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Data Analytics Applications in Oil and Gas Industry in Indonesia: Some Implementation in SKK Migas and Pertamina Hulu Rokan (PHR)

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Abstract. The application of data analytics becomes a growing trend in the Oil and Gas Industry. The implementation of digital transformation relying on Artificial Intelligence and Data Science such as Machine Learning, etc. is increasingly being found in various sectors in the upstream oil and gas industry and is even expected to contribute more portion in the future. In Indonesia, where upstream oil and gas industry still gives significant contribution to the country income, the growing trend of the data analytics drives the business process improvement by transforming the conventional approaches into new ways based on data sciences in order to raise effectiveness and efficiency.

As one of the strategic institutions, which is responsible for managing the upstream oil and gas industry in Indonesia, SKK Migas has succeeded in developing an Integrated Operation Center (IOC), which integrates monitoring systems of Production Sharing Contract (PSC) Operators data all over Indonesia. Not only carrying out the monitoring function, the IOC has also a role as collaborative support to encourage the development of digital transformation in SKK Migas and PSC Operators towards a center of operational excellence. In carrying out its mission, SKK Migas cooperates with all PSC operators in Indonesia to gradually modernize the automation technology, build integrated dashboards and systems as well as encourage the data analytics into real program implementation that can create value and improve business process.

This paper summarizes the digital innovation based on data analytics applications developed in the upstream oil and gas industry in Indonesia, which concentrates on a pilot project in SKK Migas and several application summaries of Pertamina Hulu Rokan (PHR). Derived from the IOC roadmap which places the data analytics as ultimate objective of the future development, an Oil Production & Lifting Data Analytics System which involves the data science as a prediction tool is built in order to realize the vision into reality. The system has successfully unified the puzzles of the lifting operational data which simplifies the evaluation and analysis into dashboards to speed up the decision making process. The next cases describe some data science applications developed by Pertamina Hulu Rokan (formerly Chevron Pacific Indonesia) starting from building Integrated Optimisation Decision Support Center (IODSC) as data science center of expertise. It consists of some applications involving data analytics like Integrated and Real-Time Prediction and Prevention Tool to Prevent Oil Congealing and Production Loss, that has been successfully reducing the congeal issue in Rokan block. Likewise with other application using Artificial Intelligence approach, it has been successfully developed to automate the classification of dynamometer card for rod pump failure identification. Another application that is no less advanced is the implementation of fuzzy logic to analyze ESP performance with limited surveillance data. It succeeds to detect ESP failure symptoms using limited surveillance data.

Keyword(s): data analytics, machine learning, artificial intelligence, etc.

1 Introduction

Oil and gas is a major source of energy in the entire world and still becoming the main backbone in redefining the global economy including in Indonesia. Since oil and gas production involves the use of high technology, there is always a need to develop new technology and strengthen operations to increase effectiveness and efficiency. Moreover, in the mature oil and gas fields like in Indonesia, the interaction of increasingly sophisticated computer technology is expected to be a key to provide added value for productivity and efficiency.

Since 2019, SKK Migas has launched upstream oil and gas transformation programs that carry a big vision to return the glory of oil production of 1 million barrels of oil per day and gas production of 12,000 MMSCFD. To make the dream come true, the improvements in various sectors must be carried out. The preparation of some program pillars to strengthen the mission toward the big vision must be established into a strategic planning which is then derived into action plans realistically. Furthermore, the transformation pillars underlying the process improvement are translated into programs like organizational and human resource management towards a center of excellence, simplification of permit process through a one-door-service policy, acceleration of commercial potential and last but not least digitalization programs.

In terms of the digitalization programs, SKK Migas has established Integrated Operation Center (IOC) which has succeeded in unifying the Production Sharing Contract (PSC) Operation monitoring systems and leading a collaborative support for the development of the digital industry in the upstream oil and gas sector [1]. The massive programs developed by the IOC, ranging from data collection and integration reflected into various visualization dashboards, are now available and towards leveling up through the application of data science. There are some targets to be addressed, including to transform the big data collection into information which can create more values instead of the visual data set with limited manual interpretation.

Implementation of data science in PSC operation is actually not really new. However, only few companies are actually implementing real-scale of data analytics and getting more values of it. Pertamina Hulu Rokan (abbr. PHR, formerly Chevron Pacific Indonesia) is the one that is successfully developing of data science by means of establishing Integrated Optimisation Decision Support Center (IODSC). Starting from only a few applications, now is available dozens of ones that have been successfully developed and even towards expansion to other affiliates of Pertamina's subsidiaries. The success of PHR is expected to be followed by other PSC companies, thus providing added value in optimizing the oil and gas production process in the context of the broadening application.

