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H Field Development: Past, Present, and Future – A Journey to Achieve New Peak Production after 35 Years of Depletion

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Abstract. H Field was discovered in 1975 and starting the first production in 1983. The first peak oil production was achieved in 1987 and then continued decline. In 2017, a subsurface study was conducted by re-interpretation of existing 2D-seismic data, well logs, and formation evaluation with result local attic opportunity and generate recommendation to execute drilling campaign. After 35 years of production, a drilling program consist of three infill wells were executed in 2018 and delivering a very success result by achieving a second peak oil production with incremental production 300% from existing baseline. By the success of these three infill wells, a followed-up drilling campaign consist of four infill wells was initiated and executed in 2021 which again had yielded good result to deliver the third peak production. To reduce further geological uncertainty, a 3D-seismic package will be acquisitioned in 2023 and will be used for further development infill wells. Throughout the last 5 years activity, various challenges, and uncertainties from subsurface and surface have been overcome such as 2D-seismic, structural geology, fluid contacts, deep well drilling, Low-Quality Reservoir (LQR), limited fluid flow, early water breakthrough, high reservoir temperature, high wellhead pressure, and aging flow line. This paper illustrated the chronology and lesson learned of H Field journey, from initial development to recent development, and its future development.

Keyword(s): Field Development; Drilling Campaign; Peak Production; Seismic; Artificial Lift; Formation Evaluation; Surface Facility

1 Field Background

H Field is located in Rokan Block, part of Central Sumatra Basin, Riau Province, Indonesia. This field formed as three-way dip closure with strong-water drive mechanism which produce oil from reservoirs within Menggala (MN) and Pematang (PM) Formations. Hitam Field is categorized as a small and high-risk field, due to its small reserves, deep well ~7,000 ft MD with high temperature ~310 ˚F and presented in low-ranking compared to other fields in Rokan Block. H Field was discovered in 1975 and starting the first production in 1983 from 4 producer wells. The first peak oil production was achieved in 1987 and then continued decline until 2017. The field production was maintained from optimization of existing wells. In that time, there were no field development activity since at that time, it was believed H Field has high uncertainty in such geological factor due to the only having 2D seismic data. Based on new subsurface study in 2017, it generated high confidence plan to initiate a further field development program in H Field.

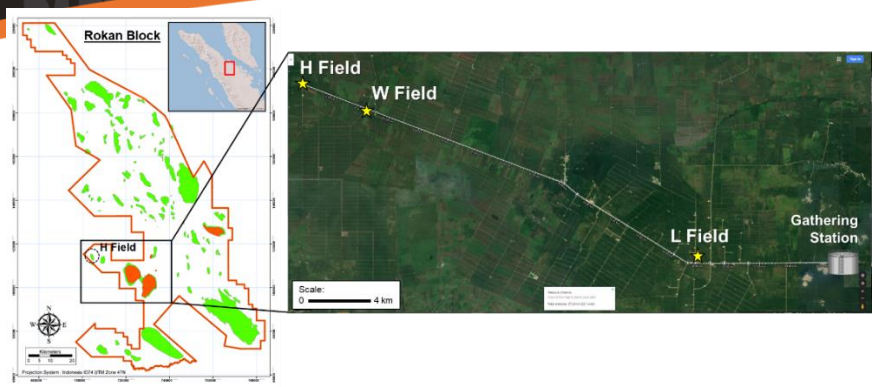

Figure 1. H Field location in Rokan Block

2 Field Development Project 2017-2018

In 2017, a subsurface study was conducted by re-interpretation of existing 2D-seismic data, well logs, and formation evaluation with recommendation of three infill wells (H-6, H-7 and H-8) drilling campaign to improve the low field recovery in H Field.

A fit for purpose subsurface study was initiated to understand the low recovery factor in Hitam (RF ~17%) and its remaining opportunity. The study was started by re-assessing the 2D seismic data consisting of 27 seismic lines with multi-vintages. Seismic re-balancing and data conditioning, well seismic tie in all wells (5 wells), horizon and fault interpretation, horizon miss-tie correction, velocity modelling, and time-to-depth conversion were conducted to update the structural interpretation. The new structural framework had resulting in wider closure area and therefore larger gross rock volume. The effort then continued with developing the first formation evaluation for 5 wells in the field. The formation evaluation flow process started from data collection-reprocessing-QC, then petrophysical evaluation (volume of shale, porosity using "sandstone porosity water saturation -SSWP", permeability, water saturation with simandoux method), completed with validation using side-wall core and core data. In the other hand, a parallel effort for stratigraphic analysis and fluid contact assessment were also conducted to enclose the subsurface study G&G/ static aspect by carefully honoring the production and engineering data/ reservoir dynamics aspect. The result of the study was fascinating and deliver high confidence plan to initiate a further field development program after 35 years of depletion.

