production figures for gas and oil in the Semberah field since 2018 can be seen in Figure 13 & 14 below.

Acknowledgments

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Figure and Table

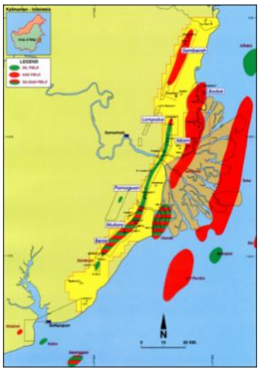


Figure 1: WK Sanga-Sanga

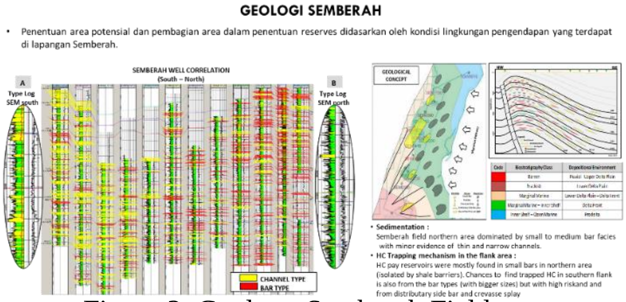


Figure 2: Geology Semberah Field

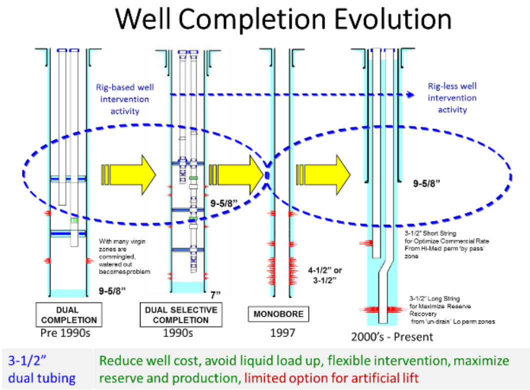


Figure 3: Completion Evolution in PHSS

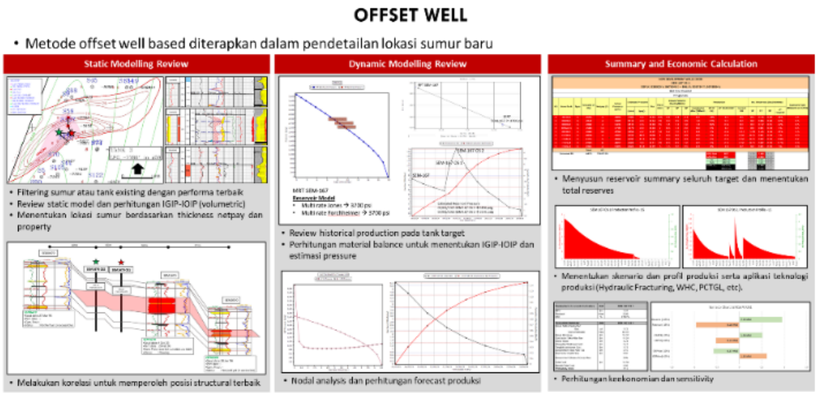


Figure 4: Offset Well Method Applied in Semberah Field

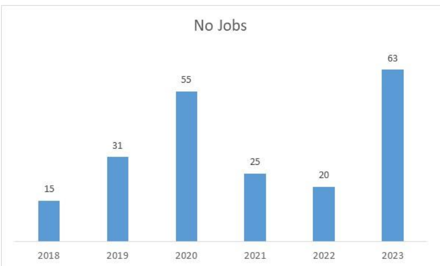


Figure 5: WO Jobs Year 2018-2023

No Jobs	209
Total Initial Rate Oil (BOPD)	3728.06
Total Initial Rate Gas (MMscfd)	53.09
Incremental Reserve (BCFe)	10.74