2 Data Analytics Architecture and IOC SKK Migas

2.1. Data Analytics Architecture

According to Gartner [2], there are some types of data analytics implementation which is commonly found in industry, as illustrated in the following Figure 1.

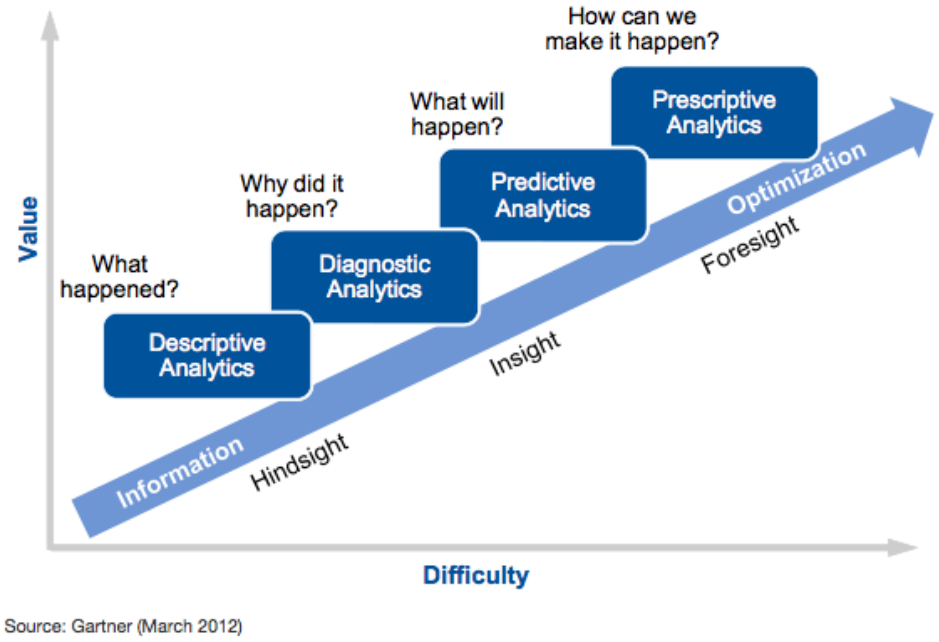

Figure 1. Four Types of Analytics [Gartner; March 2012]

They are divides into four types of the architecture of analytics, namely:

2.1.1 Descriptive Analytics

It is the traditional analytics to describes what happened in the company. It is often used to get an insight into the performance of the company or organization in the past. It is usually presented from various data source covering from raw data, and summarize the data into common and standard reports. They usually answer the standard questions about what happened? When did it happen? and Where did it happen?

2.1.2 Diagnostic Analytics

The second type of analytics is diagnostic analytics which focuses on diagnosing problems or occurrences in the data. The analyst will try to figure out why these are happening or looking for the answer of the root cause of the problem. By obtaining the information why things happen, it allows the company to adjust its operations to improve the situation.

2.1.3 Predictive Analytics

The third one is predictive analytics. This type deals with making predictions on what is going to happen based on historical data. Usually it involves some forecasting methods that will predict the next data that helps the planning team to analyse the data trend in the future for the certain purposes. It dedicates to finding what the best action to be taken for a given situation is. It is an optimization stage whereby we will look into how to do things better.

2.1.4 Prescriptive Analytics

The last one is the most valuable form of analytics namely prescriptive analytics. Prescription uses optimization and algorithms to advise "What should we do?"or How can we make it happen? This segment of analytics revolves around prescribing decisions and actions to the business. This is both the hardest and most valuable form of analytics.

Development of the data analytics in the upstream oil and gas industry in Indonesia is in principle following the above architecture. The majority is found in the level of the descriptive and diagnostics analytics. Only few companies have reached the predictive and prescriptive level, as the high one of analytics.

2.2. The SKK Migas IOC Toward Data Analytics

Development of the SKK Migas IOC is in general divided into two phases. The first phase focuses on system integration and process visualization that combine several types of data, namely real-time, daily, weekly, monthly and yearly data. In this stage, the dashboards are developed massively, starting from only 5 main dashboards available in the first year, and then expanded into 65 main dashboards along with thousands of derivative dashboards in the second year [1, 3].

