SIMPLE MULTI ATTRIBUTE RATING TECHNIQUE APPROACH TO DECIDE BEST ALTERNATIVE FOR LLP COMPRESSOR INSTALLATION PROJECT AT OFFSHORE PLATFORM

FINAL PROJECT

In partial fulfilment of the requirements
for the master's degree
from Institut Teknologi Bandung

By:
PRAYUDI NOVERRI
Student ID: 29120385

Master of Business Administration Program
School of Business and Management
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Koleksi digital milik UPT Perpustakaan ITB untuk keperluan pendidikan dan penelitian

Koleksi digital milik UPT Perpustakaan ITB untuk keperluan pendidikan dan penelitian

ABSTRACT

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By
PRAYUDI NOVERRI
Student ID: 29120385
(Master of Business Administration Program)

Date of Passing of Final Test (……….)
Date of Graduation Ceremony (……..)
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Final Project Counsellor: Meditya Wasesa, S.T., M.Sc., Ph.D.

Three of the Delta Mahakam Block's offshore gas fields are already at decline phase. LLP (low-low pressure) compressor project that has the objective of decreasing well operating pressure is proposed to maintain gas production levels. The project will be completed in three phases, beginning with the pilot project. The pilot project was completed in 2021, but the liquid rate was higher than expected. Higher liquid rates have delayed project completion and increased the cost of additional equipment. Root cause analysis with the Kepner-Tregoe method concludes that a higher liquid rate is due to inaccurate measurement. A new plan for the next phase must be decided in order to accommodate the most recent evaluation, which is based on the pilot project results.

The research is focused on defining the best course of action that will be implemented for the third phase of the LLP project. The third phase, which is planned for eight offshore platforms, is the primary focus of this research. Recent evaluation of the third phase indicates cost increases, revenue reductions, and project execution delays. A Simple Multi Attribute Rating Technique (SMART) approach is used to evaluate four alternatives for the third phase, namely: (1) cancel the LLP compressor installation on eight offshore platforms; (2) install the compressor on eight offshore platforms in the same time frame; (3) install the LLP compressor only on selected offshore platforms; and (4) install the LLP compressor on eight offshore platforms in sequence. Five attributes for alternative evaluation are profit, cost, production, and compliance with regulations. Attributes are defined with value-focused thinking and refer to key performance indicators (KPIs) for companies. Based on the SMART result, it is concluded that LLP compressor installation on four selected offshore platforms is the best choice.

Keywords: Decision Analysis, Kepner-Tregoe, SMART method, Value Focused Thinking, Mature Gas Field Development

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ABSTRAK

SIMPLE MULTI ATTRIBUTE RATING TECHNIQUE UNTUK MENENTUKAN ALTERNATIF TERBAIK PADA PROYEK KOMPRESSOR LLP DI ANJUNGAN LEPAS PANTAI

Oleh
PRAYUDI NOVERRI
Student ID: 29120385
(Program Studi Magister Administrasi Bisnis)

Tanggal Lulus Sidang (……….)
Tanggal Wisuda (……..)
Program Master of Business Administration,
Institut Teknologi Bandung, 2022
Pembimbing Tesis: Meditya Wasesa, S.T., M.Sc., Ph.D.

Tiga lapangan gas lepas pantai di blok delta mahakam sudah memasuki fase penurunan produksi. Proyek kompresor LLP (low low pressure) yang bertujuan untuk menurunkan tekanan operasi sumur diusulkan untuk mempertahankan tingkat produksi gas. Proyek ini akan diselesaikan dalam tiga tahap, dimulai dengan Pilot Project. Pilot Project berhasil diselesaikan pada 2021 akan tetapi memiliki liquid rate yang lebih tinggi dari ekspektasi. Liquid rate yang lebih tinggi menyebabkan keterlambatan hasil proyek dan peningkatan biaya untuk peralatan tambahan dari Pilot Project. Analisis akar penyebab dengan metode Kepner-Tregoe menyimpulkan bahwa liquid rate yang lebih tinggi terjadi karena pengukuran yang tidak akurat. Rencana baru untuk tahap berikutnya harus diputuskan untuk mengadaptasi evaluasi terbaru berdasarkan hasil Pilot Project

Penelitian ini difokuskan untuk menentukan tindakan terbaik yang akan diterapkan untuk proyek LLP fase ketiga. Fase ketiga, yang direncanakan untuk delapan anjungan lepas pantai, menjadi fokus utama penelitian ini. Evaluasi terakhir untuk fase ketiga menunjukkan kenaikan biaya, pengurangan pendapatan dan penundaan pelaksanaan proyek. Pendekatan Simple Multi Attribute Rating Technique (SMART) digunakan untuk mengevaluasi empat alternatif untuk tahap ketiga yaitu (1) Membatalkan pemasangan kompresor LLP ke delapan anjungan lepas pantai, (2) Memasang kompresor LLP ke delapan anjungan lepas pantai dalam jangka waktu yang sama, (3) Memasang Kompresor LLP hanya untuk anjungan lepas pantai tertentu, (4) Memasang kompresor LLP ke delapan anjungan lepas pantai secara bertahap. Lima atribut untuk evaluasi alternatif adalah keuntungan, biaya, produksi, dan kepatuhan terhadap peraturan. Atribut didefinisikan dengan Value-Focus Thinking yang mengacu pada key performance indicator (KPI) perusahaan. Berdasarkan hasil SMART, disimpulkan bahwa pemasangan kompresor LLP ke empat anjungan lepas pantai terpilih merupakan pilihan terbaik

Kata Kunci: Analisa Keputusan, Kepner-Tregoe, metode SMART, Value Focused Thinking, Pengembangan Lapangan Gas Tua

VALIDATION PAGE

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By:

PRAYUDI NOVERRI

Student ID: 29120385

Master of Business Administration Program

School of Business and Management

Institut Teknologi Bandung

Approved,

Bandung, 29 December 2022

Final Project Advisor

Meditya Wasesa, S.T., M.Sc., Ph.D.

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Name: Prayudi Noverri

Student ID: 29120385

Signed ______________________

Date : 06 Dec 2022

ACKNOWLEDGEMENT

All praise to Allah SWT and Prophet Muhammad SAW for giving me the blessing and knowledge to complete this final project, which is the last assignment for my study as a Master of Business Administration student at the Institute Technology of Bandung.

In this opportunity, the author would like to express his appreciation and thanks to those who have been supporting in completing the final project. They are:

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- All the parties which the writer could not mention one by one.

This final project still has much room for improvement, and I am humbly open to receiving any feedback. I hope this final project may bring a valuable source of knowledge for all the readers.

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LIST OF ABBREVIATIONS

ABBREVIATIONS	NAME
PHI	Pertamina Hulu Indonesia
PHM	Pertamina Hulu Mahakam
SDP	Subsurface and Development Planning
SKK MIGAS	Satuan Kerja Khusus Pelaksana Kegiatan Usaha Minyak dan Gas Bumi
PUDW	Pertamina Upstream Development Way
POD	Plan of Development
FID	Final Investment Decision
LLP	Low Low Pressure
LTP	Liquid Transfer Pump
MMSCFD	Million Standard Cubic Feet per Day
MMBTU	Million British Thermal Unit
BLPD	Barrel Liquid per Day
BCF	Billion Cubic Feet
BOPD	Barrel Oil per Day
KBOE	Kilo Barrel Oil Equivalent
NCF	Net Cash Flow
NPV	Net Present Value
PSC	Production Sharing Contract
KPI	Key Performance Indicator

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Chapter I – Introduction

1.1. Background

Natural gas is a gaseous hydrocarbon that is colorless and highly flammable. It is frequently associated with crude oil, which is primarily composed of methane and ethane. As a fossil fuel, natural gas is used for electricity generation, heating, cooking, and as a fuel for certain vehicles. It is also important as a raw material in the manufacture of plastics and a wide array of other chemical products, including fertilizers and dyes.

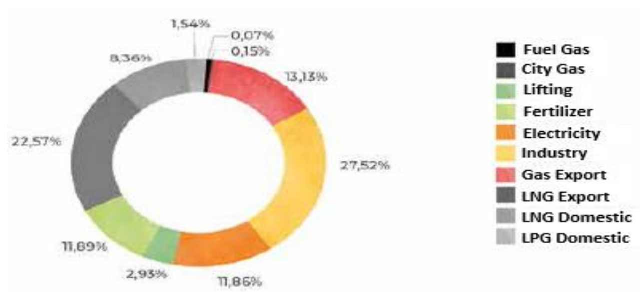
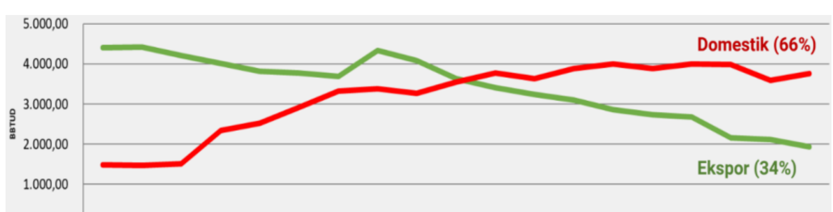


Figure 1 Natural Gas Usage in Indonesia (Source SKK Migas Annual Report 2021)

Since 2002, natural gas production in Indonesia has already exceeded oil production. In terms of decline rate, natural gas has a less severe decline (3–5% decline per year) compared to oil (10–12% decline per year). High natural gas production is aligned with a positive trend that also tends to increase for domestic needs, based on the SKK Migas Annual Report 2021. while the trend for natural gas exports is decreasing. Higher prioritization for domestic needs is done by the Indonesian government to support the growth of national industry and improve economic growth in developed areas while still considering revenue optimization for Indonesia. Natural gas is primarily allocated to the industrial sector, followed by electricity generation and fertilizer.



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Prognosa 2021
Ekspor	4.397,0	4.416,0	4.202,0	4.008,0	3.820,0	3.775,0	3.681,0	4.336,0	4.078,0	3.631,0	3.402,3	3.237,2	3.090,3	2.859,8	2.736,3	2.668,9	2.155,3	2.108,2	1.931,3
Domestik	1.480,0	1.466,0	1.513,0	2.341,0	2.527,0	2.913,0	3.323,0	3.379,0	3.267,0	3.550,0	3.774,0	3.631,7	3.881,6	3.996,8	3.880,4	3.994,6	3.984,7	3.592,8	3.752,7

Figure 2 Indonesia Natural Gas Allocation (Source SKK Migas Annual Report 2021)

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As previously stated, natural gas production in Indonesia has decreased by approximately 3-5% per year. The decline figure is based on the aggregated production drop from all domestic natural gas fields, but the rate of decline can vary significantly, particularly for brown fields (which have been producing for more than ten years). Active action and strategies have to be taken to improve natural gas production and also to support the Indonesian government's target to reach 1 million BOPD and 12 billion SCFD by 2030. There are four main strategies that are formulated by the Ministry of Energy and Mineral Resources to achieve the target. First, maintain current production levels through optimization of production in existing fields. Second, speed up the transformation of contingent resources into production. Third, accelerate the implementation of enhanced oil recovery, both secondary and tertiary. Fourth, improve and accelerate massive exploration activity.

PT Pertamina, as the biggest national energy company in Indonesia, is the main company responsible for fulfilling oil and natural gas demand in the country. Under subholding upstream, optimization efforts are made to maintain production from existing fields and increase exploration to get additional production. Most of the oil and gas fields that are handled are already at a very mature stage, which will be very challenging. There are a lot of issues to be tackled, such as depleted reservoir pressure, high water production, and aging facility equipment.

This writing discusses the installation of LLP (low-low pressure) compressors at gas offshore fields in one of PT PERTAMINA's subsidiaries. Installation will create a lower pressure at the wellhead that will prolong the production of gas wells, which is declining due to low reservoir pressure and water production. However, several issues arose from the pilot projects, resulting in project delays and decreased profitability. Therefore, an analysis of the scenarios needs to be built and addressed to ensure the project can be executed successfully and would provide additional gas production to fulfill Indonesia's gas demand.

1.2. Company Profile

1.2.1. PT. PERTAMINA HULU INDONESIA General Profile

PT PERTAMINA HULU INDONESIA (PHI) is a subsidiary company of PT PERTAMINA (PERSERO), whose main business is in the upstream oil and gas sector, based on the Deed of

Establishment of a Limited Liability Company No. 39 dated September 28, 2015, which was approved by the Minister of Law and Human Rights on December 28, 2015. PHI is established as a holding company to control, manage assets, and upstream business activity of Pertamina at the domestic level for the exterminated operational field that is located on Kalimantan Island. PHI manages five subsidiaries, namely PT Pertamina Hulu Mahakam (PHM), PT Pertamina Hulu Attaka (PHA), PT Pertamina Hulu Sanga Sanga (PHSS), PT Pertamina Hulu Kalimantan Timur (PHKT), and PT Pertamina Hulu West Ganal (PHWG).

Nama Entitas Anak *Subsidiary Name*	**Lokasi dan Wilayah Operasi** *Location and Operational Area*	**Persentase Kepemilikan Saham oleh PHI** *PHI Share Ownership Percentage*	**Tahun Berdiri** *Year of Establishment*	**Status Operasi** *Status of Operations*
PT Pertamina Hulu Mahakam	Kalimantan Timur *East Kalimantan*	99,93%	2015	Operator *Operator*
PT Pertamina Hulu Attaka	Kalimantan Timur *East Kalimantan*	99,00%	2017	Tidak Mengelola Wilayah Kerja *Not Managing Any Working Area*
PT Pertamina Hulu Sanga Sanga	Kalimantan Timur *East Kalimantan*	99,00%	2017	Operator *Operator*
PT Pertamina Hulu Kalimantan Timur	Kalimantan Timur *East Kalimantan*	99,00%	2018	Operator *Operator*
PT Pertamina Hulu West Ganal	Kalimantan Timur *East Kalimantan*	99,00%	2019	Bukan Operator *Non-Operator*

Figure 3 Pertamina Hulu Indonesia Working Area (Source PHI Annual Report 2021)

PHI's business activities include exploration and development, exploitation drilling and well intervention, production, as well as lifting and commercial. There are two business products: oil and gas. There are six types (grades) of oil (including condensate), namely the Handil Mix Crude (HMC), Senipah Condensate (SCD), Bekapai Crude Oil (BCO), Attaka Crude Oil (ACO), Sepinggan Yakin Mix (SYM), and Bontang Return Condensate (BRC), that are distributed to support domestic needs and ensure energy security improvement. Gas products are marketed to all customers through sales portfolios and comprise domestic pipeline gas and liquefied natural gas (LNG).

Re-Organization Impact to PT PERTAMINA HULU INDONESIA

In the last quarter of 2021, there was a restructuring and reorganization at PT Pertamina. Holding-Sub Holding was established, and the organization changed in its mission to gain

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more effectiveness in operation and produce more oil and natural gas for the country. All upstream business is handled by Sub Holding Upstream, which goes by the name of PT. Pertamina Hulu Energy (PHE). There are five subsidiaries under Sub Holding Upstream which categorized based on the area

- Region 1, operated by Pertamina Hulu Rokan (PHR), has its operating area on Sumatra Island. The region is divided into 4 zones: Zone 1 (11 fields from Aceh to Jambi), Zone 2 and Zone 3 (Rokan Field, an ex-terminated field from CPI), and Zone 4 (eight fields that are located in South Sumatera).
- Region 2 is known as "Pertamina EP," and it covers Western to Central Java Island as well as the entire offshore area surrounding Java Island. the region into 3 zones: Zone 5 (PHE ONWJ block), Zone 6 (PHE WMO block), and Zone 7 (Pertamina EP Asset 3 block).
- Region 3 is operated under the name Pertamina Hulu Indonesia (PHI), and the operating area is on Kalimantan Island. The region is divided into 3 zones: Zone 8 (Pertamina Hulu Mahakam), Zone 9 (Pertamina Hulu Kalimantan Timur), and Zone 10 (Pertamina Hulu Sanga-Sanga).
- Region 4 operated under the name Pertamina EP Cepu (PEPC), with the operating area on Central and Eastern Java (onshore), Sulawesi Island, and Papua. Zones 11 to 13, which were previously operated by Pertamina EP Asset 4, Pertamina EP Asset 5, and Pertamina EP Cepu, are now divided into three zones.
- Region 5 operated in the overseas area beyond the border of the Indonesian Republic under the name Pertamina International EP (PIEP). The region is divided into 3 zones: Zone 15 (Algeria), Zone 16 (Iraq), and Zone 17 (Malaysia).

Following the implementation of subholding, the PHI shareholder is altered. The update is regulated in the Deed of Shareholders Resolution of PHI No. 7 (Jun 2021) for the delegation of authority from PT. PERTAMINA (PERSERO) to PT PERTAMINA HULU ENERGI and the Deed of Shareholders Resolution No. 2 (Sept 2021) for shares transferred that are owned by PT PERTAMINA (PERSERO) to PT PERTAMINA HULU ENERGI. Through those deeds, PT Pertamina Hulu Indonesia is legally a subsidiary of PT Pertamina Hulu Energy.

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The working area of Pertamina Hulu Indonesia also altered after reorganization, as 11 additional fields were added to the PT Pertamina Hulu Indonesia portfolio.

