TOTAL'S Experiences in Tackling Mature Field Challenges in The Mahakam PSC*

Henricus Herwin[1], Bayu Giriansyah[2], and Irfan Taufik Rau[2]

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[1]TOTAL E&P Indonesie, Balikpapen, Indonesia (henricus.herwin@total.com)
[2]TOTAL E&P Indonesie, Balikpapen, Indonesia

Abstract

The core of challenges in mature field management is a tale of mismatch between two trends – increasing needs as a result of reservoir maturity and decreasing means due to degradation of asset integrity. Typical outcomes of this incongruity are declining production, weaker economics of new projects, more complex surface constraint, and decreasing reserves of new wells. Further complications may occur as consequence of external factors such as volatility of oil and gas price, new regulations, contractual conditions, and logistic constraints.

Mahakam Block has been in operation for over 40 years, and the aforementioned challenges are getting more evident as most of the fields become mature. The story of Mahakam began with the development of oil fields in 1974 when Bekapai was put into production, followed by Handil Field a year after. The shift from being oil producer to mainly gas producer occurred in 1990 when Tambora and Tunu fields were started-up. In 2007, the production of Sisi-Nubi gas fields which are located at more distal area of the Mahakam Delta commenced. Most of the fields are becoming mature except for South Mahakam fields (Stupa, Mandu, Jempang, and Mentulang) which were started-up in 2012. As of early 2017, Mahakam is still the biggest gas producing block in Indonesia and has produced nearly 19 trillion cubic feet of gas along with approximately 1.5 billion barrels of oil. The complexity of the operations can be portrayed through the vast number of drilled and producing wells of over 2,000 and 700 wells respectively. In consequence, maintaining the continuously maturing Mahakam assets requires tremendous efforts and investments.

This paper shares TOTAL's experiences in tackling mature field challenges in Mahakam on a field basis due to the uniqueness of every field. No single solution is available in the sense that each field requires distinctive strategies. Tunu main zone, for instance, succeeded to maintain its plateau through lowering network pressure, reducing costs by lighter well architecture, and lowering well spacing to re-access disconnected reservoirs and find smaller new reservoirs. Meanwhile, redevelopment has been undergone by Handil and Bekapai fields through implementation of pressure maintenance, new EOR screening, 3D seismic, and intensive drilling. Additionally, Bekapai Field has gone through

gas debottlenecking projects including construction of new gas pipeline that doubled the gas rate capacity to 100 MMscfd. These redevelopments managed to boost both the oil and gas recovery factors of Handil and Bekapai fields.

In the end, this paper is concluded by the elaboration of recommended best practices in prolonging the life of mature fields. Revamping mature assets through major risk assessment, data management to improve database, and optimization of the quality and quantity of personnel is crucial prior to envisaging innovative technologies as it is risky to implement innovative techniques on degraded installations. Moreover, being aware and prepared to anticipate external factors is important since those factors are getting more sensitive as the assets mature. Lastly, it is emphasized that distinctive evaluation and actions for each asset are the key to ensuring the continuation of Mahakam story.

Introduction to Mahakam

The Mahakam Delta is located in East Kalimantan, Indonesia, and acts as the seaward extension of the Kutei Basin which makes it also often referred as the Lower Kutei Basin. Past tectonic activities in the region resulted in the development of three main structural axes: Internal Axis, Median Axis, and External Axis. Shown in Figure 1, Tambora and Handil fields are located at the Internal Axis while the Median Axis includes Tunu, Bekapai and Peciko fields. Further from the shoreline, the External Axis consists of Sisi and Nubi fields.

In terms of stratigraphic zonation, Mahakam fields are typically comprised of main zone, which is the main interest and the most prolific part the field, and shallow zone. Some fields also possess upper, lower, and deep zones. The Internal Axis is characterized by main zone reservoirs below U9.5 with delta plain environment. The Median Axis has its main zone which is dominated by delta front mouth bars globally located between U9.5 and U6 while the External Axis shows main zone reservoirs in the interval of U6-U2.5.