Due to the generated data at the hugh level, there is a need to use data science approach to level up the analysis and manage the big data resulting from the integrated systems. Data Science is an umbrella that encompasses data analytics, using the approach of multiple disciplines – Mathematics, Statistics, Computer Science, Information Science. It includes concepts like data mining, data inference, predictive modeling, and machine learning algorithm, to extract patterns from complex datasets and transform them into actionable business strategies. On the other hand, the conclusion about the information they contain is drawn from the process of examining data sets involving the aid of specialized systems and software.

Some strategies are prepared to start a pilot project of data science in the IOC SKK Migas. Benchmarking and knowledge sharing, as seen Figure 2, were previously conducted by inviting the data science experts from PSC Operators, Universities and Professionals, to give enhancement over new ideas of such applications oriented to increased production, suppressing disruption and process businesses improvement.

The addressed process business is how to systemize the oil lifting management that utilizes the predictive analytics feature to forecast the oil production and use it then to estimate the available oil stock for lifting allocation. The system, as so called Sistem Informasi Analitik Produksi dan Lifting (abbr. SIAP LIFTING), is hence built to cope with the weakness of the previous method which is relying on non-system based individual approach.

Figure 2. IOC Knowledge Sharing (IOC Forum)

3 Data Analytics Application in the SKK Migas IOC

Machine Learning, as part of Artificial Intelligence (AI), is used to predict future values based on existing historical values. The development of the technology makes it possible to apply machine learning in almost all applications. Broadly speaking, the process is divided into two, namely the process of making a model from historical data using certain machine learning algorithms and the prediction process using a previously built model. The process can be seen in the Figure below.

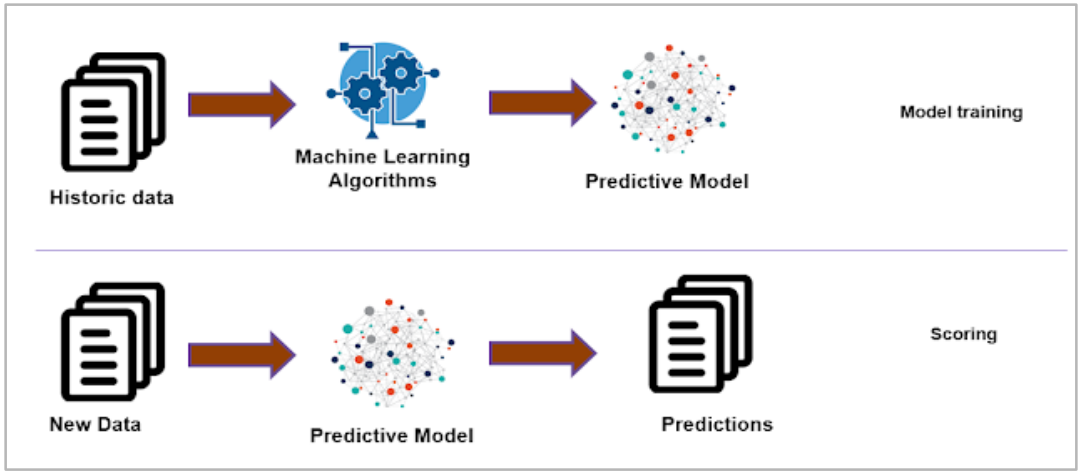

Figure 3. Machine Learning Mechanism

To solve real-world problems using machine learning, one must know whether the problems soluble using regression, classification, forecasting, or clustering approach. Based on the category, the appropriate algorithm is selected to generate the sufficient model. From various machine learning algorithms available, none is the best. Therefore, the selection of an algorithm or model must be based on the problem at hand and related to the best algorithm that can make predictions close to the true value. For each existing problem, some algorithms or models will be presented and provide for users to select the best one as desired.

In terms of the data analytics systems developed, there are two groups of problems that has to be solved, namely time series forecasting and regression (regression). Time series forecasting is the process of analyzing time series data using statistics and modeling to make predictions and inform decision making. In the prediction of the time series, it takes a data point at a consistent interval (e.g. day, week, month, etc.) over a certain time period rather than just recording data points intermittent or random. In other words, time is an important variable because it shows how the data adjusts during the data point and the final result. This provides additional sources of information and the order of dependence between data. This prediction requires an extensive data collection with representative sample sizes to improve prediction results. In addition, a lot of data history also ensures that every trend or pattern found is not an outlier and can explain seasonal variance.

The more historical data is used, it increases the probability that it contains useful information, which is advantageous. For daily data, time series can predict the value of a few days to the next few months even for the next few years. Some models that are used to predict oil and gas produc`1 tion in this context are ARIMA, SARIMA and PROPHET. These models are popular since 1990 and are most widely used today in Time Series Forecasting as well as other applications. The model algorithms are open source and are easily found in the Python programming library.