Figure 4 PHI Working Area After Re-Organization (Source PHI Annual Report 2021)

1.2.2. PT. PERTAMINA HULU MAHAKAM (PHM) General Profile

PT Pertamina Hulu Mahakam is a subsidiary of PT Pertamina Hulu Indonesia. PHM was established based on the Deed of Establishment of a Limited Liability Company No. 40, dated December 15, 2015. PHM officially took over operation and management of the Mahakam Block from Total E&P Indonesia, the previous operator, on January 1, 2018, for a 20-year contract period.

The Mahakam Working Area spans 3,266.44 square kilometers in East Kalimantan Province, from the swamp of the Mahakam river delta (swamp) to the waters of the Makassar Strait (offshore). PHM manages seven oil and gas fields, namely: Bekapai, Handil, Tunu, Tambora, Peciko, Sisi Nubi, and South Mahakam. Most of these fields have been in production for more than 40 years; therefore, they have issues with old production facilities and production decline. Aging production facilities need to be carefully maintained to ensure production continuity. The field is also experiencing a natural decline at a rate of 50% per year.

Various efforts are needed to tackle those issues so that the economic level is maintained without compromising the safety aspect. To tackle the operational challenge and support the production sustainability of the Delta Mahakam Block, PHM is implementing these three strategies: (1) baseline management—optimization of existing well production; (2) integrated development management—increase reserves from existing fields; and (3) stepping out—searching for additional resources through subsurface study and exploration in the Delta Mahakam Block area.

Regarding to PT. PERTAMINA re-organization become holding and sub-holding, there is no impact to PT PERTAMINA HULU MAHAKAM positioned as still remains under PT PERTAMINA HULU INDONESIA.

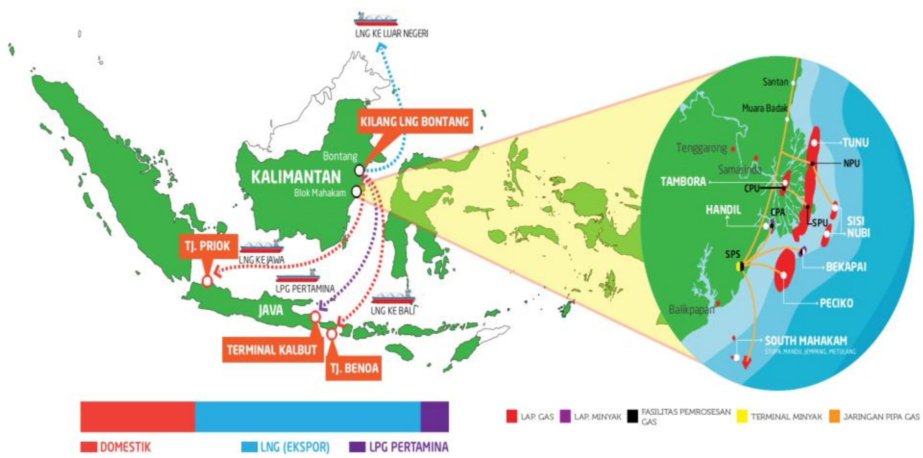

Figure 5 Pertamina Hulu Mahakam Working Area (Source PHM Internal Document)

1.2.3. PT. PERTAMINA HULU MAHAKAM (PHM) Vision and Mission

PT Pertamina Hulu Indonesia (PHI) and PT Pertamina Hulu Mahakam (PHM), as part of the Pertamina Sub-Holding Upstream, have the vision "to become a world-class oil and gas company." The definition of a world-class oil and gas company is to be able to compete with other global companies and to perform company activity by applying national and international standards.

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To reach the vision, PT Pertamina Hulu Indonesia (PHI) and PT Pertamina Hulu Mahakam (PHM) have defined their missions. "To Manage Oil and Gas Operation Activity by Focusing on Added Value Creation for Stakeholders Through the Paradigm of a World-Class Company That Consists of Innovation in Technology, Strong Fundamentals in Business, and Excellence in Operation."

- Innovation in Technology means promoting strong innovation culture.
- Strong Business Fundamental means prioritizing synergy between each function
- Operational excellence means putting a lot of thought into HSSE (Health, Safety, Security, and Environment), running operations in a way that is reliable and sustainable, and being socially responsible.

1.2.4. PT. PERTAMINA HULU MAHAKAM (PHM) Organization Chart

There are 5 gas fields and 2 oil fields in the Delta Mahakam Block that have to be managed by PT. Pertamina Hulu Mahakam Several functions and divisions were in charge of those fields to ensure oil and gas production activities could be performed in a good manner. The main focus of this research is on three gas fields that are located offshore, namely Peciko, Sisi Nubi, and South Mahakam. Because these fields have been producing for over 20 years, they already have low reservoir pressure and increased water production. As a result, many wells are no longer producing natural gas and are being shut down. Based on the three strategies that have been mentioned before, action is needed to improve the recovery factor of field reserves by reviving shut-in wells.

LLP (low-low pressure) compressor is installed on an offshore platform following a technical review based on field behaviors and technology reliability. To carry out this project, each function's cross-function must be synergized as part of the implementation of strong business fundamentals. The organization chart that will be in charge of the offshore platform's LLP's compressor can be seen in the diagram below:

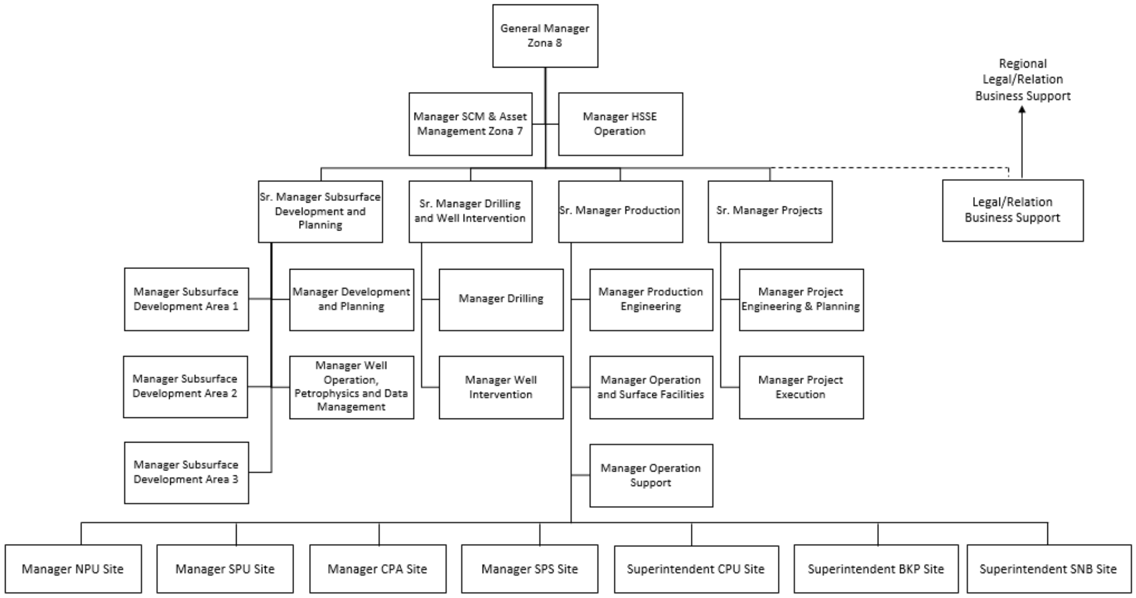

Figure 6 Pertamina Hulu Mahakam Organization Chart (Source PHM Internal Document)

The general manager has the most authority in Zone 8. There are four main functions related to operation activity under the general manager and two support functions that are required to assist the main function task. The main functions comprise subsurface development and planning (SDP), drilling and well intervention (DWI), production operation (PO), and project management (PRJ). A senior manager is appointed for each main function. Support functions consist of Supply Chain and Asset Management (SCM) and Health, Safety, Security, and Environment (HSSE) that are led by the manager. Business support such as legal, human capital, etc. is handled directly by PT Pertamina Hulu Indonesia (PHI). To ease coordination and communication, several workers for business support from PHI are appointed and located in PHM.

The evaluation of a new project, like putting a low-low pressure compressor on an offshore platform, starts with subsurface development and planning. The final decision is made by a senior manager. Under the senior manager, the team was divided into five small teams: subsurface development area 1 (swamp gas fields), subsurface development area 2 (offshore gas fields), subsurface development area 3 (oil fields), the well operation, petrophysics, and data management teams, and development and planning. As projects will be implemented for offshore gas fields, Subsurface Development Area 2 is responsible for

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evaluating the subsurface potential and generating production forecasts. Development and planning are in charge of a project's economic evaluation. Based on this evaluation, the subsurface and planning teams will provide targeted offshore platforms that will have additional reserves after the project.

The subsurface and planning teams need some assistance and advice to check project feasibility from the surface facility team (under the Senior Manager of Projects). The project engineering team will provide an evaluation related to surface equipment and layout for an additional compressor at existing facilities, including cost predictions and a project timeline. Discussion is also performed with the well intervention team (under the senior manager of drilling and well intervention). The well-prepared intervention team will provide the intervention program and costs required to prepare well in advance of the project. As no additional well is to be drilled in this project, the drilling team is not involved.

Project realization will be done by the Project Execution Team (under Senior Manager Project). After the project is completed, it will be handed over to and managed by several teams overseen by the senior manager for production, including the operation and surface facilities team, the SPS site team in charge of Peciko and South Mahakam Field, and the SNB site team in charge of Sisi Nubi Field. Support from the other team is also needed during project execution and operation after the project from the SCM (Supply Chain Management) team, the HSSE (Health, Safety, Security, and Environment) team, and the Business Support and Legal team.

1.3. Business Issue

Strategies to fight field production decline

Mahakam Block has already been producing for 40 years, and based on the oil and gas field production phase (Figure 7), it is already in the production decline phase. Several actions must be taken during the decline phase to keep the field operating as long as possible until it reaches an abandonment rate where the profit from gas or oil production already equals

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operating expenses. It will be a challenging task for PT Pertamina Hulu Mahakam, which has been given a mandate by the Special Task Force for Upstream Oil and Gas Business Activities (SKK MIGAS) to manage the Mahakam Block for 20 years, from 2017 to 2037.

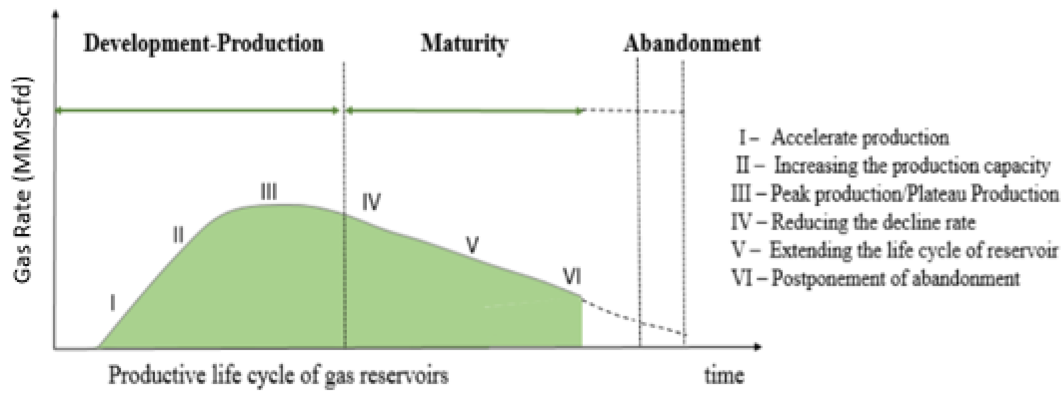

Figure 7 Gas Field Production Life Cycle (Lupu, D, 2019)

To ensure production sustainability, three main strategies that have been formulated as follow:

1. Baseline Management

   This strategy is performed at existing wells with the objective of keeping the wells producing as much as possible. Activities related to baseline management in the context of subsurface and surface equipment can be seen in the table below:

Table 1 Activities in Subsurface for Baseline Management

Activities	Detail Definition	Cost	Activity Type
Work Over Well	Open remaining hydrocarbon reservoir by perforated using explosive. New open reservoir can be produced together with old reservoir. Old reservoir to be isolated if no more oil and gas production.	Low to Medium	Routine Operation
Well Stimulation	Production rate of open reservoir can be drop due unwanted and damaging material from reservoir during production. Stimulation is performed to put back production to previous condition. It is	Medium to High	Routine Operation

	performed by chemical injection such as acid, solvent or polymer to reservoir		
Well Repair & Service	Repair mechanical problem of wells such tubing leak, tubing parted and downhole equipment failure. During mechanical problem, hydrocarbon production from well is not allowed due to safety concern	Low	Routine Operation

Table 2 Activities in Surface for Baseline Management

Activities	Detail Definition	Cost	Activity Type
Lowering Operating Pressure	Surface operation pressure is governed by surface facility equipment such as pump (oil production) or compressor (gas production). Reservoir pressure will be continually decline along the production. To sustain production, operation pressure also need to be lowered. New pump or compressor that have lower suction pressure is needed for this activity	High	Project Operation
Debottlenecking	Hydrocarbon production from well can be limited due to surface equipment facility capacity. Action that can be performed to increase surface facility capacity such as install bigger flow line, change choke size, install bigger separator, etc.	Low to High	Routine and Project Operation (depend on job scope)

2. Integrated Development Management – increase reserves from existing field

   Incremental reserves are achieved by drilling new wells in areas that have not yet been drilled by existing wells. Mahakam blocks have a unique geological setting. Its reservoir bodies are small and have limited connectivity, limiting the amount of hydrocarbon that can be transported by well. As a result, a large number of wells must be drilled in order

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to maintain Delta Mahakam Block oil and gas production. The drilling strategy used by Mahakam is depicted below, and it demonstrates how many wells are required to penetrate the bodies of many reservoirs. This strategy is called infill well drilling.

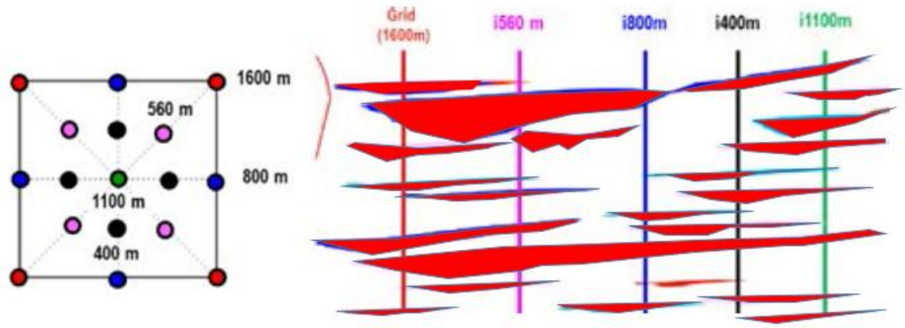

Figure 8 Infill Well in Delta Mahakam Block (Source PHM Internal Document)

3. Stepping Out – looking for additional resources by subsurface study and exploration at vicinity area of Delta Mahakam Block.

   Due to extensive infill well application across Mahakam Block, amount of reservoir body become limited. Therefore, action to find new reservoir body have to be performed by looking potential at step-out or vicinity area of Delta Mahakam Block

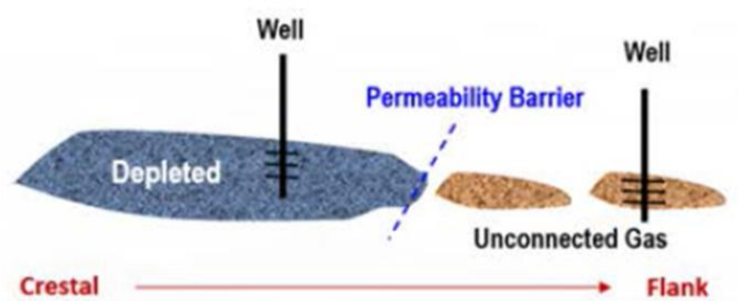

Figure 9 Exploration Well in Delta Mahakam Block (Source PHM Internal Document)

Both second and third strategies need subsurface study that is performed by subsurface and development planning. Result of study is performed in term of new well proposal that will be drilled by drilling. Short explanation about drilling activities is as follow:

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Table 3 Activities for Infill and Step Out/Exploration Wells

Activities	Detail Definition	Cost	Activity Type
Drilling	Drilling activities is the process of creating new well bore in purpose to access reservoir body. More production oil or gas is expected in case drilling target is to reservoir volume that have not been connected by existing well, step-out reservoir and exploration area.	High	Project Operation

From the previous explanation, project operation requires high cost; therefore, it needs several steps of review before being executed. Project review is performed externally by Special Task Force for Upstream Oil and Gas Business Activities (SKK MIGAS) and internally by Pertamina Upstream Subholding. Pertamina has its own decision gate process for project proposals called PUDW (Pertamina Upstream Development Way), as shown in the figure below.

Figure 10 Decision Gate for Project Proposal (Source PERTAMINA Internal Document)

LLP Compressor Project

The focus of this research is related to baseline management strategies for three gas offshore platforms, namely Peciko, Sisi Nubi, and South Mahakam, that are already in the production decline phase. Based on recent production data, 40% of wells in Peciko, Sisi Nubi, and South Mahakam are in no flow condition due to decreasing reservoir pressure and increasing water production. An illustration of the problem can be seen below.