Expanding the Search

The tale began when TOTAL E&P Indonesie was established in 1968 and became the party for oil and gas exploration and exploitation in Mahakam Contract Area together with JAPEX (currently known as INPEX Corporation). Over the last 40 years, the activity in the Mahakam area represents a dynamic balanced between on-going exploration, appraisal, and phased development. In the early 1970s, the exploration in Mahakam Area was focused on structural plays. 2D seismic acquisition was performed and it was followed with an aggressive exploration drilling campaign. Six wells were drilled and unfortunately, all wells were dry except for two wells with gas shows. The seventh and last well drilled in 1972 dramatically became the game changer since it resulted in the discovery of Bekapai Field, an oil field located near the Median Axis. After this first discovery, extensive exploration efforts were carried out through drilling exploration wells and seismic acquisitions. It resulted in the discovery of Jumelai, Handil, and Tambora fields which coincides with the start-up of Bekapai Field in 1974. When the oil production started to decline, a regional synthesis using sequence stratigraphy concept was chosen to redefine petroleum system, allowing identification of new targets linked to stratigraphic concepts within or near to the existing fields. As a result, Tunu Field, the biggest gas field in Indonesia was discovered in 1977 followed by the discovery of Peciko gas field 6 years later.

The shift from being oil producer to mainly gas producer that occurred in the late 1980s when Tambora and Tunu fields were started-up became inevitable as Mahakam oil production kept declining. The start-up of Peciko Field in 1999 also helped boost Mahakam gas production that reached its peak in 2005. As most of the fields were becoming mature, efforts to explore and exploit hydrocarbon from more distal areas of the Mahakam Delta became more crucial. In the 1990s, understanding the new trapping model particularly its hydrodynamic component was another key to discover other offshore fields mostly in South Mahakam (Stupa). In 2007, the production of Sisi-Nubi gas fields which are located at the external axis commenced, followed by South Mahakam fields (Stupa, Mandu, Jempang, and Metulang) which were started-up in 2012. Dedicated exploration efforts to date, portrayed through approximately 200 exploration and delineation wells and more than 20,000 km of 2D seismic as well as nearly 8,000 km^2 of 3D seismic, have been carried out (Figure 2). Additionally, the significant progress on seismic reprocessing and new 3D seismic acquisition in the late 2000s and highly supported by the technology improvement in drilling and completion, allowed to unlock the shallow gas zone potential, which supposed to be the drilling hazard to become a reliable axe of development. Proactive and systematic acquisition of subsurface data (pressure measurements, sampling, seismic data, and sedimentological observations) and continuous challenging of the petroleum model have been the key elements in Mahakam's journey to maintaining its deliverability despite the maturity of the fields. As of early 2017, Mahakam is still the biggest gas producing block in Indonesia and has produced nearly 19 trillion cubic feet of gas along with approximately 1.5 billion barrels of oil (Figure 3).

Beyond Main Zone

Development of a field typically commences from the most prolific zone where the most part of the initial hydrocarbon in place is located. In several cases, development starts from the zone that provides the most economical value despite having lower hydrocarbons in place. In other words, a field will be developed initially from the zone that acts as the main interest, hence the name main zone. However, as the field matures, and the main zone depletes, it is necessary to seek opportunities to unlock potentials from other zones such as shallow zone or deep zone. Tunu Field has become the benchmark for shallow zone development within the Mahakam PSC. Meanwhile, Handil has successfully proven that producing deeper zone dominated by dry gas could bring additional value on top of the conventional oil and gas cap system within the main zone.

Previously considered as geo-hazard, Tunu shallow development which was launched in 2009 successfully became a crucial part of Tunu and Mahakam production. Tunu shallow zone currently contributes to 45% of the overall Tunu Field production. The key of the development is the use of 3D seismic as the main factor to determine target reservoirs and well trajectory. The creation of a 3D full field potential gas geobody inventory provides a map of sweet spots that guide interpreters in identifying the targets by also integrating drilling and surface constraints. 160 seismic driven wells have been drilled to date with significant success ratio.

While Tunu Field shows the success of shallow zone development, Handil Field managed to prove the possibility of deep zone development. Initially the field was developed from the main zone which consists of oil reservoirs with initial gas cap. The gas production from deep zone, which is dominated by dry gas, was previously used mainly for gas lift as a support for the main zone oil production. When the main zone was depleted, Handil Field managed to maintain its deliverability through optimizing the production from its deep zone. The main challenge of producing the resources is the decrease in quality of reservoir properties due to compaction. Therefore, hydraulic fracturing was performed in some areas to improve the productivity of the reservoirs and to ultimately sustain the production of Handil Field.