Regression analysis is a technical process that estimates the relationship between the dependent variable and the independent variable. The values of independent variables are usually considered "causing" or determining the values of the dependent variable. Some regression models that will be used to predict the increase or reduction of oil and gas production are Linear Regression and Polynomial regression.

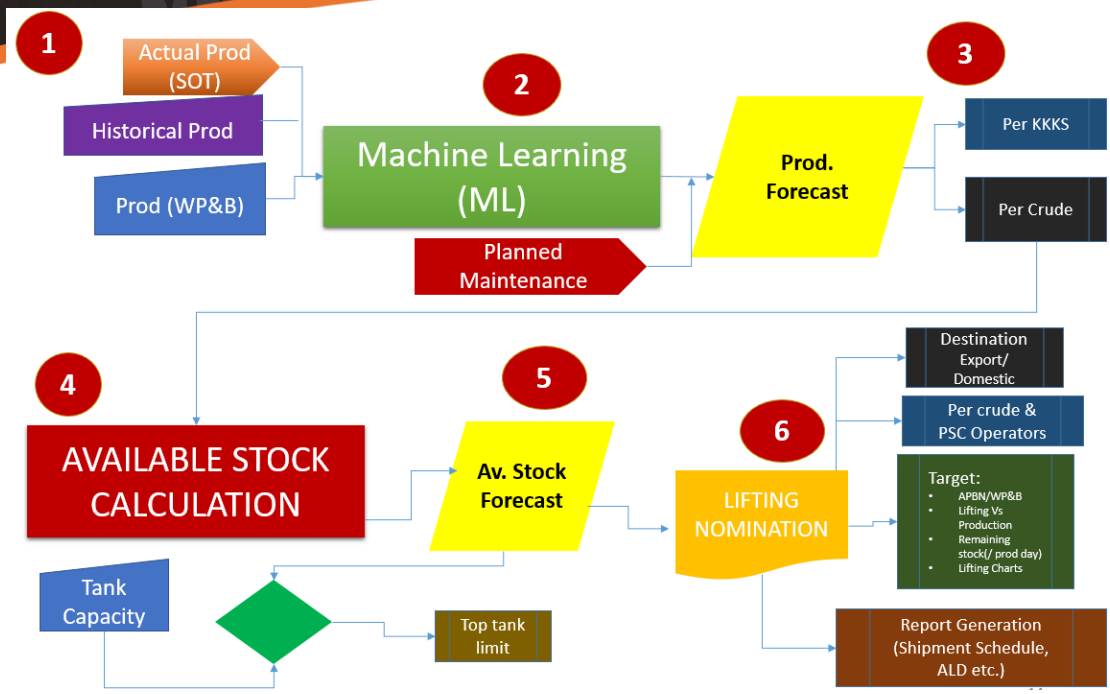

Figure 4. Simplified Data Flowchart of Oil Production & Lifting Data Analytics System

Figure 4 shows a simplified diagram of Oil Production and Lifting Data Analytics System, which uses Machine Learning as algorithm to predict production forecast based on actual production, historical production and production planning from Work Program & Budget (WP&B). The result from the production forecast is then used to estimate available oil stock and be compared to the tank capacity to determine the top tank limit. The oil stock must be then nominated before top tank occurs as well as considering oil lifting target monthly, quarterly and annually. As output of the system, some dashboards and statistical charts are available to presents the report generation, production and lifting outlook and associated targets. The use of machine learning replacing the human role of the previous manual method avoids subjectivity in terms of the production forecasting, thus providing the more consistent result.

Figure 5 shows some associated dashboards where the prediction data from machine learning is used to calculate the available stock. Users are given flexibility to select the best model based on the highly accurate production forecasting criterion, so that the prediction data used for the next calculation is closest to the actual one with a value of 96.9% accuracy. The calculated data is then derived into some statistical charts and the numbers visualizing the needed information, associated to the objective of the oil lifting targets for all and individual PSC operator. The historical charts like oil stocks, lifting and production are presented to enhance the analysis providing the decision maker the more comprehensive information in dealing the oil lifting nomination with PSC Operators. In addition to that, the remaining oil stocks distributed into the terminals in Indonesia are available as well, so that users can evaluate which terminal is still having the available to lift oils for being nominated to maximize the oil lifting target.