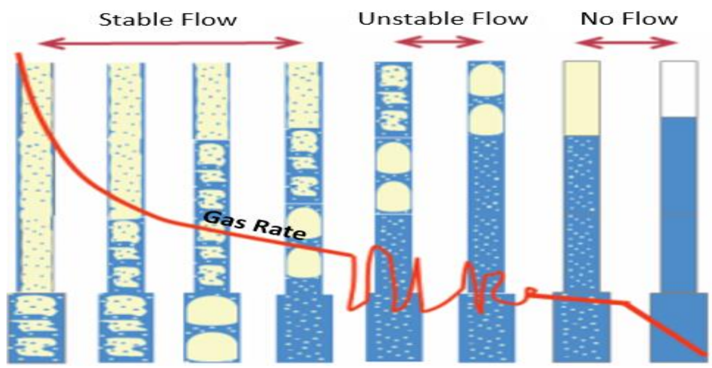

Figure 11 Gas Well Production Behavior (Sankar, S., & Karthi, S. A. (2019))

It is a common problem at gas fields that have produced for a long time. Actions need to be performed to optimize production from existing wells. There are generally known techniques to prolong the production of gas wells, such as surfactant injection, velocity string installation, operation pressure reduction with a compressor, gas lift injection, and electrical submersible pump installation. Installation of a new system to prolong the production of an existing well is categorized as a project operation and requires high costs. Therefore, best option and project proposal have to be performed by followed PUDW process:

1. Initiation – Project Concept Proposal

   Joint study is performed within subsurface team, project team and production team to choose the best technique for prolong gas production from existing wells. All option is reviewed based on surface facility readiness, operation complexity and compatibility with reservoir behavior. At this phase, it is concluded that lowering operation pressure is the best option. Impact of lower operating pressure can be described by figure below

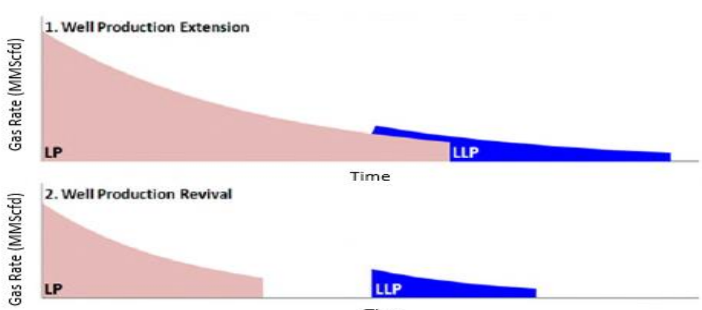

Figure 12 Expected Result from Lower Operating Pressure (Source PHM Internal Document)

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2. Selection and Further Study – Project Definition

Lowering operation pressure can be achieved by installing new compressor and related equipment such as separator, liquid transfer pump, and flow line. Further assessment is performed in this phase related to subsurface and surface aspect. Subsurface aspect is reviewed by Subsurface Development and Planning team. Aspect that are reviewed such as platform target, estimated additional reserves and production figure. Surface aspect is reviewed by project team such as compressor type, compressor suction pressure, compressor location, supporting equipment design. In this phase is concluded LLP (low-low pressure) compressor type will be installed at several offshore platforms.

As a new action that have not been done before, directly install several well head compressors to many offshore platforms is very risky due to project size, equipment reliability, and reservoir behavior uncertainty. LLP Compressor installation is split into three phases for 11 offshore platforms in Peciko, Sisi Nubi and South Mahakam.

- Phase 1 (Pilot Project) will be performed at 1 offshore platform in Peciko Field.
- Phase 2 will be performed at 2 offshore platforms in Peciko Field
- Phase 3 will be performed at 8 offshore platforms at Peciko, Sisi Nubi and South Mahakam Fields.

Result from phase 1 (pilot project) will be used to re-evaluate second and third phase prior to execution.

At this step, SKK MIGAS approval is requested by submitting POD document that is regulated by Pedoman Tata Kerja (PTK) POD Rev-3. Plan to perform LLP compressor project in three phases is stated in POD document and agreed by SKK MIGAS.

3. Execution

FID (Final Investment Decision) for Pilot Project is approved on 2019. Project is prepared and executed on 2020. FID for other phase is still not awarded at that time. Pilot project for LLP compressor and related equipment installation is completed on May 2021. However, higher liquid rate than estimation from well is observed during

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compressor operation. Installed equipment cannot handle the actual liquid rate. As the consequences, LLP compressor cannot be operated due to need of equipment modification. Next project phase that have same operation design as pilot project has to be delayed due to further evaluation that have to be done in term of subsurface and surface aspect.

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Previous Compressor Project

MP (Medium Pressure) compressor and LP (Low Pressure) compressor project have been performed previously in Peciko Field. No specific compressor project has been done for Sisi Nubi and South Mahakam Field as both fields flow to existing facilities that already equipped with MP and LP compressor.

LP compressor project in Peciko is completed on 2010 by installing 2 LP compressors at onshore. Objectives of compressor installation is to maintain gas production that start to decline at MP pressure. Despite same objectives with LLP compressor, there are several difference between those project:

- Expected production gain from LP compressor project is higher than LLP compressor project. The magnitude is two times than expected production gain from LLP compressor project
- Size of LP compressor also bigger than LLP compressor. Although already at declining phase, field production six times higher than current production. Therefore, big capacity of compressor is needed have to be installed at onshore
- LP compressor is installed at onshore surface facilities due its size and weight cannot be supported by offshore platform structure

Field production decline is decrease at range 20-30% after LP compressor project. However, as reservoir pressure continue decrease, operating pressure have to be lowered further. Good result from LP compressor have led to proposal of LLP compressor installation.

Based on above explanation, there is business issue related to execution of next phase LLP project after pilot project result is deviated from initial assumption. Impact analysis may reveal that LLP compressor may not beneficial anymore to certain platform due to change in production gain, production profile and economical aspect. Economic evaluation is solely used to decide LP compressor project go or no-go. Same approach also used in LLP compressor initially. However, economic evaluation is no longer enough based on external and internal environment analysis that is related to factor such as political, social-culture and legal. Further elaboration for external and environment analysis will be discussed in further chapter. Additional criterion has to be added in the evaluation to have well-rounded view of LLP compressor project. Therefore, best course of action have to be decided based on several criteria to ensure next project phase is still advantageous and bring value for SKK MIGAS and PT PERTAMINA HULU MAHAKAM.

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1.4. Research Objectives

As explained above, main business issue is to define best action for next phase of LLP compressor project at offshore platform after of unexpected result from pilot project. Thus, this research has two main objectives, those are:

1. Analyze why pilot project has unexpected liquid rate and define the impact of pilot project next phase of LLP Compressor Project
2. Generate a decision analysis to decide the best comprehensive alternative for next phase of LLP Compressor Project

1.5. Research Question

With the aforementioned research objectives, the following research questions below are stated as a guidance in generate the systematic thinking for problem solving determination within the decision analysis:

1. Why pilot LLP compressor project has higher liquid rate than estimation?
2. What is the impact of the pilot project failure on the success of the next phase of LLP compressor project?
3. What are the criteria to evaluate the best alternative for next phase of LLP compressor project?
4. What is the best course of action that will be implemented for next phase of LLP compressor Project?

1.6. Scope and Limitation

This research is focused to Phase 3 of LLP compressor project that will be performed in three offshore gas fields. Phase 2 is not discussed in this research as phase 2 execution already approved by SKK MIGAS and PERTAMINA Subholding Upstream to be executed and planned for start-up on 2024. Therefore, data and the recommendation will be dedicated only for those three gas fields. In determine the best alternative to be implemented future LLP project, this research will use Kepner-Tregoe and SMART Method. This method will be elaborated further in following chapter(s).

There will be some constraints and limitations in this research as described below:

1. Scenarios which will be compared in the research already discussed internally. There will be several scenarios that will be compared:

    a. Cancel Phase 3 LLP compressor project to all offshore platforms target
    b. Perform Phase 3 LLP compressor project to all offshore platforms target in same timeframe
    c. Perform Phase 3 LLP compressor project only to selected platform and cancel to non-selected
    d. Perform Phase 3 LLP compressor project in sequence.

    Evaluation with Material Balance method in simulation model is used to estimate production profile and cumulative production gain from LLP compressor project for each platform. Result already validated internally. Details of the scenario will be discussed in the following chapters.

2. PSC (Production Sharing Contract) economic model will be used in economic calculation with incentive scheme that is given by SKK Migas on December 2020. The economic model is applied due to Pertamina Hulu Mahakam as contractor for SKK Migas to manage Delta Mahakam Block. The right of the block is expired at December 2037. Therefore, the calculation (including the production forecast) will be generated until December 2037 only.

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3. Economic parameters such as hurdle rate, operating cost, conversion rate, oil and gas price, that will be used in the economic calculations are based on the regulation applied in Pertamina Hulu Mahakam for 2021-2022.

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Chapter II – Business Issue Exploration

2.1. Conceptual Framework

Numerous problem could emerge anytime in business activity. However, majority of people approach problem in an unstructured manner. Lack of structure could cause a roadblock to find solution as problem may become something that cannot be solved due to lack of clarity. Although solution may be found, it could be impractical and may not may not be the best one. Therefore, problem solving models are applied in order to find problem root cause and best solution from several alternatives.

There are a variety of models that can be employed to discover a solution. One of the model is Six Step Model. The study process will begin with defining the problem and determining the fundamental cause. Then it will move on to developing alternatives and picking a solution, followed by solution execution and any takeaways or lessons learned from this study.

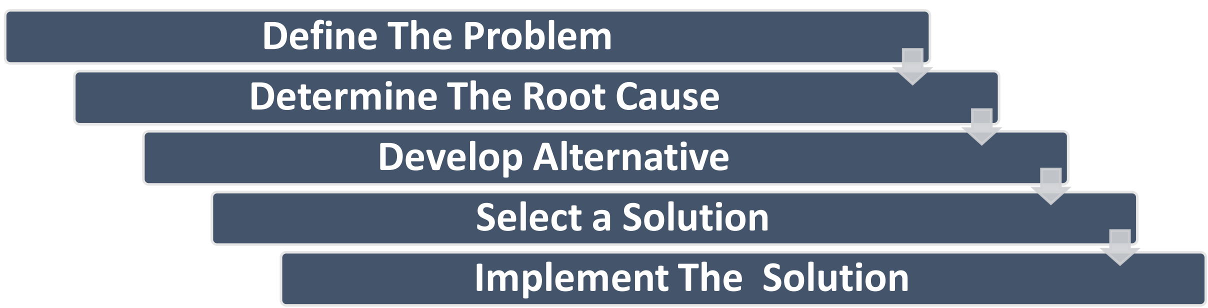

Figure 13 Six Step Model of Problem Solving (Nickols, F. (2020))

2.2. Research Methodology

2.2.1. Research Method

This research will use quantitative methods that use numbers and graphs. A quantitative approach is chosen to select the best alternative solution for a future project. This method will help business leaders understand the situation and make business decisions. Several key parameters for alternative evaluation will be converted to a value function that will be evaluated by the decision-making method for multiple criteria. Sensitivity analysis is to be performed to understand the impact of each key parameter on the selected option.

The focus of this research, as mentioned in Chapter 1, is the LLP compressor project for three gas fields located offshore of the Delta Mahakam Block. The value of a project is altered as a result of a pilot project that deviates from expectations. Several tools will be used to comprehend the project situation, assess the impact of the pilot project results on the next phase of the LLP compressor project, and identify the root cause to avoid repeating the problem in future projects.

2.2.2. Research Design

The main issue in this study is to define the best course of action for the Phase 3 LLP compressor project. Because the next project phase evaluation is based on the pilot project results, the root cause of any unexpected results from the pilot LLP compressor project must be identified. After the root cause is identified, further evaluation for the next project phase can be performed to find the best solution and implement it in offshore gas fields.

Therefore, the design of the research will begin with the Strengths-Weaknesses-Opportunity-Threat Analysis (SWOT Analysis) to give a picture of business situational analysis and the Kepner-Tregoe method to determine the root cause of the problem. This step will be provided in Chapter 2.

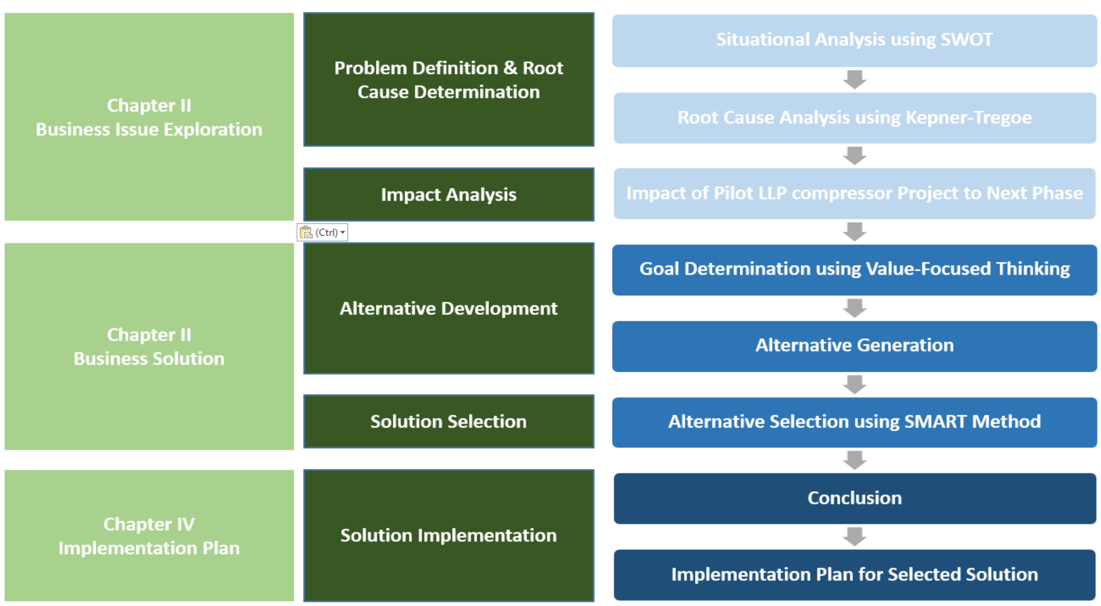

Figure 14 Research Framework

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The research will then continue to determine the desired goals using the value-focused thinking method. Based on those desired goals, a set of alternatives is to be defined and evaluated. Then the Simple Multi-Attribute Rating Technique (SMART Method) will be performed to select the best solution. This analysis will be reported in Chapter 3. In the last chapter, there will be conclusion and implementation plan for phase 3 of the LLP compressor project.

2.2.3. Literature Review

2.2.3.1. SWOT (Strength, Weakness, Opportunity, Threat) Analysis

Before coming to a decision, an evaluation of the situation must be conducted in order to identify the factors that will affect the problem. To understand the situation and position, it is important to study the advantages and disadvantages that come from within and outside the company. Therefore, a methodical approach is required to analyze those factors.

SWOT analysis is a strategic planning framework used in the evaluation of an organization, a plan, a project, or a business activity. Therefore, it is a significant tool for situation analysis that helps identify organizational and environmental factors. SWOT analysis allows firms to evaluate their current situation and future prospects by simultaneously considering internal and external factors. SWOT has four components: "strengths," "weaknesses," "opportunities," and "threats." Strengths and weaknesses are internal factors and attributes of the organization, while opportunities and threats are external factors and attributes of the environment. SWOT analysis is depicted in a four-quadrant box that allows for a summary that is organized according to the four section titles. The following table is a SWOT analysis, with its four elements in a 2x2 matrix.

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Figure 15 SWOT Analysis Matrix (Newton, P., & Bristoll, H. (2013))

Each component of SWOT need to be understand thoroughly to enable insightful analysis. Explanation for each component can be seen below:

- Strengths: Strength means that something is more advantageous when compared to something else. In this sense, strength refers to a positive, favorable and creative characteristic
- Weaknesses: Weakness refers to not having the form and competency necessary for something. Weakness means that something is more disadvantageous when compared to something else. In this regard, weakness is a characteristic that is negative and unfavorable
- Opportunities: Opportunity means a situation or condition suitable for an activity. It is a convenient moment or circumstance that the organization can take advantage of. Opportunity is an advantage and the driving force for an activity to take place. For this reason, it has a positive and favorable characteristic.
- Threats: Threat is a situation or condition that jeopardizes the actualization of an activity. It refers to a disadvantageous situation. For this reason, it has a negative characteristic that should be avoided.

To facilitate a SWOT analysis, managers use a set of strategic questions that link the firm’s internal environment to its external environment

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		External to Firm	
	Strategic Questions	**Opportunities**	**Threats**
Internal to Firm	**Strengths**	*How can the firm use internal strengths to take advantage of external opportunities?*	*How can the firm use internal strengths to reduce the likelihood and impact of external threats?*
	Weaknesses	*How can the firm overcome internal weaknesses that prevent the firm from taking advantage of external opportunities?*	*How can the firm overcome internal weaknesses that will make external threats a reality?*

Figure 16 Strategic Question for SWOT Analysis (Rothaermel, 2017)

PESTEL analysis will be used to assess the external environment in order to mitigate threats and capitalize on opportunities. The analysis is suggested by Rothaermel. The PESTEL model groups the firm's general environment into six segments: political, economic, sociocultural, technological, ecological, and legal (Rothaermel, 2021).