Getting Mature

The core of challenges in mature field management is a tale of mismatch between two trends – increasing needs as a result of reservoir maturity and decreasing means due to degradation of asset integrity. Typical outcomes of this incongruity are declining production, weaker economics of new projects, more complex surface constraint, and decreasing reserves of new wells. Further complications may occur as consequence of external factors such as volatility of oil and gas price, new regulations, contractual conditions, and logistic constraints. Mahakam Block has been in operation for over 40 years, and the aforementioned challenges are getting more evident as most of the fields become mature. In consequence, maintaining the continuously maturing Mahakam assets requires tremendous efforts and investments. These efforts include three main aspects that have to be optimized: baseline, well intervention, and new wells or new projects.

Maintaining the production baseline is fundamental and necessary before performing additional actions to improve production. In the case of Handil Field, maintaining the baseline is done by implementation of gas lift, water injection, and gas injection. In addition to conventional gas lift system, retrievable gas lift (REGAL) system has been introduced to allow gas lift implementation on wells that are not initially designed for gas lift with low additional costs. In a reservoir scale, after it has undergone water injection for improving sweep and pressure maintenance, lean gas injection is performed to immiscibly displace the remaining oil within the reservoir. Typically, gas is injected at the crestal to sweep back the remaining oil downwards to the production well. This process is called Double Displacement Process (DDP) or Gravity Assisted Tertiary Gas Injection.

Well intervention jobs can be classified into two categories: routine and non-routine. The routine jobs comprise additional perforation and zone change for which detailed assets portfolio is a necessity. The portfolio needs to be updated in a regular basis and its evolution through time must be closely monitored. On the other hand, non-routine jobs include inaccessible reservoirs which are located below restriction inside wellbore and need to be unlocked prior to perforation (fishing, milling, or washing). Non-routine jobs also cover accessible reservoirs that cannot be directly perforated due to operational reasons. As the portfolio for routine jobs declines, the role of non-routine jobs now becomes more prominent. In consequence, the number of more difficult and costly well intervention jobs is expected to rise as the field matures.

Well intervention portfolio will gradually decrease when no drilling activity is present. Thus, drilling new wells is crucial to maintain the well intervention portfolio and ensure the sustainability of well intervention operations and the deliverability of the field. However, it has become more difficult to find economical wells as the expected resources will be declining as the field matures. Innovative actions are therefore necessary to overcome the challenge. Tunu Field, for instance, succeeded to maintain its production through reducing new well costs by lighter well architecture, and lowering well spacing in order to re-access disconnected reservoirs and find smaller new reservoirs. This well architecture optimization allows marginal wells that possess limited resources to be drilled and improve the recovery of the field (Figure 4).

Bekapai Phase 1 and 2 Re-Development which was initiated in 2008 becomes a perfect example for mature field gardening through new projects. After reaching its lowest point at 1,000 bopd in 2007, Bekapai managed to bounce back and reach its new peak of production at 14,500 bopd in 2016 through implementation of pressure maintenance, 3D seismic, intensive drilling, and surface along with production optimization. Specifically, Bekapai Field has gone through gas debottlenecking projects including construction of new 12” x 16 km gas pipeline from Bekapai offshore processing facility to onshore terminal through Peciko offshore network that doubled the gas rate capacity to 100 MMscfd.

Additionally, revamping mature assets through major risk assessment, data management to improve database, and optimization of the quality and quantity of personnel is crucial prior to envisaging innovative technologies as it is risky to implement innovative techniques on degraded installations. Moreover, being aware and prepared to anticipate external factors is important since those factors are getting more sensitive as the assets mature. Lastly, distinctive evaluation and actions for each asset are the key to ensuring the continuation of Mahakam story.