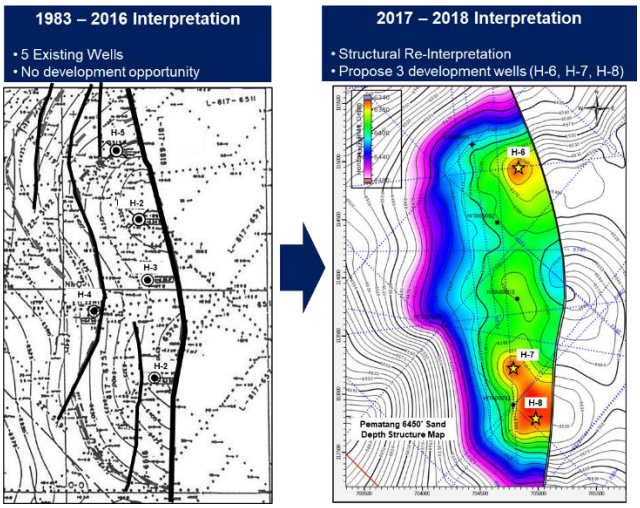

Figure 2. Structural Interpretation Update after 2017 Subsurface Study

The 1st drilling well campaign, H-6 well was spudded and Put on Production (POP) in 2018. H-6 well originally was planned to produce from Pematang sand only, namely PM6450 Sand and PM6550 Sand. However, post drilling result encountered additional oil-bearing from MN sand. During initial completion H-6 well open commingle all 3 sands with 1st test result ~2,100 BOPD with 9% Water Cut (WC). After 3 months production this well experiencing early water breakthrough which suspected contribute from PM6550 sand, since the PM6450 showing dry result from the swab test. After adding perforation in PM6450 to increase productivity, along with isolating PM6550 Sand and keep opening MN sand, the well performance was improved with oil gain >200 BOPD by decreasing water-cut and flatter decline rate. Key lesson learned from H-6 well performance is related perforation strategy improvement during initial completion to minimize risk of early water breakthrough and to minimize risk of low-rate production from low permeability interval.

H-7 well was second development executed in 2018. This well originally was planned to produce from 2 Pematang sands (PM6450 and PM6550). However, post drilling indicated only PM6450 sand showing good hydrocarbon thickness. Single sand strategy has been implemented during initial completion, but this well experiencing limited fluid flow during early production and has been mitigated by sizing down pump size and adding more perforation interval in PM6450. Workover strategy to add longer perforation interval in PM6450 Sand have enabled this sand to flow adequately. Single production from PM6450 Sand has successfully delivered very good well performance with 1st test ~1,000 BOPD, 7% WC and low-moderate increase in water-cut trend. Moreover, H-7 well has opportunity from unperforated interval in MN Sand, but it suggests being contingent opportunity once additional surveillance data such as swab test from nearby wells have available.

Last drilling campaign in 2018 was H-8 well. Similar with H-6 Well, this well originally was targeted to produce from Pematang sand only (PM6450 and PM6550), but opportunity from MN sand look promising. Thus, H-8 well open commingle all 3 sands with 1st test result ~1,200 BOPD, 40% WC. This well was experiencing higher decline rate during first six-month production and following by more stable decline rate. There is an opportunity for water shut-off program to isolate wet zone interval when H-8 well producing with less economic rate.

H field located at the most western field from gathering station and it generated some challenges in term of fluid assurance with distance about ~35 km from H Field to gathering station. After all 3 new additional wells start producing, production line in H Field experiencing high system pressure (increased up to ~100 psi) and it needed to shut-in existing well producer. Short term strategy was mitigating by increasing pressure switch setting from 250 psi to 300 psi. Pressure switch setting at 300 psi is considered safe based on evaluation of current Maximum Allowable Working Pressure (MAWP) is 350 psi.