VRIO analysis is another method suggested by Rothaermel for analyzing the internal environment. VRIO analysis will explain and predict firm-level competitive advantages. A firm can gain and sustain a competitive advantage only when it has resources or capabilities that satisfy all of the VRIO criteria, which are valuable (V), rare (R), costly to imitate (I), and organized to capture value (O). (Rothaermel, 2021).

SWOT analysis is a widely used in management framework. However, cautious approach is needed. A problem with this framework is that a strength can also be a weakness and an opportunity can also simultaneously be a threat. SWOT also static assessment which take snapshot of moving target. It focuses on an organization’s attention in one moment (Koch, 2000). SWOT analysis also a time dependent. Therefore, SWOT analysis should be updated regularly based on the latest condition of internal and external factor

2.2.3.2. Kepner – Tregoe Method

Kepner – Tregoe method is introduced by Charles Kepner and Benjamin Tregoe. They published their book about problem solving and decision making in 1965, The Rational Manager. Later in 1981, update version of their book is released that titled The New Rational Manager. Model of Kepner-Tregoe is continue evolving and latest version of the model looks such the diagram shown below:

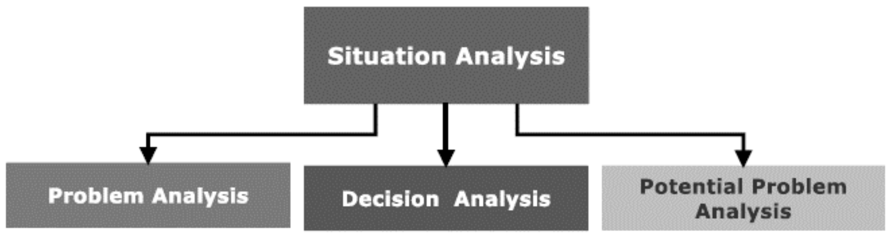

Figure 17 Kepner – Tregoe Method (Kepner, C. H., & Tregoe, B. B. (1981))

As the diagram shows, the process attempts to answer four basic questions that will related to each block. Situation analysis haven to be performed first to understand what is going on of a situation or a problem. It followed by problem analysis to find the reason of an event is occurred or happen. After causes are identified, next step is to found what action to confront the issue. Decision analysis will be performed to find options that we had and to choose the best one. Finally, understand risk and threads is performed in potential problem analysis

The K-T Problem Solving & Decision-Making method is a step-by-step process for successfully solving problems, prioritizing issues, making good decisions, and analyzing potential risks and opportunities. It has four basic areas:

Table 4 Kepner-Tregoe Steps (Kepner, C. H., & Tregoe, B. B. (1981))

Kepner-Tregoe Steps	Explanation
Situation Analysis	For difficult problems, clear thinking is required. Clarify the factors that matter in difficult circumstances and decide how to prioritize and resolve problems. A strategy is designed to effectively resolve each issue, including

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	what assessment is necessary, who should be involved, and when certain actions should be implemented. Situation Appraisal simplifies complicated situations quickly, highlights priorities, and prevents action without direction.
Problem Analysis	Find the root cause by compiling and analysing relevant facts regarding the situation. Possible reasons are found and then compared to the facts. Investigation the true reason of the problem and analyse cause will give additional insight to find the solution. Before any fixes are applied, the cause of the problem must be determined.
Decision Analysis	Evaluate an appropriate range of alternatives and assess related risks prior to making a decision. Decision Analysis ensures fully informed choices that maximize benefits and minimize risks.
Potential Problem Analysis	Prepare for threats to the success of planned efforts. Reasons of each potential issue will be identified. Then, prepare action to avoid potential issue and create contingency plans if problems arise.

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In this thesis, KT Problem Analysis will be used to understand what is the issue in LLP pilot project. The method is chosen as it provides clear thinking and structured model for solving a problem. Using this method will reduce or avoid making assumptions in problem solving. Thus, reactive actions that happened due to jumping into conclusion in fixing problem can be prevented (Nickols, F. (2020)). KT Problem Analysis will help us to understand the cause of problem by gathering, collecting, organizing, and analyzing key information(s). Possible causes are identified and checked with the fact. All steps ensure the root cause is known before fixes are implemented.

There are several steps to be done in KT Problem Analysis method:

- Problem Definition

  Generalized statement of the problem must be reworded into clear statement. Object or deviation have to be explicitly shown in the statement. Then, further investigation to determine underlying cause can be performed (Kepner, C. H., & Tregoe, B. B. (1981)). Therefore, the first thing to do in problem definition is give name to the problem. Problem name must be specific, precise and focus. Correct problem name is very important as analysis and evaluation to correcting the problem is based on the name of the problem

- Problem Description

  The next step is problem analysis is to describe the problem in detail. There is four dimension that need to define thus problem can be investigated further

  - "what" - identification of the deviation,
  - "where" - location of the deviation,
  - "when" - the timing of the deviation,
  - "extent" - the magnitude of the deviation.

  Information on the effects of any deviation will fall within one of these four dimensions. The answers to these questions will give exactly the kinds of information that will be most useful for the analysis (Kepner, C. H., & Tregoe, B. B. (1981)).

  Four-dimension definition of the problem will give us clear understanding of the problem. After that as distinction evaluation will be done for each dimension. This steps have objective to isolate the issue thus focus to find possible cause can be performed

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PROBLEM STATEMENT: Number One Filter Leaking Oil

	SPECIFYING QUESTIONS	*IS — PERFORMANCE DEVIATION*	*IS NOT — CLOSEST LOGICAL COMPARISON*
WHAT	WHAT specific object has the deviation?	IS Number 1 Filter	COULD BE but IS NOT Numbers 2-5
	WHAT is the specific deviation?	IS leaking oil	(No logical comparison)
WHERE	WHERE is the object when the deviation is observed (geographically)?	IS observed at the northeast corner of the filter house	COULD BE but IS NOT observed at other filter locations
	WHERE is the deviation on the object?	IS observed at the cleanout hatch	COULD BE but IS NOT observed at other filter locations, at cleanout hatches of Numbers 2-5
WHEN	WHEN was the deviation observed first (in clock and and calendar time)?	IS first observed 3 days ago, at the start of the shift	COULD BE but IS NOT observed before 3 days ago
	WHEN since that time has the deviation been observed? Any pattern?	IS observed continuously, on all shifts	COULD BE but IS NOT observed when the unit is not in use
	WHEN, in the object's history or life cycle, was the deviation first observed?	IS first observed as soon as oil goes into the filter, at the start of the shift	COULD BE but IS NOT observed at a time later on in the shift
EXTENT	HOW MANY objects have the deviation?	IS Number 1 Filter only	COULD BE but IS NOT Numbers 2-5
	WHAT is the size of a single deviation?	IS 5-10 gallons of oil leaked per shift	COULD BE but IS NOT less than 5 or more than 10 gallons per shift
	HOW MANY deviations are on each object?	N/A	N/A
	WHAT is the trend? (. . .in the object?) (. . .in the number of occurrences of the deviation?) (. . .in the size of the deviation?)	Stable — leaks daily, about the same amount	COULD BE but IS NOT increasing or decreasing in frequency or in size

Figure 18 Problem Description (Kepner, C. H., & Tregoe, B. B. (1981))

- Possible Causes Identification

Previous step will give comprehensive description in term of identity, location, timing and magnitude. The next questions of "IS" and "IS NOT" are aimed to find distinction for each problem dimensions. The distinction evaluation will provide a key feature that characterizes the identity, location, timing and magnitude of the problem. Therefore, the hints of potential root cause can be discovered

Brainstorming is excellent method for generating a list of possible cause that can explained the problem. Wide list of ideas can be easily captured with Brainstorming. However, efficient process of brainstorming can only happen with good knowledge and experience. Certain problem-related knowledge and experience with a comparable problem would be of great assistance in identifying potential causes.

- Test The Possible Causes

It is very important to list every possible cause. The list will help us to maintain objectivity and reduce disagreement about what is source of problem. All gathered

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fact will be used to judge relative likelihood of possible causes (Kepner, C. H., & Tregoe, B. B. (1981)).

True cause must explain every part of the deviation. Possible cause will be compare to each problem dimension to evaluated and judged whether the possible cause is the source of problem. Also in this step the control of the cause will be determined, which one is controllable, which is not. This is an important step to determine which cause can be fixed, which cause is not.

- Determine The Root Cause

  The root cause is discovered based on one of the potential causes stated in the previous phase. The root cause is the most fundamental cause of a specific situation, such as inconsistency or deviation. Consequently, when a root cause is appropriately addressed, the situation will be routed back to desired results. Once the underlying cause has been determined with certainty, a solution can be designed to prevent a recurrence of the problem. Therefore, a recheck for the problem's recurrence should be conducted, after solution execution

Given in a number of instances are uncontrollable factors, such as the existence of a natural cause (weather, season, climate, etc.). Therefore, the control of the cause must be specified, and the root reason must be a controllable cause, before corrective action can be established.

Table 5 KT Root Cause Analysis Worksheet (Kepner, C. H., & Tregoe, B. B. (1981))

POSSIBLE OF ROOT CAUSE	DISCUSSION	TESTING THE CAUSE	CONTROLLABLE / UNCONTROLLABLE
External Factor			
Material			
Man			
Tools			
Equipment			

Measurement			
Method			

2.2.3.3. Value Focus Thinking

Decision making usually focuses on choosing best choice among alternative. Alternatives needs to be generated as much as possible either it relevant or not. Focusing on alternative will limit our point of view at decision situation. To improve process of choosing best option, value have to be defined first prior alternative construction. It is values that are fundamentally important in any decision situation. Putting focus to value will provide guide not only to find better alternatives but also to decide better. (Keeney,1996).

There are three significant difference between value focuses compare to alternative focus. First, most effort will be directed toward value definition in explicit and clear manner. Second, value expression activity is performed at the beginning before any activities. Third, articulated values will be used as guide to create alternatives (Keeney,1996).

It is important to have list of objectives and values as mainly said by almost all expert of decision making. However, it is not easy to use the list to guide decision process. There are several step include numerous procedure in value focus that will enable us to have full use of values. First, create an initial list of goals. Second, classified objectives as means or fundamental objectives and logically constructed. Third, generate options that utilized list of value and objectives. The fourth step is to assess options to discover reasonable decision opportunity

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Figure 19 Value as a Foundation (Keeney, 1994)

2.2.3.4. SMART (Simple Multi Attribute Rating Technique)

It is a very hard task whenever decision problem involves several goals. Decision maker tend to refrain from making trade-offs within objectives. As the result, optimum option cannot be achieved. Chosen option either only perform good on only one objectives or option that may have good performances at several objectives but overlook of its poor performance elsewhere. The problem emerged as a result of the decision maker's low information-processing ability. When confronted with a vast and complicated situation, there may be too much information to process at once, forcing the decision maker to rely on simplified mental techniques, or heuristics, to make a conclusion (Goodwin &Wright, 2004)

Tools that used to handled decision of based on various desired attributes is called Multi Attribute Decision Making (MADM). The main goal of MADM is to help the person making the decision break down big, complicated problems into smaller, more manageable ones that can be solved separately and then put back together. The method is made up of a series of steps that break the decision problem down into three parts: the alternatives, the criteria for judging how well the alternatives work, and the relative importance of the criteria. To find the best solution of the

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problem is not the goal of MADM. The method has to be seen as tool ease difficult thinking process whenever multiple things is considered in taking decision

AHP (Analytic Hierarchy Process) and SMART

There are two methods of MADM that are widely used, namely AHP (Analytic Hierarchy Process) and SMART (Simple Multi Attribute Rating Technique).

AHP allow the use of qualitative as well as quantitative criteria in evaluation. Basically, the method composed of two steps. First, determine the relative weight of each attributes. Second, determine the relative ranking of alternatives. AHP users will assess the relative of each attributes in an intuitive manner by using pairwise comparison. Pairwise comparison is a method that ensure consistency during attribute evaluation to defined relative weight

SMART also can be used for qualitative and quantitative criteria. SMART also enable to define relative weight of attributes and ranking of alternatives. The difference with AHP is rating of alternatives is assigned directly in the natural scales of criteria. Different scale of attributes will be converted to a common internal scale. This step enables summation of value from each attributes that lead to alternative ranking

SMART method is chosen for alternatives evaluation in LLP compressor due to several reasons as follow:

- Value-Focus Thinking can only be used with SMART method. AHP with pairwise comparison is used arbitrary system that is depend on value for each assessor. Therefore, joint value such as KPI (Key Performance Indicator) cannot be used in AHP
- SMART method is work better than AHP for large number of attributes that will be used in alternatives evaluation.
- SMART method have better process in handling new criteria or alternative compare to AHP. SMART method is proposed to change current evaluation

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step in Pertamina Hulu Mahakam that rely solely to profit attributes. Attributes that relevant to project may change depend on internal and external environment condition. To have robust and consistent method, SMART is chosen

- AHP is work better to assess alternative that have different technology approach. For example, to find other technology besides LLP compressor. In this study, LLP compressor still the main choice. SMART method will be easier to follow and give better understanding of alternative selection based on several attributes

SMART Method

SMART is one of MADM analysis tool which Edwards put forward in 1971. SMART has been used a lot because both the answers the decision maker needs to give and the way these answers are analyzed are easy to understand. The method is likely to give a better understanding of the problem and be acceptable to a decision maker as analysis is done clearly. SMART can be applied in many different decision making situation. The methods comprise of eight stage that will need back and forth process between each stages (Goodwin &Wright, 2004). The eight stages are:

1. Identification of the decision maker: Find out who makes the decision. From the start of the analysis, it is need to know who is in charge of doing the decision analysis.
2. Identification of alternatives: The different courses of action or set of projects/alternatives should be identified.
3. Identification of relevant evaluation criteria: The criteria that are relevant to the decision problem should be found so that each of the options listed in stage 2 can be evaluated.
4. Numerical assessment of the performance of each alternative on each criterion: For each of the identified criteria, values for how well each option meets that criterion need to be found.

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5. Assignment of importance weights for each of the evaluation criteria: Each criterion needs to be given a weight that shows how important it is to the person making the decision.
6. Calculation of a weighted average of the values that is assigned each of the alternatives: These calculations makes it possible to measure how well one alternative performs in comparison to the other alternatives, when performance is measured across all the defined criteria.
7. Provisional decision: Preliminary choice can be made once the overall performance of each option has been determined. In this phase, the results of the various options can be compared, and the model can be fine-tuned if necessary.
8. Sensitivity analysis: Sensitivity analysis is carried out in order to see how robust the solution is in terms of small changes.

2.3. Analysis of Business Situation

2.3.1. Offshore Field Situation

Latest gas fields condition that are located in Delta Mahakam need to be review in order to understand the need of LLP project. There will be three gas field that briefly explained as follow:

- South Mahakam Field

South Mahakam is the youngest field compare to other two fields. It has started to produce natural gas since 2012. The South Mahakam area is located off the coast of the Mahakam Working Area (WK) with a distance of approximately 35 km southeast of Balikpapan and with a seawater depth of 45-60 m.

South Mahakam area consists of 4 main fields, namely Stupa, Mandu, Jempang-Metulang, and Jumelai. In term of geological context, there are two main reservoir series namely Sepinggan Deltaic Sequence and Jumelai Sand Interval. No structural fault in South Mahakam. Both interval have characteristic of consolidate sand and have depletion drive as production mechanism. South Mahakam already performed four development phase to optimize gas recovery

Phase	Field Development
Phase 1	Development Stupa Field (Main and Central panel) via SP-1
Phase 2	Development of Stupa field (West and Central panel) and East Mandu through SP-2 and MD-1 platforms
Phase 3	Development of the Jempang-Metulang field through JM-1 platform
Phase 4	Addition of infill wells in Stupa, Mandu and Jempang-Metulang fields

Figure 20 South Mahakam Development Phase (Source PHM Internal Document)

- Sisi Nubi Field

Sisi Nubi Field is located off the coast of the Mahakam Working Area (WK), with a seawater depth of 60-80 m, about 25 km from the Mahakam delta. Sisi field was discovered in 1986 and Nubi field was discovered in 1992. Nubi field began production in November 2007 while the Sisi field began in November 2008

There are 2 normal fault structures with an NNE-SSW direction, which divides the field into several panels, namely, Side Structure is divided into 2 main panels: West Side and Central Side. Nubi structure is divided into 4 main panels: West, Central, North, and East. In term of reservoir formation, there is three zone that can be described in Sisi Nubi Field. Zone classification are Shallow Zone, Fresh Water Sand Zone and Main Zone. All intervals have depletion drive as production mechanism. In term of sand consolidation, Shallow and Fresh Water Sand have less sand compaction compare to main zone. Sisi Nubi currently already performed four development phase

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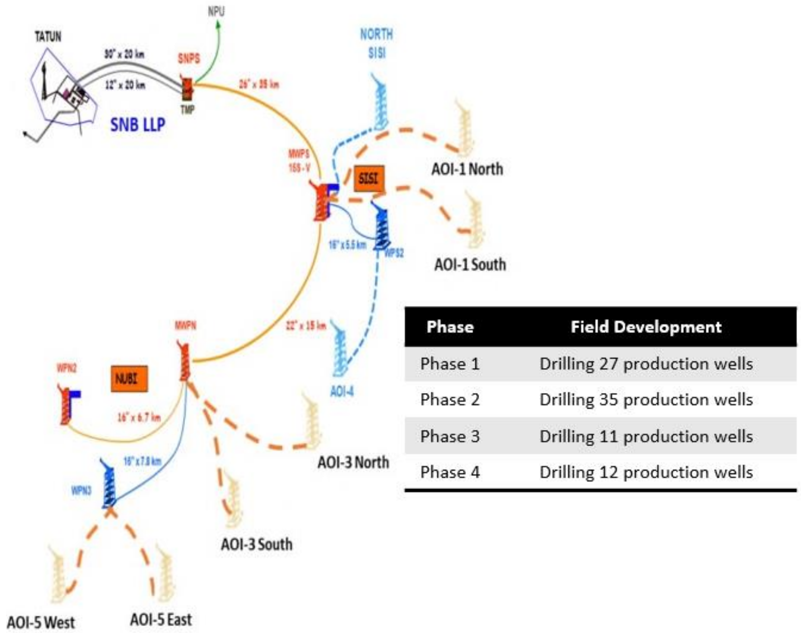

Phase	Field Development
Phase 1	Drilling 27 production wells
Phase 2	Drilling 35 production wells
Phase 3	Drilling 11 production wells
Phase 4	Drilling 12 production wells

Figure 21 Sisi Nubi Development Phase (Source PHM Internal Document)

- Peciko Field

Peciko is the oldest field compare to other two fields. It is discovered in 1983 and has started to produce natural gas since 1999. It is located off the coast of East Kalimantan, with a seawater depth of 30-50 m, about 60 km from Balikpapan.