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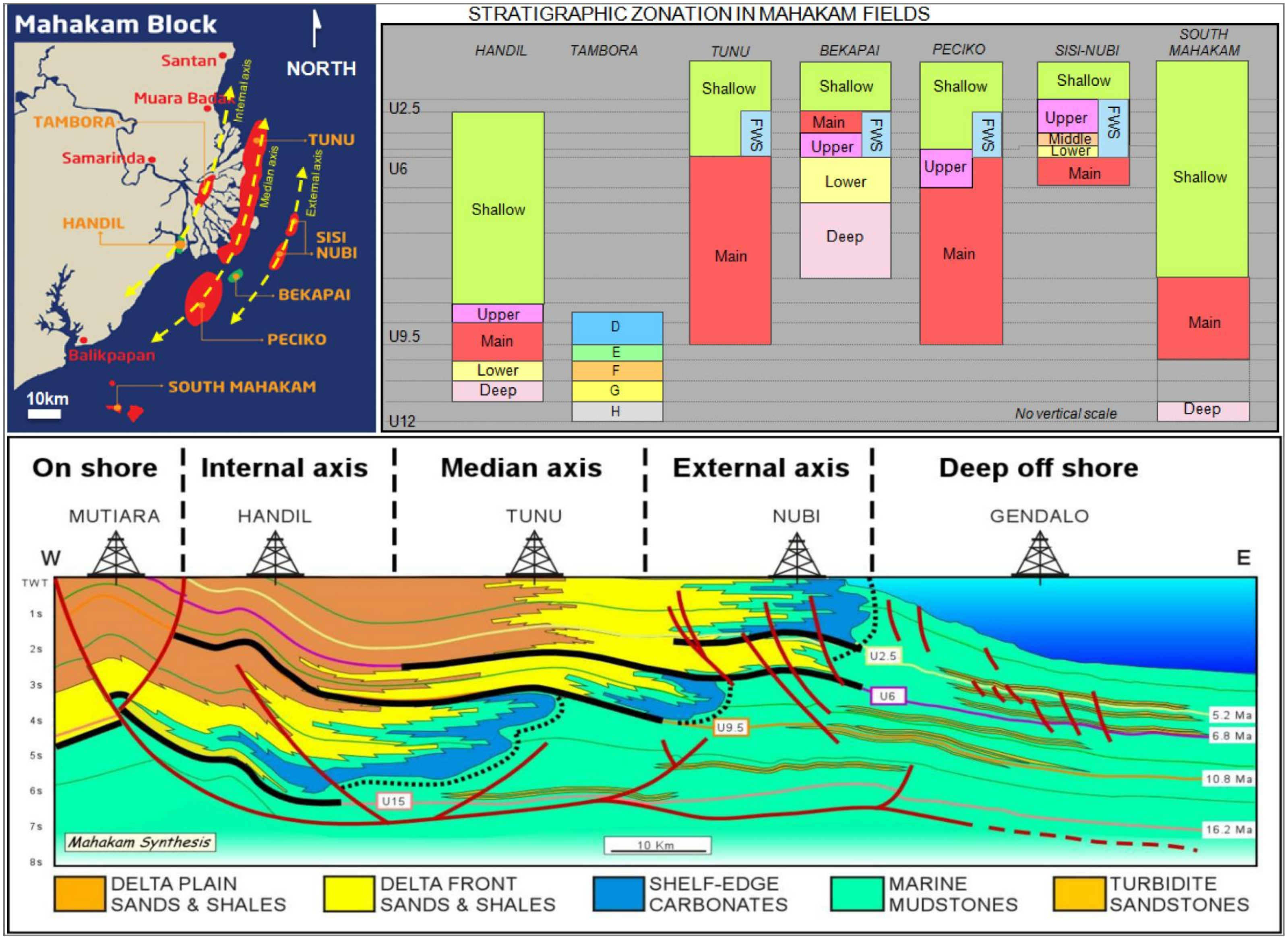

Figure 1. Mahakam Geological Framework.