After 35 years of production, infill drilling campaign in 2018 were delivering a very success result by achieving a second peak oil production with incremental production 300% from existing baseline.

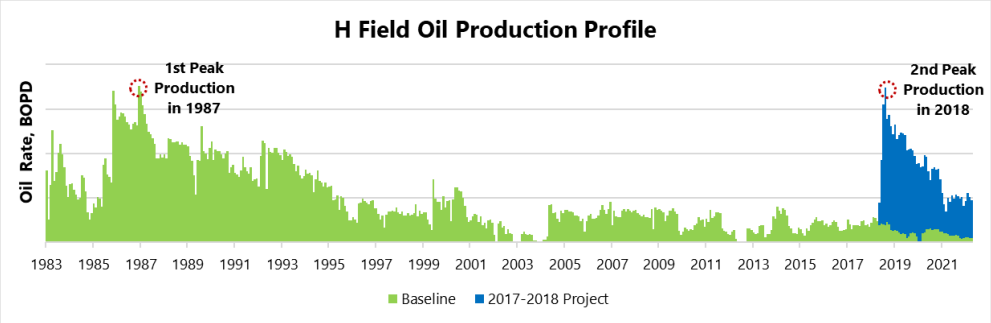

Figure 3. H Field Oil Production Profile after 2017-2018 Project

3 Field Development Project 2021-2022

By the success of these three infill wells, a followed-up drilling campaign consist of four infill wells was initiated. Infill well to reduce acre spacing with at least 230 m distance from existing wells. Post-drilling, a seismic reinterpretation exercise was conducted to address structural uncertainty encountered during drilling, and to improve understanding of the reservoir structure. The structural map has been updated using new well data and proposal well type are infill reduce spacing play with no attic structure. Proposed wells are located between active producer wells which above Current Oil-Water Contact (COWC) from new drilled wells with far vertical stand-off (48 – 66 ft). Infill wells candidate also positioned on 120 m away from main fault uncertainty envelope. This distance was considered safe regarding the maximum swing of fault position during 2D-seismic migration process. Last drilling campaign in 2018 showed actual structure position is lower with average 22 ft (0.34% of depth). Reserves estimation and production forecast have been accommodated with the infill play concept.

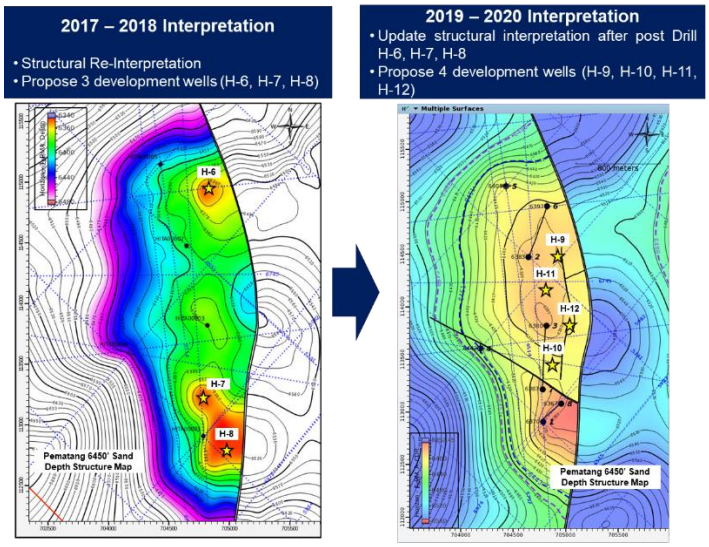

Figure 4. Structural Interpretation Update Post 2018 Drilling

In term of pressure data, H Field indicated has relatively stable pressure with no significant pressure drop. High probability H Field has strong water drive aquifer support. In a strong water drive aquifer support with 3-way dip closure, the drainage volumes/ shape is distorted to be “non-circle” drainage. Most of the well drainage well covers the down-dip area which close to aquifer causing the up-dip area/ area between wells to fault to be “undrained” and becoming infill drilling opportunity.

Formation evaluation also improved by utilizing Hydrocarbon Potential Evaluator (HPE) as a data clustering analysis. This analysis is needed to improve reservoir characterization and perforation interval selection during initial completion strategy, especially in low quality reservoir condition.