Like South Mahakam and Sisi Nubi, there are several producing layer in Peciko that have different characteristic. In general, there are three gas producing interval namely, very shallow zone, fresh water zone and main zone. Main zone is the primary Peciko gas reserves that have consolidated sand and depletion drive as production mechanism. Fresh Water Sand and Very Shallow zone located at shallower depth therefore sand is looser compare to main zone and has support from aquifer that maintain reservoir pressure. Peciko have performed nine development phase to maintain and optimize its production. One of the development phase is LLP compressor installation at SWP-G that is completed on 2021.

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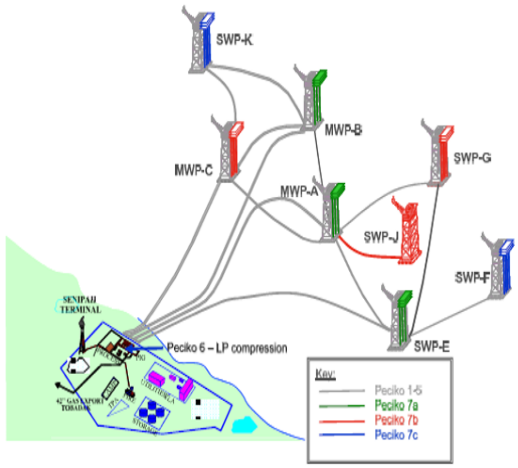

Phase	Field Development
Phase 1	MWP-A and MWP-B Platform
Phase 2	MWP-C Platform
Phase 3	SWP-G Platform
Phase 4	SWP-E and SWP-K Platform
Phase 5	Infill well at initial 6 platforms and SWP-F platform
Phase 6	LP compression at Onshore
Phase 7	Platform extension at Initial 7 platforms and SWP-J platform
Phase 8	LLP compression at Offshore Platform (in progress)
Phase 9	Infill well at existing platform

Figure 22 Peciko Development Phase (Source PHM Internal Document)

2.3.2. LLP Compressor Pilot Project

It can be inferred from field situation that is explain in previous chapter. All offshore gas field have performed several field development phase to maintain its gas production. It also can be seen in production figure below that show Peciko, Sisi Nubi and South Mahakam field already at declining phase. Therefore, future development plan has to be prepared.

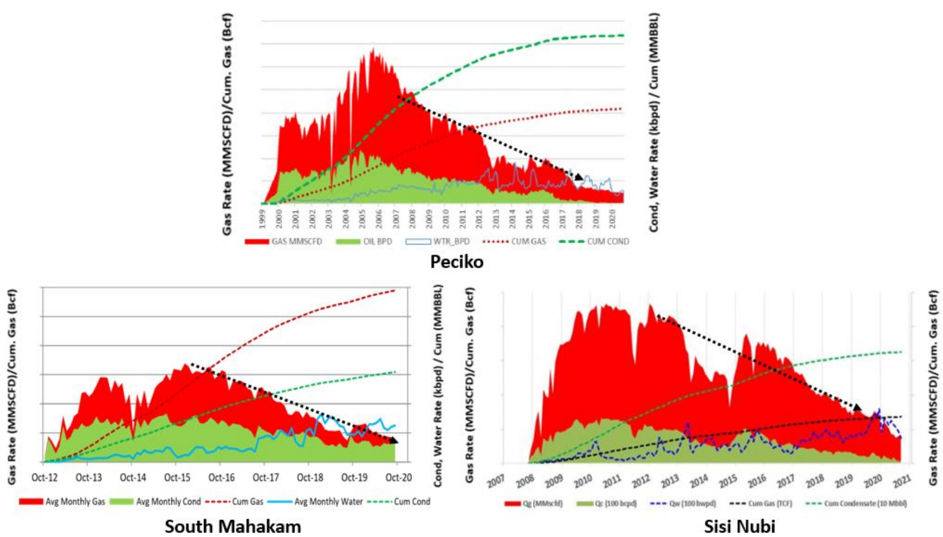

Figure 23 Production Profile of Three Gas Offshore Field (Source PHM Internal Document)

There are three strategies that currently perform by PHM that used as guidance for next plan of development. First is Baseline Management, second is Infill Well Initiatives and third is Stepping Out. Compressor Installation to provide lower flowing pressure for gas production is in line with Baseline Management strategy. Expected impact after LLP compressor installation are decrease well gas production decline, prolong well production by reduce minimum rate and abandonment pressure and improve well gas production.

The approach of lowering well head pressure is relevant to reservoir behaviour and character. Based on reservoir data observation and analysis, natural depletion is agreed to be the main production drive for three offshore gas fields. Production drive is the main energy that enable gas is being produced from subsurface up to surface thru well. Depletion drive can be described as big balloon that have been filled fully with gas. After gas is being release from the balloon, balloon will become smaller that indicate reduction of pressure. Pressure will continue to decrease whenever volume of gas continue flow out from the balloon. Analysis that usually used to determine type of production drive at gas field is called P/Z (pressure) plot. It can be seen from figure 25, field with depletion drive will have straight line when pressure data is plotted to total volume of production gas. In case of additional energy from other source which usually aquifer, the slope is not straight anymore and will start to deviate when water encroach and replace gas in reservoir that have been produced.

In term of reservoir, gas flow out is not as easy as illustrated in balloon example. There is a lot of restriction as flow is happen thru porous area. A point of pressure when gas cannot flow anymore from reservoir to surface is called abandonment pressure. There is several factor that affect abandonment pressure such as reservoir permeability, well bore size, water production, well head flowing pressure and etc. One of the factor still controllable and easier to change compare to other factor is well head flowing pressure.

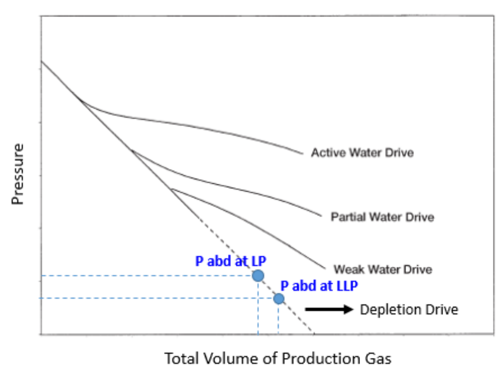

Figure 24 Production Mechanism (P/Z plot) and Pressure Abandonment (Ahmed, T. (2018)

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Lowering well head pressure will bring benefit to improve gas field production based on theoretical view. However, reservoir behaviour is complex and may deviate with engineering expectation. It's decided to implement LLP condition in stage. The objective is to gather subsurface data before next application to other fields and also to have experience in smaller project scale. Based on SDP team review and recommendation, pilot project is performed at one offshore platform (SWP-G) in Peciko Field. FID (Final Investment Decision) approval is received on 2019 and project is completed on May 2021. Pilot project work scope as follow:

- Installation of LLP Compressor with capacity 8 MMscfd
- Installation of inlet separator, inlet filter, and liquid transfer pump as a support system for the LLP Compressor with capacity 300 blpd
- Modification of structure (deck extension), piping system, electricity, instrumentation, control system, safety system to support new equipment.

Several issues are found during pilot project execution which related to project cost, schedule and subsurface uncertainty. Each issue will be discussed as follow:

- Project Schedule

  The project was completed nine months late compared to initial planning. In general, it is closely related due to outbreak of Covid-19 that is happened at the end on 2019. Contractor workshop that is performed manufacturing and fabrication of LLP compressor package is closed for two months. Addition to that, several issue related to delivery also take place such as cargo line up in Shanghai and document clearance at Jakarta before package is finally received by Project Team

  Crucial activity to make sure BC package is fit for purpose that is called FAT (Factor Acceptance Test) must be performed offline. As the result, many action item have to be followed up in Indonesia. Unfortunately, many action item cannot be cleared at contractor yard in Indonesia which lead to several malfunction such as mechanical issue, sensor anomaly and air cooler issue that just found after LLP compressor is installed at offshore platform. Repair and waiting material for repair have caused delay to project delivery

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Man power limitation also cause the delay. Amount of worker number need to be reduce 30% due to health protocol implementation to prevent Covid-19 outbreak in working area. It is estimated of one-month delay related to man power reduction

- Project Cost

  10-11% incremental cost is observed on this project which mostly related to delay of project and additional repair activity and material upon compressor installation. Additional management cost is added after man power utilization is longer than initial schedule. Cost related material and repair activity also not expected. Cost related repair can be avoided if FAT was performed properly

- Actual Liquid Rate

  During the Site Acceptance Test of the Booster Compressor, it was found that the actual liquid rate of the LLP wells exceeded the initial design. Actual liquid rate is ten times than expected liquid rate. Provided LTP (Liquid Transfer Pump) is not able to pump out liquid fast enough from two-phase separator that is located before compressor. Because of that, emergency shut down is always triggered due to high liquid level in separator. The separator has function to separate gas from any liquid before flow to compressor. If there is liquid rate that pass thru separator, it will severely damage the compressor. Corrective action is carried out by operating a temporary LTP (Liquid Transfer Pump) using an OLP (Offloading Pump) that have bigger capacity than existing LTP. As the result, SAT (Site Acceptance Test) 72-hour Performance Test is successfully carried out properly and safely as planned. SAT result show compressor can run until its maximum capacity and additional production gain is obtained from well target.

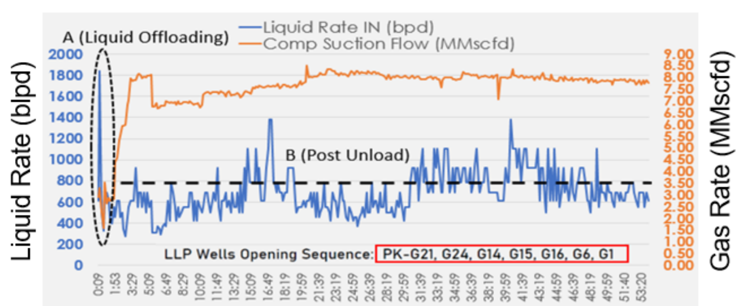

Figure 25 SAT Result of Pilot Project (Source PHM Internal Document)

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Action to reduce liquid rate is discussed within SDP team, Project Team and Well Intervention Team. Based on discussion, there are two steps to be performed. First step is subsurface intervention. Intervention is done by perform mechanical isolation to reservoir that produce high liquid rate. Well observation program is created to find the liquid source. After liquid source is found an equipment called casing patch will be set in front of the reservoir.   Second step is surface modification. This step is performed if first step is not successful. Bigger capacity of LTP have to be installed permanently to handle high liquid rate

First step action unfortunately not possible to performed due to two reason:

- It is found that gas and water is produced simultaneously from reservoir based on result from well observation program.
- Reservoir that is suspected as liquid source is not accessible to set casing patch. Action to remove restriction is not possible as it could damage existing open reservoir

Therefore, surface modification become the only solution for high liquid rate issue in Pilot Project. Unfortunately, LLP compressor that already installed cannot be used until surface modification is performed. Project team review conclude following required major modification:

- Electric Driven Liquid Transfer Pump
- Electric Power Generator
- Additional Deck Extension

As discussed on chapter I, major modification has to follow internal process to get FID (Final Investment Decision) prior to execution. Therefore, delay of production for Pilot LLP compressor project is expected for 16 – 24 months

2.3.3. External Environment with PESTEL Analysis

PESTEL, as reflected in the abbreviation of Political, Economic, Socio-cultural, Technological, Environment, and Legal, will evaluate the external major forces that interact with the company business and will be the main driver of the company’s performance. This

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analysis will help the company to come up with the best business strategy to manage the business challenge.

Political (P)

Oil and gas industry in Indonesia has been active for more than 130 years, since the first oil discovery in North Sumatra in 1885. Indonesia's oil and gas business activities are divided into the upstream sector (exploration and exploitation) and the downstream sector (processing, transportation, storage, and trading). In general, upstream oil and gas business activities by oil companies in Indonesia are based on a Production Sharing Contract (PSC), between the government, acting through the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas), and the oil companies as PSC contractors.

With national oil production declining, the government supports any project that can boost production. The government's support is expressed by amending Government Regulation (PP) Number 79 of 2010 as PP 27/2017 addressing cost recovery profit-sharing contracts and PP 53/2017 regarding gross split profit-sharing contracts. These two policies offer risk-adjusted investment options in Indonesia. The contractor might propose split improvements and tax advantages through SKK Migas to make the investment more attractive.

Geopolitics might affect project outcome. The war between Russia and Ukraine since end of February 2022 have harmed the global economy by disrupting supply chains and raising energy prices. Russia and Ukraine manufacture nickel, aluminum, and palladium. Material delays could affect industrial operations and the supply chain. Many parts and equipment that are needed in oil and gas project are still imported. Supply chain disruption due to the war could increase project costs and delay project execution

Economic (E)

Natural gas production demand in Indonesia have been increasing, it is expected of increase up to 36% of energy demand in Indonesia. Natural gas production is needed as allocation of natural gas is mostly for industry sector, followed by electricity generation and fertilizer. To answer the need, Indonesia government thru Energy and Mineral Resources Ministry and SKK MIGAS have target to reach 1 million BOPD and 12 billion SCFD by 2030. To achieve that, one of the strategy that is formulated by Indonesia government is to maintain current production level through optimization of production is existing field. Installation LLP system at brownfield such as Peciko will enable gas field to maintain its natural gas production level. Production level that is maintained will be used to supply increasing demand of natural gas

Delta Mahakam Block have been producing since 1974, therefore Pertamina Hulu Mahakam already had several contract of gas buyer at domestic and international market. Commitment to international market have better gas price compare to domestic market. International market has gas price between $7-8/MMbtu while domestic market has gas price between $5-6/MMbtu. There is also uncommitted gas for volume gas that have not fully absorbed by committed market. Gas is sold thru spot market that have wide range of gas price from $4-8/MMbtu depend on market needs and situation

Sociocultural (S)

One of Indonesia's most essential energy sources, oil and gas are widely used in transportation, industry, and homes. Data from the International Energy Agency (IEA) indicates that Indonesia's energy consumption has increased significantly from 1990 to 2019 due to the country's large population. Despite a growing awareness of green energy, Indonesians continue to rely on oil and gas for their energy needs.

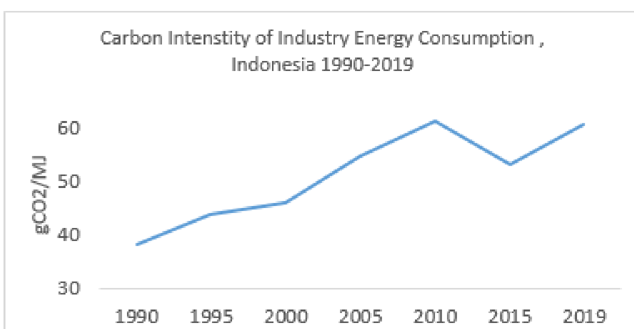

Figure 26 Carbon intensity of Industry in Indonesia (Source International Energy Agency)

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Technology (T)

Innovative technologies help oil and gas companies streamline and simplify operations by creating intelligent enterprises. Adaptation of new technology is even more critical to mature fields in Indonesia. Technological advancement will help mature field development to improve its operational efficiency and cost-effectiveness.

Oil and gas recovery is continuously improved due to the development of oil and gas lifting technology. For mature gas fields, technology such as LLP compressor is needed to improve gas recovery and maintain gas production. While for mature oil fields, enhanced oil recovery is the key technology to improve oil production.

Recent technological innovations like artificial intelligence (AI) are also commonly applied to oil and gas industries. Pertamina Hulu Mahakam have used AI to find a new well location and optimize the current business process by performing automation.