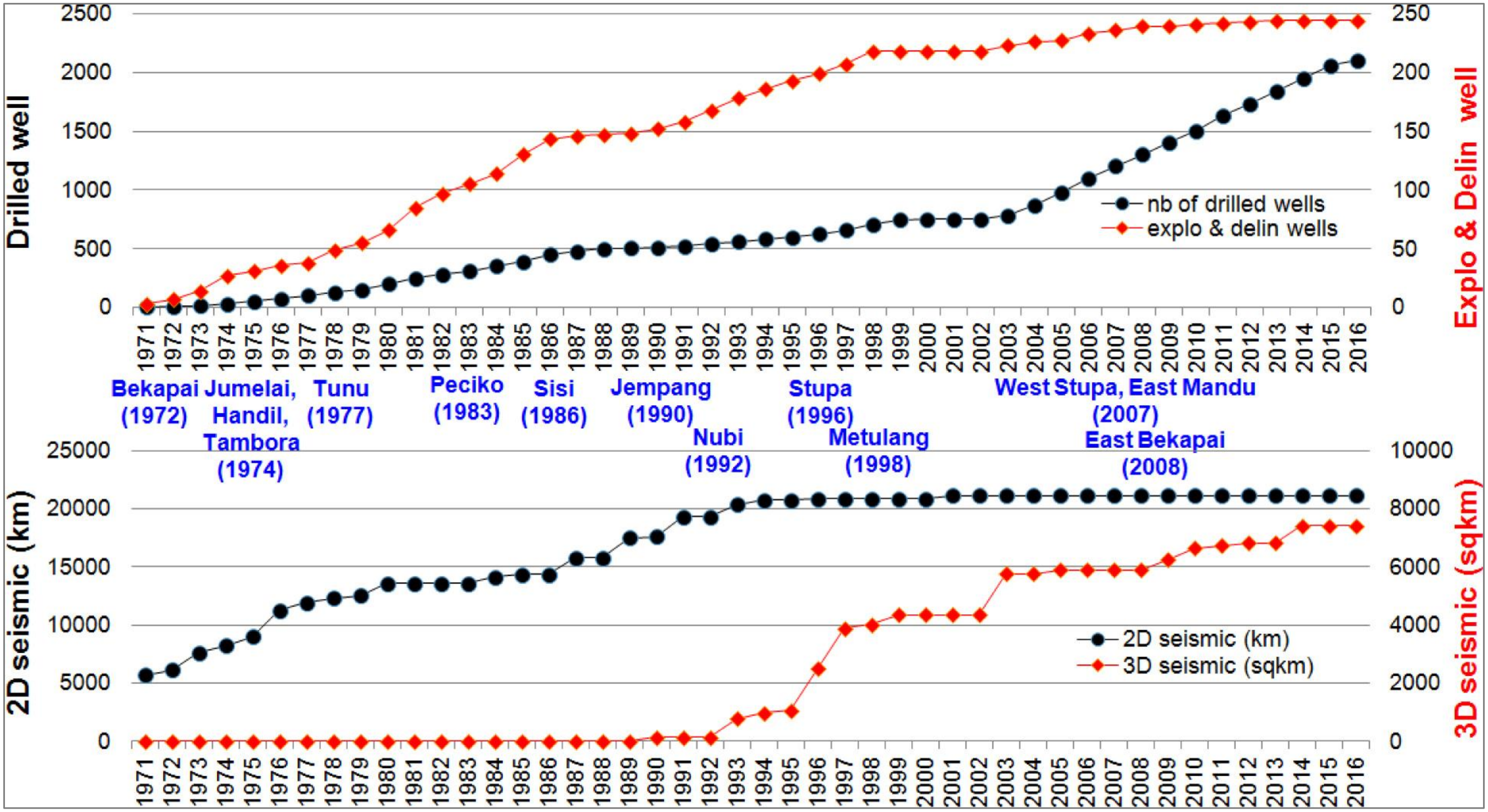

Figure 2. Exploration Drilling and Seismic Acquisitions vs Discoveries.