Prior to well drilling execution, project team realized with some constraint on production capacity limit for current MAWP constrain. Based on the surface simulation analysis, it predicts system pressure could increase up to ~120 psi after adding fluid rate ~6,000 BFPD which would exceed current MAWP. H Field pipeline integrity improvement project was initiated in 2020 to install pipeline sleeve on specific pipeline segment with red category. Total more than 1,000 pairs sleeve were installed on 30 km pipeline and successfully improve MAWP into ~500 psi.

First drilling campaign in 2021 was H-9 well. H-9 well originally was planned to produce single from PM6450 Sand based on outstanding result from well analog H-7 which producing from single PM6450. However, post drilling result identified unexpected attic potion of MN sand that was encountered with good oil saturation. Thus, it decided to open commingle MN and PM6450 during initial completion. H-9 well deliver 1st test result at ~2,200 BOPD with 16% WC and following by higher decline rate on first three-month production. Currently, wells still producing with good economical rate, and plan to execute workover program by isolating MN sand.

Next well is H-10 well which was spudded and POP in 2020. H-10 well produce from single PM6450 as original target. However, during early production, HT-10 well experiencing limited fluid flow and required to execute workover program. Based on swab test result, it showed existing perforation interval delivered very small rate with less than 100 BFPD and it could not be produced with existing Electric Submersible Pump (ESP) due to issue on ESP motor temperature which has less cooling system in high temperature reservoir. Water cut from swab test indicated PM6450 has full oil with WC less than 5%. Based on this finding, project team decided to add longer perforation interval ~20 ft and fluid rate successfully improved to ~250 BFPD with surprising WC at 1%. After 6 months production well keep producing at 1% WC.

Last well which executed in 2021 is H-11. This well originally was planned to produce single from PM6450 Sand. However, post drilling result identified MN sand opportunity with moderate oil saturation. Project team decided to open commingle from MN and PM6450 by expecting can meet tremendous result as previous well in H-9. 1st test result of H-11 is ~1,200 BOPD, 4% WC. Unfortunately, well experiencing rapid WC increase after 1 month production. Based on swab test result, MN sand indicated to be wet, whereas PM6450 indicated low rate. Based on this finding, this well recommended to isolate MN sand and add longer perforation at PM6450. Well successfully produce after WO with good production at ~300 BOPD, 40% WC.

H-12 was last well from 2021-2022 H field development project. Well was spudded and POP in 2022. H-12 well produce from single PM6450 as original target. Based on lesson learned from previous wells, H-12 applied strategy to open longer interval and lower fluid rate due to uncertainty of reservoir quality. Well successfully produce with 1st test result 225 BOPD, 48% WC. There is an opportunity to increase the fluid rate based on current fluid level.

Production contribution from 2021-2022 development project had yielded good result again which deliver the third peak production

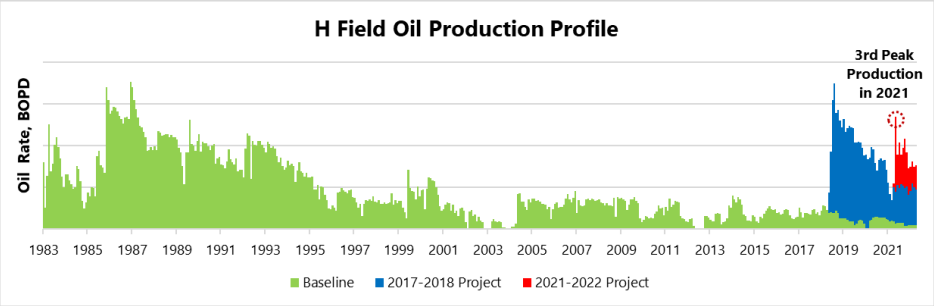

Figure 5. H Field Oil Production Profile after 2021-2022 Project

4 Future Development Plan

Based on recent drilling result in H Field, project team plan to follow up with additional infill wells in north area, considering a good bypass oil potential based on drilling result in H-9 and H-11. Two infill wells plan to be executed in 2023 with concept infill reduce acre spacing from low quality reservoir PM6450 sand as primary target. Well positioned nearby well H-2, H-6, H-9 and H-11 which has good geological structural control.