Environmental (E)

Environmental protection is equally as vital as safety in the oil and gas industry. Any environmental harm caused by company operations will have a direct influence on the company's image, as well as on its share price and valuation. The cost of environmental protection and risk mitigation is regarded to be less than the cost impact of any environmental accident, which can be in the billions of dollars, as was the case with the BP Gulf of Mexico oil spill. Environmental aspect must be meticulously controlled throughout all operational and project activities.

The Covid-19 epidemic has adversely affected all oil and gas projects in Indonesia. Unfortunately, the LLP pilot project in Pertamina Hulu Mahakam must be conducted at the onset of the Covid-19 pandemic. In terms of project execution, the pandemic has caused manpower constraints, bad communication, and ineffective work activity. Numerous adjustments must be made to the project to ensure its continuation while preventing the spread of the virus among the workers. Fortunately, no positive cases of Covid-19 were detected on-site throughout project execution.

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Recently, the movement to Net Zero has been the new vision of almost all energy companies and stipulated in company business strategy. It will be the consideration for the company to review the economical limit of oil and gas production with the anticipated of lowering demand for fuel energy in the next 10 years.

Legal (L)

The highest law that governs the oil and gas in Indonesia is the Constitution Law of the Republic of Indonesia (UUD 1945). All of the natural resources in Indonesia are owned by the government of Indonesia and managed for the prosperity of the people of Indonesia. The upstream oil and gas industry is well regulated and follows law Act#22 the Year 2001 oil and gas. SKK Migas as the authority of upstream oil and gas activity act on behalf of the government of Indonesia to manage the PSC contract with the contractors.

2.3.4. Internal Environment with VRIO Framework

Valuable (V)

This criterion shows whether the firm has the valuable resources or capabilities that allow the firm to exploit opportunities or neutralize the threat from the external environment.

Pertamina Hulu Mahakam is one of Indonesia's biggest oil and gas producers with a proven record of having excellent operation and safety performance. The company also has a proven record of performing many development project activities in the past. Example of successful past project is compressor installation at onshore to provide HP (High Pressure), MP (Medium Pressure) and LP (Low Pressure).

LLP compressor project is compressor installation at offshore platform that have not been done before even in any oil and gas company in Indonesia. Pilot project of LLP compressor is completed on May-21. The compressor can reach its maximum capacity at 8 MMscfd. Targeted wells give production gain either thru revival or production rate improvement after switch to LLP system. It can be concluded that lowering well head pressure have been reached its objective to give additional gain to field production.

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Table 6 Well Gain after route to LLP System (Source PHM Internal Document)

Well Name	Rate at Low Pressure (MMScfd)	Rate at Low Low Pressure (MMScfd)	Gain (MMScfd)
PK-XX-1	0.0	0.3	0.3
PK-XX-2	0.0	0.3	0.3
PK-XX-3	0.6	0.9	0.3
PK-XX-4	3.3	4.3	1.0
PK-XX-5	0.5	2.9	2.4
PK-XX-6	0.7	2.0	1.3
PK-XX-7	0.3	1.5	1.2

However, there is huge issue that come from well production. Higher liquid rate with magnitude of ten times bigger than estimation is found during compressor site acceptance test. The issue has successfully managed by project and production team within four weeks by installed temporary LTP with bigger capacity. Complete compressor test can be done and completed in May-21.

Temporary LTP cannot be used for long period of operation due to need of continuous supervision by human. Additional project scope to install bigger capacity of permanent LTP has to be performed and expected to be completed on Q1-2024. LLP compressor will be kept idle. As the result, expected production gain from pilot project is delayed almost two years.

Rare (R)

A resource is rare if only one or few firms possess it. A firm is on the path to competitive advantage only if it possesses a valuable resource that is also rare.

Pertamina Hulu Mahakam produce oil and gas products which are nonrenewable resources. Complete infrastructure and commercial already available to monetize the potential hydrocarbon resources. Pertamina Hulu Mahakam also operates swamp and offshore gas fields, which is a rare competency for oil and gas operators in Indonesia.

Costly to Imitate (I)

A resource is costly to imitate if firms that do not possess the resource cannot develop or buy the resource at a reasonable price.

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The oil and gas industry is a capital-intensive business with high risk; therefore, only limited company operates in this industry. Pertamina Hulu Mahakam need years to develop its competency and reputation and become a major oil and gas company

Organized to Capture Value (O)

The final criterion is to determine whether the firm has resources or capabilities that can be used as a basis for sustainable competitive advantage. The criterion depends on the internal structure of the firm. In order to meet this criterion, a firm must have an effective organizational structure and coordinating system.

Pertamina Hulu Mahakam and its holding company is an integrated oil company whose operation ranges from upstream to downstream business in oil and gas. This integrated organization structure gives Pertamina Hulu Mahakam the additional advantage of having support also from another part of the industry sector.

2.3.5. SWOT Analysis

By combining external and internal environment analysis, we can synthesize SWOT analysis that allows us to evaluate the firm's current situation and prospects. SWOT analysis for Pertamina Hulu Mahakam related to LLP compressor project in offshore fields is described in table 7.

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Table 7 SWOT Analysis Pilot Project LLP

	Helpful	Harmful
Internal Origin	**STRENGHTS** • LLP pilot project is successfully completed by project team • Increase production from well flow to the LLP system • High technical competence to perform field development project • Existing international and domestic gas contracts with good gas price • Part of an integrated oil and gas company	**WEAKNESSES** • Liquid rate is higher than estimation. As the result, LLP system from pilot project cannot be used continuously until bigger pump is available • Overrun to pilot project cost • Delay to pilot project completion
External Origin	**OPPORTUNITIES** • High demand of natural gas in domestic market • Government fiscal incentive to promote the economical level of oil and gas project	**THREATS** • Global pandemic that will give disturbance in project execution • Geopolitics incidents such as Russia-Ukraine war. Disturbed global supply chain will affect project cost and schedule of next project phase • Entrance of replacement from renewable energy

2.3.6. Root Cause Analysis

LLP pilot project is completed on May-21. Project is completed after LLP system can be running for 3x24 hrs. Not just running, rigorous check also performed to ensure automatic system is working properly and no malfunction at sensor.

SWOT analysis shows that there are three point of harmful that are from internal origin. Project cost overrun and project delay is not evaluated further as root cause of event strongly related to occurrence of Covid-19 as global pandemic. After two years, pandemic condition has been much better after health protocol already accepted as habit and supported by full dose vaccination for additional protection. Experience and knowledge in performing pilot project will be used to improved future LLP project execution.

Further analysis will be performed find the root cause of higher liquid rate, to prevent the same issue is occurred at the next LLP compressor project phase. Based on chapter which discussed result of pilot project, higher liquid rate has caused more cost for additional scope and inoperability of LLP compressor. Therefore, KT problem analysis will be performed to analysis higher liquid rate that are observed in LLP pilot project.

Analysis KT Problem Analysis will use following steps:

- Problem Definition

Name of the problem or deviation statement have to be defined first exactly prior to it can be described and analysed. Name of the problem for Pilot LLP compressor project is "Liquid rate from well that flow to LLP compressor is higher than estimation and unable to handle by existing liquid transfer pump".

- Problem Description

After precise problem definition, next step is to describe problem in detail in its four dimension.

Table 8 Problem Description of LLP Pilot Project

DIMENSION	SPECIFYING QUESTION	IS	IS NOT
IDENTITY	WHAT What is the deviation?	Liquid rate from wells is ten times higher than expectation and unable to handle by existing LTP	Liquid rate as per estimation and can be handled by current installed LTP
LOCATION	WHERE Where is the problem occur?	Offshore platform SWP-G in Peciko Field	Other platform in Peciko Field
TIMING	WHEN When is the problem occur?	At project execution. During SAT (Site Acceptance Test) of installed LLP system	After project is completed. High liquid rate is found after certain duration of production
MAGNITUDE	EXTENT What is the extent of the problem?	LLP system is kept idle. No production gain from LLP system	LLP system is functioning Additional gain from well that flow to LLP system

- Possible Causes Identification

After problem description is done. Next step is find distinction for each dimension that followed by possible cause identification

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Table 9 Possible Causes in LLP Pilot Project Problem

Problem Statement	Liquid rate from well that flow to LLP system is higher than estimation and unable to handle by existing liquid transfer pump			
SPECIFYING QUESTION	IS	IS NOT	DISTINCTION	POSSIBLE ROOT CAUSE
WHAT What is the deviation?	Liquid rate from wells is ten times higher than expectation and unable to handle by existing LTP	Liquid rate as per estimation and can be handled by current installed LTP	Amount of liquid rate that is produced by well	Liquid measurement
WHERE Where is the problem occur?	One Offshore platform in Peciko Field	Other platforms in Peciko Field	Strategy to develop LLP system	LLP system has never been installed at the offshore platform. Reservoir behavior may be different between platforms. Therefore, LLP compressor project is performed in phases
WHEN When is the problem occur?	At project execution. During SAT (Site Acceptance Test) of installed LLP system	After project is completed. High liquid rate is found after certain duration of production	Higher liquid rate timing	Reservoir behavior
EXTENT What is the extent of the problem?	LLP compressor is kept idle. No production gain from LLP compressor	LLP compressor is functioning Additional gain from well that flow to LLP compressor	LLP compressor utilization Production gain from wells when flow to LLP compressor	LTP capacity that is installed is not enough to handle actual liquid rate

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- Possible Cause Testing

Table 10 Testing Possible Causes in Pilot Project Problem

POSSIBLE OF ROOT CAUSE	DISCUSSION	TESTING THE CAUSE	CONTROLLABLE / UNCONTROLLABLE
<u>Material</u>			
Reservoir Behavior	Main zone in Peciko have depletion drive as production mechanism. Reduction production pressure have been performed from HP (High Pressure) to MP (Medium Pressure) then LP (Low Pressure). Action is needed to maintain field production level. Significant liquid production increase is not observed at previous pressure reduction. However, reservoir behavior may be different at late time. There are not enough of well production data at very low pressure with sufficient time as reference for LLP project. Well observation program found that gas and water is produced in comingle from same reservoir. Therefore, reservoir isolation cannot be done	This possible cause is true for specification dimension of Where and When	It is not controllable
<u>Equipment</u>			
Liquid transfer pump capacity	Liquid transfer pump in LLP pilot project is design based on input from subsurface team. However, evaluation of estimated liquid rate is performed based on assumption of liquid production at current operating pressure (LP). Data from offload activity that is performed at limited duration is not used as reference	This possible cause is true for specification dimension of Extent	It is controllable
<u>Measurement</u>			

Liquid rate measurement at LLP (Low-Low Pressure) condition	Liquid rate estimation is provided by subsurface team. Estimation is performed by considering reservoir production mechanism and liquid rate at current operating pressure. Data during offload that is mimic LLP condition is not taken into account as well still not stable due to short duration and inaccuracy in liquid measurement. Reservoir behavior is not easy to predict, therefore it is necessary to gather data properly at nearing condition of future project with good measurement method and equipment.	This possible cause is true for specification dimension of What	It is controllable

- Root Cause Determination

Possible cause testing is performed to factor that mostly related to problem statement “Higher liquid rate than estimation and unable to handle by existing pump”. There are three factor that need to be evaluated, namely material, equipment and measurement.

Reservoir behaviour is categorized as material and true for problem dimension of what and when. High liquid level is closely related to these factor however it is not controllable and also not easy to predicted. For pilot project, high liquid rate is observed immediate during project execution.

Two factors that obviously related to problem are equipment and measurement. Equipment factor is true for problem dimension what and extent. There are two item related to equipment factor. First item is pump capacity that is controllable but depend on measurement factor. Second item is access inside production well. Intervention to reduce liquid production from reservoir cannot be performed. As the result, high liquid rate must be handled by bigger pump capacity

Measurement factors is true for problem dimension of what and extent and controllable. Existing pump capacity design really depends on estimation of liquid rate at expected pressure in LLP condition. However, there is issue in measurement method that have been used in data collection. Well offloading is a regular operation that could imitate LLP

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condition. Objectives of offload is for production recovery due to liquid loading issue. High liquid rate is expected and precise measurement of gas and liquid rate is not the concern during offload. There is also assumption from subsurface team that based on field liquid production at LP pressure and production mechanism. Theoretically, depletion drive will not have water support and increase to liquid production is not expected.

Liquid rate estimation for LLP condition is concluded at root cause of problem in pilot project LLP. This important conclusion will be used for further evaluation of next phase of LLP project.

2.3.7. Impact of Pilot Project Result to Next Project Phase

It has been explained in previous chapter, three phase of LLP project is proposed. Detail of project phase can be seen in table below:

Table 11 LLP Project Phase Detail (Source PHM Internal Document)

Phase	Phase 1 (Pilot Project)	Phase 2	Phase 3
Project Name	Peciko 8A	Peciko 8B	Peciko 8C, SMK LLP and SNB LLP
Field Name	Peciko	Peciko	Peciko, Sisi Nubi and South Mahakam
Amount of Platform Target	1	2	8
Work Scope	- Installation of LLP Compressor (Different Capacity for Each Platform) - Installation of inlet separator, inlet filter, and liquid transfer pump as a support system for the LLP Compressor with capacity 300-500 blpd - Modification of structure (deck extension), piping system, electricity, instrumentation, control system, safety system to support new equipment.		
LLP Compressor Capacity	SWP-G 8 MMscfd	MWP-A 8 MMscfd MWP-B 8 MMscfd	SWP-J 5 MMscfd MWP-C 5 MMscfd MWPS 12 MMscfd WPS2 8 MMscfd WPN2 5 MMscfd WPN 3 5 MMscfd JM-1 5 MMscfd MD-1 8 MMscfd
Initial start -up date	2021	2022	2023

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Based on table, next project phase has same work scope like pilot project. Main difference are number of platform and LLP compressor capacity. Issue in pilot project related to higher liquid rate than estimation can also occur to next phase. Therefore, same procedure to perform well observation program and isolate reservoir that only produce water is perform to next platform target. Well observation program is started from Jun-21 and completed on Apr-23 that already covered 10 platforms. Result is not encouraging as water production cannot be decreased by subsurface intervention. In term of liquid rate, it has magnitude 10 times higher than initial estimation. Consequences of higher liquid rate to next phase for surface equipment is as follow:

- Higher specification for liquid transfer pump from gas engine drive to electric engine drive
- Additional Electric Power Generator to support new LTP specification
- Additional time for engineering study for LLP compressor support system and structure modification
- Higher project cost that is related to higher price of LLP compressor and additional equipment

Higher liquid rate also impacted to subsurface target that is initially estimated from LLP compressor project. Subsurface targets are production rate and cumulative production gain. In petroleum engineering, there are several methods to perform production rate and cumulative production gain prediction namely Analogy, Decline Curve Analysis, Material Balance Analysis and Reservoir Simulation.

Table 12 Production forecast method at LLP (Source PERTAMINA internal document)

Method	Definition	Accuracy	Remarks
Analogy	Prediction is perform by refer to well cumulative production from surrounding fields that have same behaviour with target well	Low	This methods is not chosen, as no surrounding field that have LLP compressor
Decline Curve	Prediction is performed based on trend of well production history within fields. There is three trend that	Low to Medium	This methods is not chosen as no well within fields that

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	can be used : Harmonic, Hyperbolic, Exponential		have flow to LLP compressor
Material Balance	Prediction is performed based on equation related to mass balance. Reservoir is considered as a tank, every mass out will be replaced by mass in. The equation already considered production data, pressure data, rock properties and reservoir data	Medium	This methods is chosen as material balance workflow already established and have acceptable accuracy
Reservoir Simulation	Prediction is performed in complex geological model that consist of thousands of small tank that is interconnected. Complex mathematical model will be used to evaluate material balance that is happened at each interconnected tank. This method have more precision is describing reservoir performance	Medium to High	This methods is not chosen due to the nature of reservoir complexity in Delta Mahakam that not easily captured by reservoir simulation

As explained on figure 11 in chapter 1, higher liquid rate will cause gas well become no flow faster than well with lower liquid (Sankar, S., & Karthi, S. A. (2019)). Therefore, based on latest subsurface evaluation, expected production rate and cumulative production become lower than initial evaluation

As conclusion, impact of pilot project can be summarized with following table:

Table 13 Next Phase Project Update based on Pilot Project Result

Phase	Phase 2	Phase 3
Project Name	Peciko 8B	Peciko 8C, SMK LLP and SNB LLP
Field Name	Peciko	Peciko, Sisi Nubi and South Mahakam
Updated Liquid Rate (Blpd)	5500 blpd	Peciko 4000 – 5000 blpd Sisi Nubi 1000 – 3000 blpd South Mahakam 5000 – 6000 blpd
Update Production Gain (Bcf)	- 40%	Peciko - 19% Sisi Nubi - 43% South Mahakam - 42%

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Update Cost (Million $)	+ 15%	Peciko + 16% Sisi Nubi + 26% South Mahakam + 22%
Update Start-Up Date (Plan)	2024 (Delay 2 years)	2025 (Delay 2 years)

Phase 2 scope of work is smaller than Phase 3. Discussion with SKK MIGAS and PERTAMINA Sub Holding Upstream already performed to update the latest condition. Despite of decreasing stakes and increasing cost, Phase 2 still acceptable to be continued. FID is approved on 2022 with start-up is expected on 2024. Phase 3 have much bigger scope than phase 2. Evaluation with Value-Focus Thinking and SMART will be performed to find best scenario.