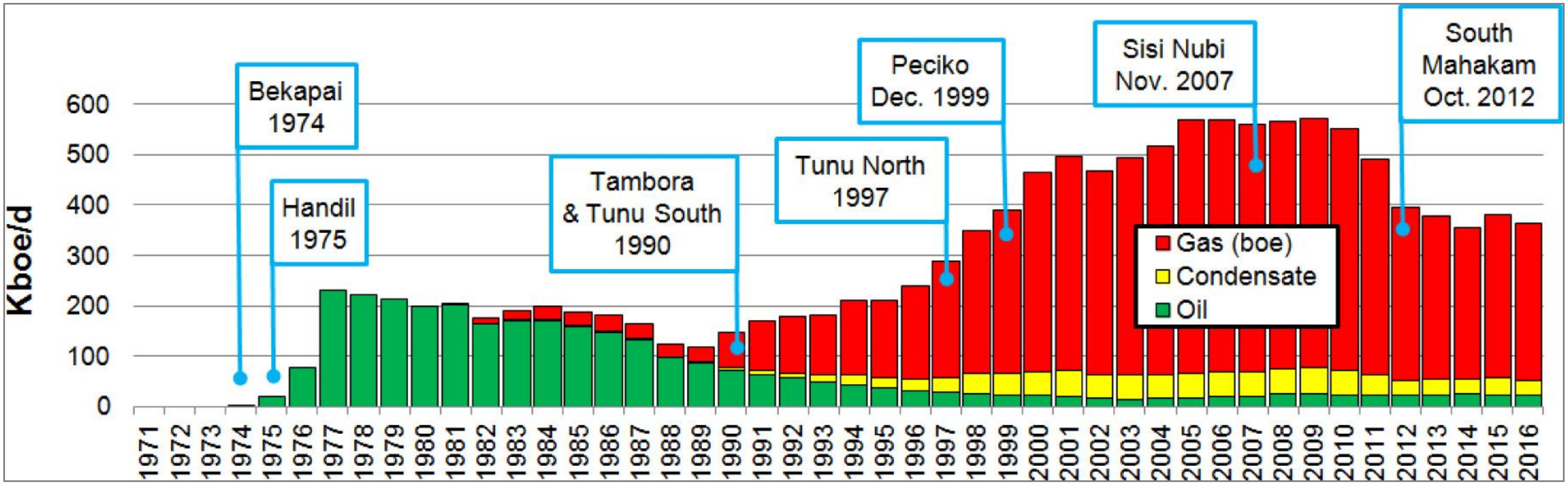

Figure 3. Mahakam Production through Time.

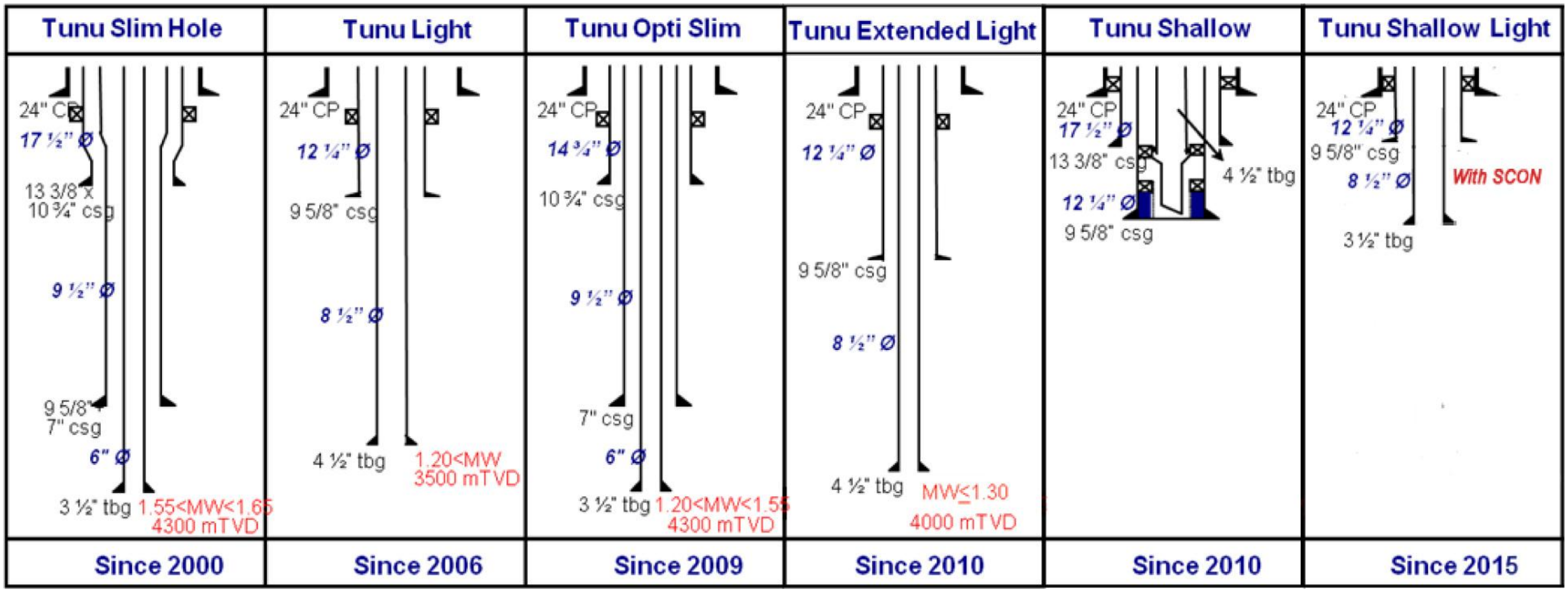

Figure 4. Continuous Well Architecture Optimization in Tunu Field.