Figure 5. Oil Production & Lifting Data Analytics System Dashboards

4 Data Analytics Application in Pertamina Hulu Rokan

Some data analytics application in Pertamina Hulu Rokan are summarized—but not limited, as follows:

4.1. Sumatera Operation SMO Integrated Optimisation Decision Support Center IODSC Success in Embracing Digitalisation and Innovation to Deliver Business Results

This paper [4] describes the success story of Chevron Pacific Indonesia's (PT. CPI) Sumatera Operation (now Pertamina Hulu Rokan) to deliver improved business results through the implementation of an Integrated Optimization Decision Support Center (IODSC). By developing and implementing digital solutions ranging from the simple, such as Short Message Service (SMS) gateway to monitor rig status, through to the more advanced, such as Artificial Intelligence to identify failing equipment, the value creation was successfully achieved in terms of lost production opportunity (LPO) reduction, reduced expenses, improved energy efficiency and optimized hydrocarbon production. Key to this systematic adoption is IODSC's Integrated Exception Management (IEM) system, which supports CPI employees in their daily tasks by:

- Managing large amounts of data captured each day and using data science to change it to actionable information.
- Capturing exception criteria based on Subject Matter Experts (SME) knowledge that automatically identifies and prioritizes wells and equipment operating outside the desired condition (exception signals).
- Housing workflows to enable review, action and close-out of the exception signals.

As a result of this systematic implementation of improved workflows and digital solutions, within 2 years of commencement the IODSC exceeded it's 5 year value creation target.

4.2. New Integrated and Real-Time Prediction and Prevention Tool to Prevent Oil Congealing and Production Loss

The next paper [5] describes the hydrocarbon oil reservoirs aging and oil production declining problems, and due to continuous change of oil characteristics and deterioration of production flowlines and shipping pipelines, oil congealing is becoming an increasingly major challenge in maintaining continuous production for both light and heavy oil operations. Thousands of oil barrels are ever lost on daily basis across the oil industry due to oil congealing indicating that there is a significant gap in industry knowledge to understand the real root causes and how to address or mitigate them.

The idea to solve the problem relies on developing a comprehensive real-time and integrated prediction and prevention tool to help eliminate or minimize lost production due to oil congealing. The development included two stages: oil rheology and non- Newtonian modeling, and prediction algorithm and digital tool development. By this system, the congeal issue can be reduced significantly and loss production opportunity are sucessfully avoided.

4.3. Dynamometer Card Classification Using Case-Based Reasoning for Rod Pump Failure Identification

Described by [6], Sucker Rod Pumps (SRP) have been extensively utilized in the Duri field Heavy Oil Operations Unit (HOOU) for more than 6000 production wells. Approximately 2000 of these wells are equipped with dynamometer online that generates a daily dynamometer card (DC). Historically, the pump cards evaluation has led to the identification of several mechanical pump issues such as a traveling valve and standing valve leak that directly impact production.

One step of the traditional process to identification of rod pump failure is based on a manual pump card shape analysis performed for individual wells by different engineers throughout production history. To improve efficiency and reliability of shape analysis, Artificial Intelligence-based data analysis has been recently integrated by using a modified Case-Based Reasoning or computer reasoning by analogy approach where new problems are solved by comparison to analogous problems solved in the past.

4.4. Electrical Submersible Pump (ESP) Performance Analysis using Fuzzy Expert System with Limited Surveillance Data in X Field

As described in [7], X Field is a mature waterflood field with huge number of production wells (>1,000 wells). Currently, 100% of wells are producing with Electrical Submersible Pumps (ESPs) as the artificial lift method with wide range of production rate between 100 BFPD – 18,000 BFPD. A fast and robust tool is required to monitor those wells so that proactive action can be taken to restore production and prevent oil loss due to unexpected down time caused by ESP failure. This paper illustrates the application of Fuzzy

Logic (FL) approach to develop detection tool of ESP failure symptoms using limited surveillance data such as production rate, ampere, and working fluid level. Diagnosis is performed by processing trend of each parameter in several evaluation windows within set of expert rules. It allows production engineers to monitor ESP performance and recognize early signs of gradual failure before it becomes more severe over running time and focus can be prioritized for the most severe wells. This analysis is powerful in stable condition with long historical data in order to have clear trend. It is not intended to be used in unstable condition such as start up or sudden failure due to power outage. After 12 months tool implementation, it is successful to add more than 61 MBO to production from 28 proactive pump replacement jobs that has been proposed based on the tool detection.

Conclusion

Some case studies of data science applications from SKK Migas dan Pertamina Hulu Rokan are presented. The success stories are expected motivating other PSC operators to follow such development of data analytics, thus providing added value in optimizing the oil and gas production process and business processes in the context of the broadening application.

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