2.4. Conclusion of The Business Analysis

Three offshore field namely Peciko, Sisi Nubi and South Mahakam already at phase of production decline. In order to maintain its production and to follow company strategy to optimize production from existing wells (Baseline management), LLP project is proposed. LLP project will be performed in three phases. First phases as pilot project is done at one offshore platform at Peciko.

Pilot phase is completed on 2021 and issue is found for project cost, schedule and subsurface behaviour. Higher liquid rate that is related subsurface behaviour have the biggest impact to utilization of LLP compressor. Bigger pump has to be added to solve the issue and LLP compressor will be kept idle and no production gain. Root-cause analysis found measurement that is not performed in proper manner become the main reason of the issue.

To prevent the same issue, proper measurement and well observation is performed to platform candidate for next LLP compressor project. It is found that higher liquid rate also observed to those platforms. Further evaluation for surface and subsurface issue show increase of project cost and decrease of production gain. Decrease of production gain means less revenue from the project.

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Phase 2 comprehensive evaluation conclude that project can be continued for two offshore platforms in Peciko. Phase 3 have bigger scope than phase 2 which have targeted 8 platforms in three different fields. Installation to all platforms may not beneficial, therefore a decision making process with Value-Focus Thinking and SMART will be performed to find the best scenario

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Chapter III – Business Solution

High liquid rate has cause Pilot Project being idled while wait additional modification of liquid transfer. Root cause of higher liquid rate than estimation from Phase 1 (Pilot Project) LLP compressor project have been explained in chapter 2. To prevent the same issue in next project phase, well observation program is performed to 10 platforms. It is found the same issue like Pilot Project. Surface and subsurface evaluation revealed that high liquid rate cause increase to project cost and decrease production gain (less revenue). Phase 2 that only performed in 2 platforms have been approved to be continue. Phase 3 have the biggest scope compare to other phase, it is planned on 8 platforms in three offshore fields. Further evaluation need to be performed whether to continue the project as per initial plan or only performed it to selected platform.

In this chapter, several alternative for phase 3 will be discussed. SMART method will be used to choose the best alternative that is generated within SDP team. Attribute definition and weight of each attribute will be defined by using value-focus thinking method. Value will be assigned for each attribute based on rank for each attributes. Best alternative will be chosen for alternatives with the highest value

3.1. Attributes Definition

Main objective of LLP project is to lower operation pressure that is needed to maintain and prolong production from existing wells. Additional production gain from the project will give additional profit for the company and fulfill Indonesia energy demand.

As discussed previously, phase 3 of LLP project condition have been changed due to result from Pilot Project. It is found the need of additional cost and lower production gain. As the result, LLP compressor to all target platform may not as beneficial as before. Several alternative is defined that will be analyzed further to find the best course of action.

To ensure that alternatives are aligned with company goals, attribute that will be used will be defined by value-focus thinking concept. Value is important in process for choosing best option, therefore value to be defined first prior alternative construction. PT Pertamina Hulu Mahakam

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have set of objectives from company goals that is formulated in the form of KPI (Key Performance Indicator).

The Key Performance Indicator (KPI) is a quantitative metric that measures the performance and development of a certain target over time. KPI will be a function-based objective generated from corporate objectives. KPIs are essential for ensuring that all corporate functions and teams (and each individual) are aligned with company objectives. Benefits of KPI are as follow:

- Maintain team alignment and go in the same direction as KPI built and drawn from corporate objectives.
- Conduct a corporate health assessment by observed periodically indicator in KPI
- Define the success or failure of the firm. Company strategy and objective have to be adjusted based on KPI result.
- Provide transparency and maintain objectivity for team performance evaluation that is performed with quantitative measurement in KPI

Based on discussion of role for each team in organization chart explanation, evaluation of new project such as lowering operation pressure at offshore platform started from Subsurface Development and Planning that has a Senior Manager as decision maker. Senior Manager of subsurface development and planning is only one of the four senior manager that is managed by General Manager that is appointed as the highest commander in PT Pertamina Hulu Mahakam. Therefore, KPI from Subsurface Development and Planning team will be derived from the KPI of General Manager since KPI of the General Manager represents the company goals. KPI general manager can be seen from table below

Table 14 KPI PT Pertamina Hulu Mahakam (Source PHM Internal Document)

No		UNIT	TARGET 2021	POLARITAS	BOBOT (%) Sub	BOBOT (%) Total
A. Financial						
1	EBITDA	USD Million	890.83	Maximize	5	25
2	Economic Profit	%	26.02	Maximize	5	
3	Production Cost per Unit	USD/boe	19.70	Minimize	5	
4	Development Cost per Unit	USD/boe	11.21	Minimize	3	
5	Investment Realization	%	85-100	In Range	3	
6	Zone Operational Cost	%	90	Minimize	4	

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B. Customer Focus						
1	Oil Production	MBOPD	23	Maximize	6	25
2	Gas Production	MMSCFD	556	Maximize	6	
3	Development Well Success Ratio	%	80	Maximize	5	
4	POD/OPLL Submission	Document	1	Maximize	4	
5	POD/OPLL Realization	%	80	Maximize	4	
C. Internal Process						
1	R/P Ratio	Year	3.1	Maximize	5	35
2	Implementation of EOR	MBOEPD	0.20	Maximize	5	
3	Total Recordable Injury Rate (TRIR)	Rate	0.47	Minimize	4	
4	PROPER & HSSE SUPREME Assessment	%	100	Maximize	4	
5	Investment Approval Efficiency	%	80	Maximize	5	
6	QR/WS Study	%	100	Maximize	4	
7	Profile Pore Pressure and Fracture Gradient new wells	%	100	Maximize	4	
8	DS Strategy Management Meeting	%	100	Maximize	4	
D. Learning & Growth						
1	Investment realization	%	90	Maximize	4	15
2	Program Strategic Initiatives	%	100	Maximize	4	
3	Management of KSI & QMA	%	100	Maximize	3	
4	Learning Hours	Hour/Worker	250	Maximize	4	
						100

There are 23 items of objectives in KPI list. However not all items are related to phase 3 LLP compressor project. Items have to be classified that in line with objectives that will be delivered by the project. Internal discussion in SDP team that consist of Senior Manager, Manager Subsurface Development Area 2, Manager Development & Planning, Team Leader of Reservoir Engineer Team Area 2 and Team Leader of Development Team define 8 items that have strong and direct relation to LLP compressor project. They are: Economic Profit, EBITDA, Production Cost, Development Cost, Oil Production Volume, Gas Production Volume, POD/OPLL realization and QR/WS study.

To make sure the validity of selected KPI component related to business situation and LLP compressor project. Analysis is performed as follow:

- Validity of KPI component that will be used for evaluation criteria that is related to business situation

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Table 15 Selected KPI Objectives Relationship with LLP compressor Project

Criteria	Objective	Relation to Business Situation
Profit	Maximize	This criterion is related to economic and political factor in PESTEL analysis. High demand of gas in domestic market have urge Indonesia Government to increase output of national and oil gas production from existing or new fields. Besides production increase, proposed project still need to profitable. Incentive can be requested by oil and gas company thru SKK MIGAS to promote economic condition of the project
Cost	Minimize	This criterion is related to economic factor in PESTEL analysis. More project may give higher output to oil and gas production but the result is not always profitable. Any effort related to cost optimization have to be done to ensure project profitability.
Production	Maximize	This criterion is related to political, socio-culture and economic factor in PESTEL analysis. Energy from oil and gas is still strongly needed by Indonesia. Needs is from industry, electricity generation and household. Fulfilment of the needs will promote Indonesia economic growth.
Regulatory Compliance	As Per Commitment	This criterion is related to legal factor in PESTEL analysis. Project for field development have to be approved by SKK MIGAS that is documented in POD document. It is company and also SKK Migas objectives to ensure project is performed as close as possible to scope that is written in POD documents

- Validity of KPI component that will be used for evaluation criteria that is related to LLP compressor project

Table 16 Selected KPI Objectives Relationship with LLP compressor Project

KPI Objective	Criteria	Objective	Relation to LLP compressor Project
Economic Profit	Profit	Maximize	Profitability is an important aspect for project evaluation. Most project profitability is evaluated by NPV method. Project will be continued in case NPV is greater than 0
EBITDA			
Production Cost	Cost	Minimize	Cost still related to profitability. Development cost is needed to perform the project while additional production cost is occurred after the project completed. To ensure profitability, project cost has to be optimized
Development Cost			
Oil Production	Production	Maximize	Final product of the project is additional production from gas and oil. Oil and gas production will bring revenue to the company. Therefore, optimized production gain from the project is important aspect. This parameter also support government mission
Gas Production			

			to reach 1 million BOPD and 12,000 MMscfd and company strategy to continue maintain field production
POD/OPLL Realization	Regulatory Compliance	As Per Commitment	To perform project for field development, POD document is submitted that have to be approved by SKK MIGAS. Contractor performance will be reviewed based on realization of project scope that have been stated in document. To do that continuous internal study have to be performed to update project result as per latest discussion thru quality review or workshop.
QR (Quality Review)/WS (Workshop) Study			

To define weight for each attribute for LLP compressor project, value from KPI general manager will be used and to be averaged. Those attributes will be the selection criteria to select best scenario. Selection criteria that is derived from KPI is considered as value that have to be followed to choose best course of action for next phase LLP compressor project.

Table 17 Averaged Weight of KPI Objectives

KPI Objectives	Criteria	Value	Weight (%)
Economic Profit	Profit	5	13%
EBITDA	Profit	5	13%
Production Cost	Production Cost	5	13%
Development Cost	Development Cost	3	8%
Oil Production	Production	6	15%
Gas Production	Production	6	15%
POD Submission	Regulatory Compliance	4	13%
FS/FID Approval	Regulatory Compliance	5	10%
TOTAL		**39**	**100%**

Those 8 items will be grouped into 5 criteria that are profit, production cost, development cost, production and regulatory compliance. For each criterion, new attributes will be assigned to ensure attributes is aligned with project evaluation. Finally, list of attributes and weight factor will be concluded as follow:

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Table 18 Attributes for LLP compressor Project Evaluation

Attributes	Criteria	Value	Weight (%)
NPV (Net Present Value)	Profit	10	26%
Production Cost	Production Cost	5	13%
Development Cost	Development Cost	3	8%
Total Volume Production	Production	12	31%
Maximum Production Rate			
Completed Platform	Regulatory Compliance	9	23%
Project Completion Year			
TOTAL		**39**	**100%**

3.2. Attributes Evaluation

Each attributes have to be evaluated before value assignment. This chapter will discuss data gathering and evaluation for each criterion

- Operation Cost

Operation cost is related to additional cost that will occurred after LLP compressor is running at the platform. Component of operation cost will be fuel for utility boat and electric power generator and maintenance cost. Total operation cost estimation is provided by production operation and already accumulated based on duration of LLP compressor utilization.

Table 19 Operation Cost

Platform	MWP-C	SWP-J	JM-1	MD-1	MWP-S	WPS-2	WPN-2	WPN-3
Operation Cost (Million $)	3.4	5.5	2.4	2.1	10.1	2.1	1.8	1.4
LLP Compressor Utilization (Year)	3	4	4	3	8	3	3	2

- Development Cost

Cost for LLP project installation will be depend on compressor capacity, LLP compressor support system capacity (such as separator, liquid transfer pump, amount of flow line, etc.), electric power generator size and deck extension requirement. Total development cost estimation is provided by project team as follow:

Table 20 Development Cost

Platform	MWP-C	SWP-J	JM-1	MD-1	MWP-S	WPS-2	WPN-2	WPN-3
Development Cost (Million $)	14.2	14.5	17.6	15.8	21.1	18.7	18.4	18.9

- Production

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As per discussion in chapter, material balance method is used to forecast production rate and cumulative production gain that will be obtained after installation of LLP compressor. Gas from three offshore fields is categorized as wet gas, therefore significant amount of condensate will also produce. Condensate rate will be generated from CGR (condensate gas ratio) that is specific for each fields. To combine gas production and condensate production, a term of barrel oil equivalent will be used. Cumulative gas production will be convert to barrel oil equivalent by multiply it to a conversion factor, while cumulative condensate will be used directly

Several constraints that used to perform prediction and forecast:

- Time limit constraint which was end of 2037 as the contract between PHM and SKK Migas will end
- Key parameter in material balance calculation such as pressure abandonment and production gain at lower operation pressure based on well observation program
- The well will be automatically shut off in the simulation if the gas rate is below 0.3 MMscfd

Table 21 Yearly Gas Production

Platform	Gas Rate (MMscfd)							
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
MWP-C	2.3	4.5	1.9					
SWP-J	2.3	4.8	4.5	1.6				
MD-1	3.6	7.4	3.7	0.7				
JM-1	0.6	1.1	1.0					
MWP-S	2.4	7.8	7.5	4.8	4.2	3.7	1.9	0.2
WPS-2	1.8	3.2	0.8					
WPN-2	0.2	4.4	0.3					
WPN-3	0.6	3.6						

Table 22 Yearly Condensate Production

Platform	Condensate Rate (MMscfd)							
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
MWP-C	6.5	12.0	5.3					
SWP-J	6.5	12.7	11.7	4.4				
MD-1	108.0	219.5	108.7	21.1				
JM-1	16.7	33.9	29.5					
MWP-S	8.0	24.0	23.2	15.0	13.3	11.8	6.4	1.3
WPS-2	6.0	10.1	2.9					
WPN-2	1.3	13.9	1.6					
WPN-3	1.5	8.2						

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Refer to table 17, there will be two attributes that is related to production that are total volume production and max gas rate. Objective of the project is to increase production of the fields that will create revenue therefore scenario that could maximize total volume production and gas rate is preferable.

To convert oil and gas volume become gross revenue, it will be multiplied by gas price and oil price assumption that based on internal direction on 2022 and will be used for future project in Pertamina Hulu Mahakam

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Table 23 Crude and Gas Price Assumption

Parameters	Number	Remark
Crude Price	70 USD/BOPD	This number will be used from 2025 to 2037, flat. This number based on the internal direction in 2022 and will be used for all of project in Pertamina Hulu Mahakam
Gas Price	6 USD/MMscfd	This number based on weighted average price from various contract with domestic and western buyer.

- Profit

  Project profitability will be determined by NPV (Net Present Value). This method mostly used by most major company to evaluate project that is need investment. Net present value (NPV) is calculated by subtracting Initial Investment (CF0) from the present value of its cash inflows (CFt) discounted at a discount rate (r). In this evaluation, scenario that give higher NPV is preferable compare to other option

  NPV = Present Value of cash inflows – Initial Investment

$$NPV = \sum_{t=1}^{n} \frac{CF^t}{(1+r)^t} - CF_0$$

Each component that is needed for NPV calculation will be explained as follow:

- Initial Investment

Initial investment is equal to Development Cost.

- Discount Rate

Discount rate or Hurdle rate represent the minimum return expected to earned on an investment based on risk for each project. Hurdle rate that will be used in this evaluation will be 10.4% based on instruction at corporate level on 2022. Hurdle rate is estimated from summation of WACC (Weighted Average Capital Cost) and premium risk based on project.