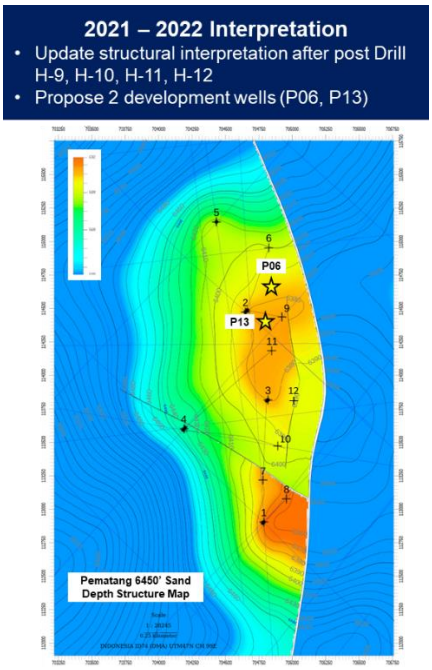

Figure 6. Structural Interpretation Update Post 2021-2022 Drilling

Understanding related COWC also has been improved based on latest drilling campaign with estimated COWC at -6457 ft TVDSS as most likely case and -6466 ft TVDSS at the minimum.

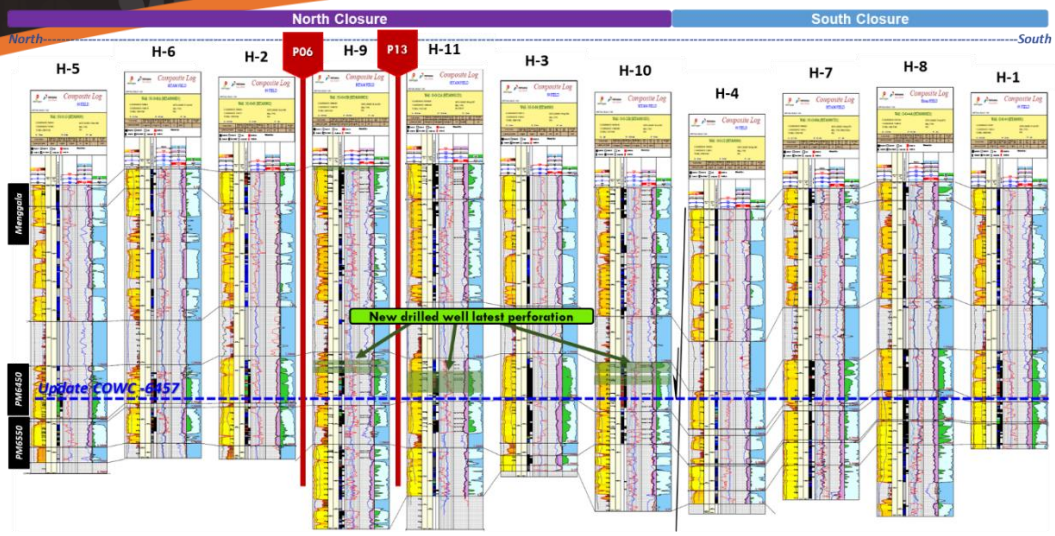

Figure 7. Current Oil Water Contact Interpretation of H Field

In addition of that, to reduce further geological uncertainty, a 3D-seismic package will be acquisitioned in 2023 and it will be used for further development infill wells.

5 Conclusions

H Field development project is considered a success, with better than expected results to achieve a new peak field production. The project team manage to tackle all surface and subsurface challenges with innovative approaches An evergreen process on post drill subsurface study significantly generated a new insights and understanding of reservoir characterization in H Field.

There are few lessons learned from development projects in H Field:

1. Maximizing the presence of seismic data, even though with only 2D-seismic data.
2. Drainage area in reservoir with has three-way dip closure and strong water drive mechanism will have distorted with “non-circle” drainage shape which mainly recovered the area near the aquifer which led to left undrained oil in area near the bounded fault
3. Utilization of Hydrocarbon Potential Evaluator (HPE) on formation evaluation, as a data clustering analysis, is needed to improve reservoir characterization and perforation interval selection during initial completion strategy, especially in LQR condition.
4. Understanding on current fluid contacts is essential to accurately determine initial completion strategy to avoid rapid water breakthrough during early production.
5. An effort to increase pipeline rating through massive pipeline integrity improvement program prior to drilling activity was successfully to increase allowable surface pressure

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