Table 6: WO Jobs Year 2018-2023

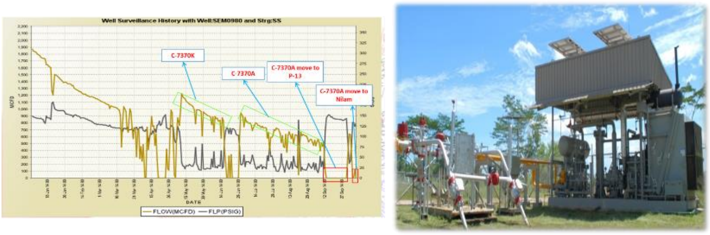


Figure 7: Wellhead Compressor Application

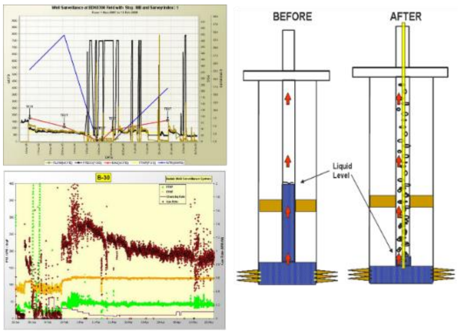
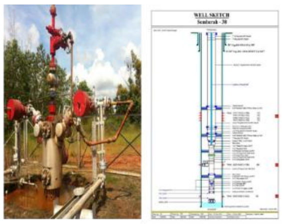
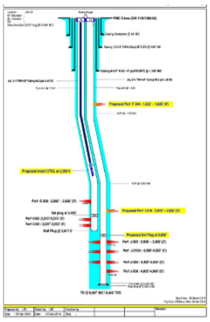


Figure 8: Capillary String Application



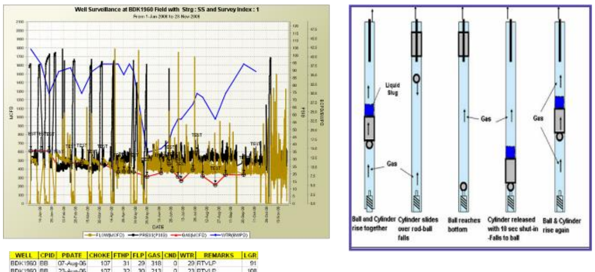
Date of Test	Choke /64"	FTHP psi	FLP psi	CHP psig	Gas MMscfd	G/L MMscfd	Remark
16-Feb-15	107	110	108	335	2.217	0.481	GL Gas
2-Jan-15	107	60	59	0	0.427	0.000	Velocity String
1-Jan-15	0	0	0	0	0	0.000	Natural

Figure 9: Gas Lift Gas + Velocity String Application



WELL	PDATE	GAS	OIL (BOPD)	WTR (BWPD)	Casing Press (PSIG)	Gas Lift Gas (MSCFD)	Remarks
MUT CTGL	13-Jun-17	0	**0**	0	-	-	Before CTGL
MUT CTGL	14-Jul-17	547	**367**	0	530	697	After CTGL

Figure 10: CTGL Success Story



WELL	CPID	PDATE	CHOKE	FTHP	FLP	GAS	CND	WTR	REMARKS	LGR
BDK1960	BB	07-Aug-06	107	31	29	318	0	29	RTVLP	91
BDK1960	BB	23-Aug-06	107	32	30	213	0	23	RTVLP	108
BDK1960	BB	05-Sep-06	107	39	36	332	0	30	RTVLP	90
BDK1960	BB	28-Sep-06	107	37	34	335	0	38	RTVLP	113
BDK1960	BB	13-Oct-06	107	36	33	495	0	36	RTVLP	73

Figure 11: Plunger lift Success Story

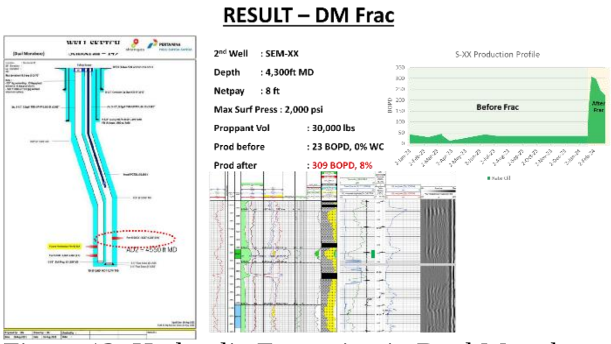


Figure 12: Hydraulic Fracturing in Dual Monobore

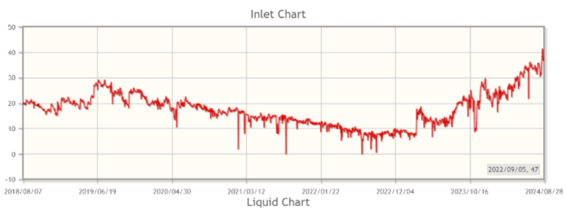


Figure 13: Gas Production Semberah 2018-2024

Figure 14: Oil Production Semberah 2018-2024