- Cash Inflow

  PT Pertamina Hulu Mahakam (PHM) is appointed by SKK Migas as contractor to manage Delta Mahakam block for 20 years. The contract between PHM and SKK Migas is formulated with specific scheme that is called Production Sharing Contract. Production Sharing Contract (PSC) is: "A Contractual agreement between a contractor and a host government whereby the contractors bear all exploration cost and development and production cost in return for a stipulated of the production resulting from this effort". From this definition, there are three main characteristics of a PSC (Johnston: 1994)

  - Is a contract between contractors and the government (owner)
  - Contractors has the obligation to provide the capital required in order to perform exploration, development, and production
  - The cost recovery mechanism is stipulated based on the production split

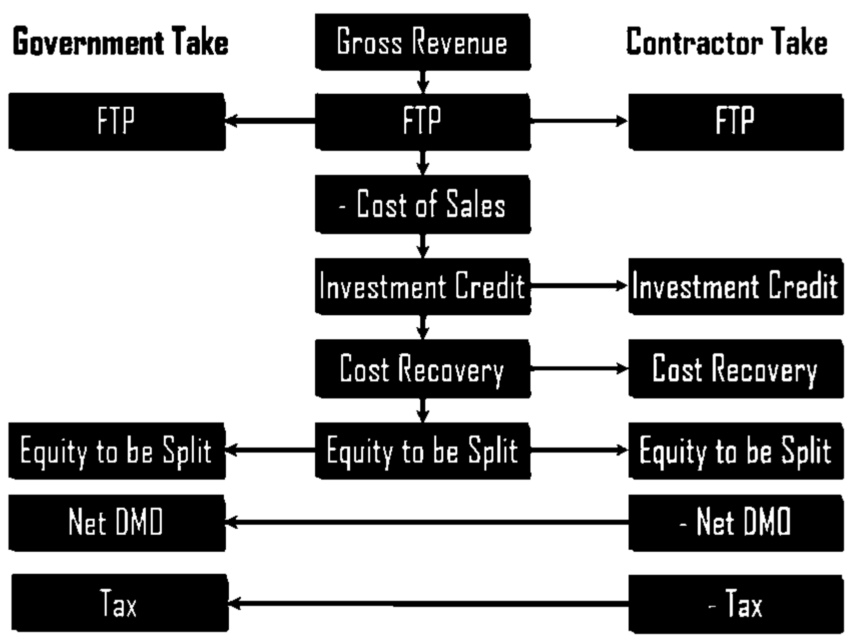

Figure 27 Production Sharing Contract (PSC) Scheme (Source PHM Internal Document)

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Cash inflow is divided between government and contractor due to PSC schema. Definition for each component in PSC model will be explained in following tables based on latest PSC MHK Block agreement:

Table 24 PSC MHK Block Component

<table>
<tr><th>PSC Component</th><th>Definition</th><th>Numbers</th></tr>
<tr><td>Gross Revenue</td><td>Value that is generated from sales of oil and gas product</td><td>Depend on volume of gas/oil production and sales price</td></tr>
<tr><td>First Tranche Petroleum (FTP)</td><td>First oil or gas tax for the government before the production split as per contract.</td><td>5%</td></tr>
<tr><td>Cost of Sales (CoS)</td><td>Cost for processing and transporting gas or LNG production</td><td>Depend on volume of gas/oil production</td></tr>
<tr><td>Investment Credit (IC)</td><td>Additional amount that contractor may collect on top of the recovery of the capital cost that it spent. It is normally conditional and given to contractor as incentive</td><td>17%</td></tr>
<tr><td>Cost Recovery</td><td>Portion of oil or gas revenue given to the contractor as reimbursement for the cost of operation it spent to perform the oil and gas activities</td><td>100%</td></tr>
<tr><td>Equity to be split</td><td>Remaining production that is shared between government and contractor after deduction of FTP, CoS, IC and cost recovery. It is depend on ratio between revenue and cost</td><td><table>
<tr><th rowspan="2">R/C Factor</th><th colspan="2">Split after tax (GOI : CTR)</th></tr>
<tr><th>Gas</th><th>Oil</th></tr>
<tr><td>0< R/C ≦1.0</td><td>65 : 35</td><td>80 : 20</td></tr>
<tr><td>1 < R/C ≦ 1.2</td><td>67.5 : 32.5</td><td>82.5 : 17.5</td></tr>
<tr><td>1.2 < R/C ≦ 1.4</td><td>70 : 30</td><td>85 : 15</td></tr>
<tr><td>1.4 < R/C ≦ 1.6</td><td>72.5 : 27.5</td><td>87.5 : 12.5</td></tr>
<tr><td>R/C > 1.6</td><td>75 : 25</td><td>90 : 10</td></tr>
</table></td></tr>
<tr><td>DMO (Domestic Market Obligation)</td><td>Portion of contractor oil that are contributed to government for national oil consumption</td><td>25%</td></tr>
<tr><td>Income Tax</td><td>Income tax is not imposed to contractor based on PSC tax regime</td><td>-</td></tr>
</table>

- Regulatory Compliance

POD document have defined to amount of platform that is targeted for LLP compressor installation and also year of completion. Project completion as stated in POD document is preferable.

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3.3. Alternative Generation

Result from pilot project is used to evaluate again next phase of LLP compressor project in term of surface and subsurface context. It is found incremental to additional cost and decrease to production gain due to impact of higher liquid rate. Economic evaluation is performed based on latest condition, found that not all platform have positive NPV. Although, project NPV will be performed in bundled for all targeted platform, presence of negative NPV for certain platform have reduced project value. Latest economical calculation for each platform is as follow:

Table 25 Economic Evaluation for Each Platform

Peciko			Sisi Nubi			South Mahakam		
Platforms	NCF	NPV	Platforms	NCF	NPV	Platforms	NCF	NPV
MWP-C	+	+	MWP-S	+	+	JM-1	-	-
SWP-J	+	+	WPS-2	+	-	MD-1	+	+
			WPN-2	+	-			
			WPN-3	-	-			

On this paper, profit that is represent by NPV is only one of the attributes that will be used for decision making. Other value that will considered beside profit is production cost, development cost, production and compliance to regulator. Therefore, several scenario is generated to optimizes value of each attributes that have been discussed previously

- Scenario 0 - Cancel Phase 3 LLP compressor project to all offshore platforms target

  Not continue phase 3 LLP is still part of decision. Therefore, this scenario still included in the evaluation. However, no added value from this scenario and also lost opportunity due to no additional gas production in this scenario

- Scenario 1 - Perform Phase 3 LLP compressor project to all offshore platforms target in same timeframe

  This is the base scenario that have expected project completion on 2025. Project NPV still greater than 0 but have been reduced after project is re-evaluated based on pilot project result. Other scenario need to be developed and review based on several attributes that has been discussed on chapter 3.1. Other scenario will be explained in scenario 2 and scenario 3

- Scenario 2 - Perform Phase 3 LLP compressor project only to selected platform and cancel to non-selected. Selection is performed based on two parameters in economic evaluation which are NCV (Net Cash Value) and NPV (Net Present Value)

  There will be two scenarios:

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- Scenario 2.1 Perform to platforms that have positive NPV
  Selected platforms are MWP-C, SWP-J, MWP-S, MD-1. Expected project completion on 2025
- Scenario 2.2 Perform to platform that have positive NCV
  Selected platforms are MWP-C, SWP-J, MWP-S, WPS-2, WPN-2 and MD-1. Expected project completion on 2025

- Scenario 3 - Perform Phase 3 LLP compressor project in sequence.
  In this scenario, platforms that have positive NPV will performed as first batch. Second batch of platforms that have negative NPV will be performed later.

  There will be two actions that can be done to improve NPV for platform that will be performed later. First action is to reduce development cost which can be done by rent LLP compressor or re-utilized LLP compressor from phase 1 and phase 2. Both action then reviewed by project team and conclude only LLP compressor re-use that can be performed. Rent option is not feasible because of required compressor capacity is not available for rent. Several scenarios for LLP compressor re-utilization will be generated. There will be scenario for re-utilized to only one platform up to all remaining platform. Prioritization is based on volume production gain

  Second action is to wait result from phase 1 and phase 2 that will be on stream in 2024 with assumption of better performance from phase 1 and phase 2. Decision to continue LLP compressor installation for second batch platform will be decided in 2025 after one-year observation of phase 1 and phase 2 performance. New LLP compressor will be provided with expected for project completion in 2027. Better performance of previous phase will also improve assumption of production gain for second batch platform. Higher production gain is higher revenue that will improve NPV. As explained before, material balance methodology is used to forecast production figure and cumulative production from LLP compressor project. Range of volume production gain need to be estimated due to subsurface uncertainty. This practice is common in oil and gas industry that are based on international reference that also already adopted by PERTAMINA. References that have been recognized and used by the international oil and gas industry estimation of oil and gas reserves and resources is Petroleum

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Resources Management System or better known as PRMS. There will be three range in prediction expected volume production gain from field development action namely Low (1P), Best Estimate (2P) and High (3P). In this scenario only, 3P case will be used for volume production gain for second batch platform. While other scenario, use 2P case for volume production gain.

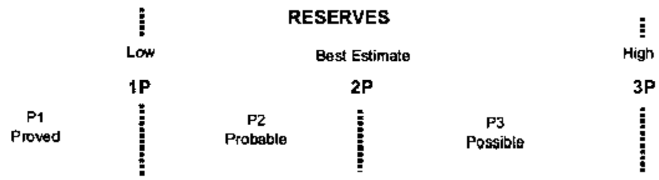

Figure 28 Volume Production Range (Source PRMS Document)

As summary, list of scenario is as follow:

- Scenario 3.1 - Better gain assumption and new LLP compressor for 4 platforms.
  Selected platforms are WPS-2, WPN-2, WPN-3 and JM-1. Expected project completion on 2027
- Scenario 3.2 - Re-utilization of LLP compressor to 4 platforms
  Selected platforms are WPS-2, WPN-2, WPN-3 and JM-1. Expected project completion on 2031
- Scenario 3.3 - Re-utilization of LLP compressor to 3 platforms
  Selected platforms are WPS-2, SWP-J and MWP-S. Expected project completion on 2029
- Scenario 3.4 - Re-utilization of LLP compressor to 2 platforms
  Selected platforms are WPS-2 and WPN-2. Expected project completion on 2028
- Scenario 3.5 - Re-utilization of LLP compressor to 1 platforms
  Selected platforms are WPS-2. Expected project completion on 2028

3.4. SMART Method to Define Best Scenario

SMART (Simple Multi Attribute Rating Technique) will be used to find the best alternative. It is a comprehensive decision making model that based on quantitative method. In SMART, there are 8 main stages, explanation for each step on this research as follow:

1. Identification of the decision maker

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Decision maker for LLP compressor project as discussed on organization structure is Senior Manager Subsurface Development and Planning and Senior Manager Project. Option for LLP compressor installation was reviewed by both team in term of subsurface and surface. Both of Senior Manager is reported to General Manager. As discussed before, KPI for both team already included in General Manager that related parameters have chosen to be used for choose the best alternatives

2. Identification of alternatives

   As discussed on alternative generation chapter, there will be 8 scenarios that will be evaluated

3. Identification of relevant evaluation criteria or attributes

   Related attributes for LLP compressor is taken from General Manager KPI. There are 4 criteria that will be used: Profit, Production Cost, Development Cost, Production and Regulatory Compliance

4. Assess the performance of each attributes

   Each attributes for each scenario will be evaluated. However, each attributes have different unit. Profit and Cost used million $ while production used barrel oil equivalent. Value will be assigned for each attributes to replace unit, therefore total value for each attributes can be summed.

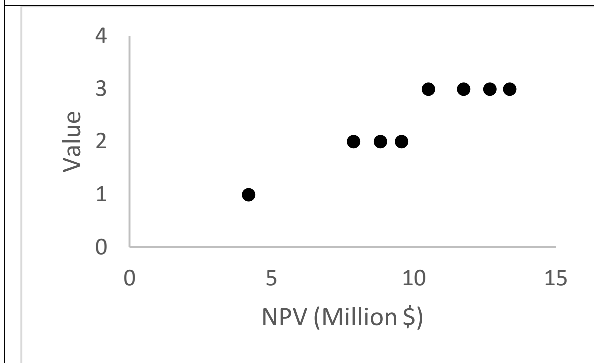
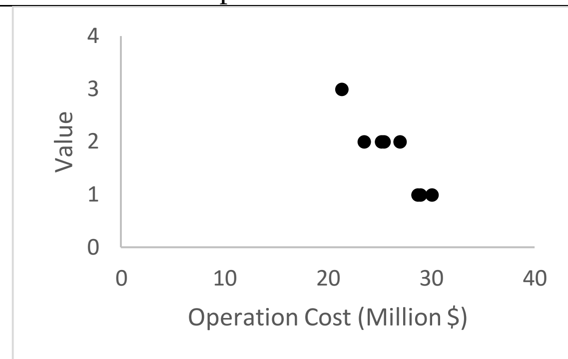
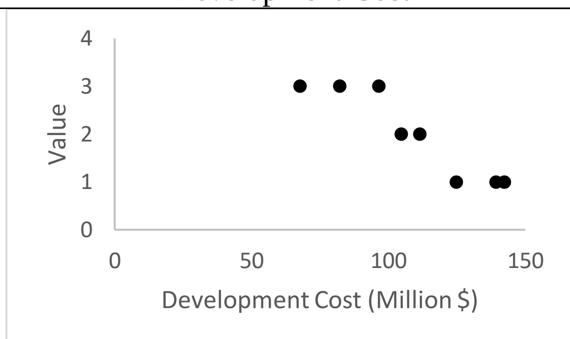
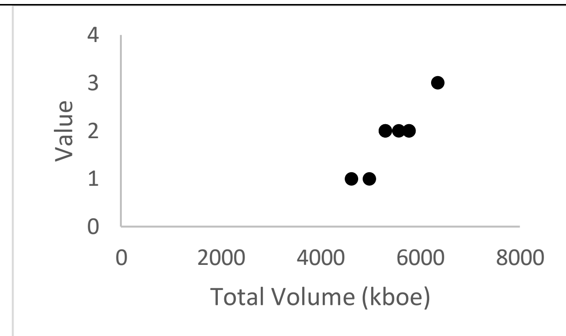
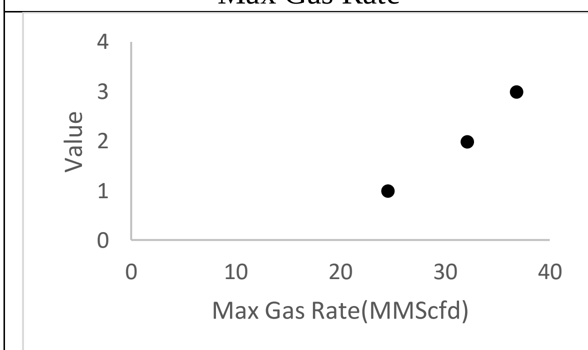
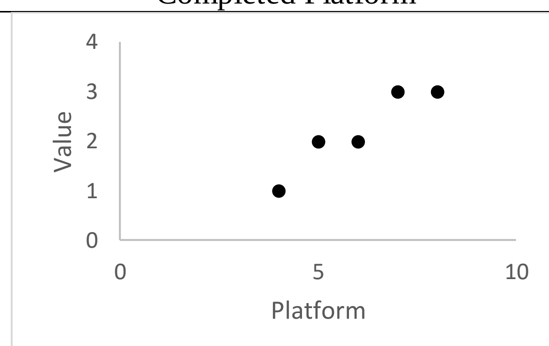
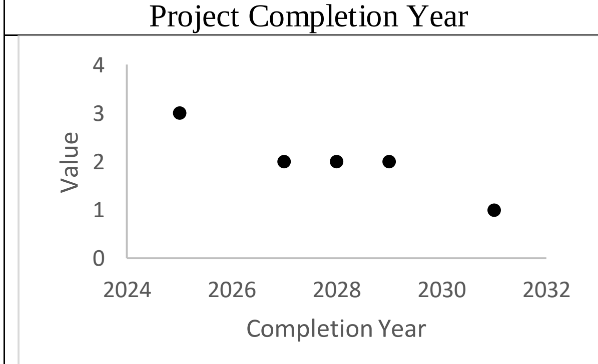
   Calculation result for each scenario before value assignment can be seen below:

Table 26 Attributes Performance for Each Scenario

Scenario	Profit	Cost		Production		Regulatory Compliance	
	NPV (Million $)	Operating Cost (Million $)	Development Cost (Million $)	Total Volume (kboe)	Max Gas Rate (MMscfd)	Completed Platform	Project Completion Year
0	0	0	0	0	0	0	0
1	4.18	28.69	139.24	5772.63	36.77	8	2025
2.1	13.38	21.33	67.51	4616.71	24.47	4	2025
2.2	8.83	25.21	104.61	5304.73	32.06	6	2025
3.1	7.88	28.99	142.14	6356.12	24.47	8	2027
3.2	9.56	30.07	124.67	5772.63	24.47	8	2031
3.3	10.51	26.97	111.23	5573.09	24.47	7	2029
3.4	11.76	25.44	96.36	5305.05	24.47	6	2028
3.5	12.67	23.54	82.11	4986.35	24.47	5	2028

Value assignment is based on ranking within each attributes as follow

Table 27 Value Function for Each Attributes

NPV	Operation Cost
	
Development Cost	**Total Volume Production**
	
Max Gas Rate	**Completed Platform**
	
Project Completion Year	
	

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Total value calculation for each scenario as follow

Table 28 Value based on Attributes Performance for Each Scenario

Scenario	Profit	Cost		Production		Regulatory Compliance	
	NPV	Operating Cost	Development Cost	Total Volume	Max Gas Rate	Completed Platform	Project Completion Year
0	0	0	0	0	0	0	0
1	1	1	1	2	3	3	3
2.1	3	3	3	1	1	1	3
2.2	2	2	2	2	2	2	3
3.1	2	1	1	3	1	3	2
3.2	2	1	1	2	1	3	1
3.3	3	2	2	2	1	3	2
3.4	3	2	3	2	1	2	2
3.5	3	2	3	1	1	2	2

5. Assignment of importance weights for each of the evaluation criteria

   Importance weight for each attributes refer to table 17 that have been discussed in chapter 3.1 attribute definition

6. Calculation of a weighted average of the values that is assigned each of the alternatives

   Weighted average of value for refer to table 17 that have been discussed in chapter 3.1 attribute definition.

7. Provisional decision plot

   Provisional decision plot is created by doing cross-plot between aggregate value and cost. Aggregate value is calculated by perform summation of attribute value after multiply to weighted average.

Table 29 Aggregate value for each scenario

Scenario	Profit	Operating Cost	Development Cost	Production	Regulatory Compliance	Total Value	Total Cost (Million $)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.26	0.13	0.08	2.46	1.38	3.38	167.94
2.1	0.77	0.38	0.23	0.62	0.92	2.92	88.85
2.2	0.51	0.26	0.15	1.54	1.15	3.31	129.82
3.1	0.51	0.13	0.08	2.15	1.15	3.10	171.13
3.2	0.51	0.13	0.08	1.85	0.92	2.56	154.74
3.3	0.77	0.26	0.15	1.54	1.15	3.26	138.20
3.4	0.77	0.26	0.23	1.23	0.92	3.10	121.80
3.5	0.77	0.26	0.23	0.92	0.92	2.79	105.65

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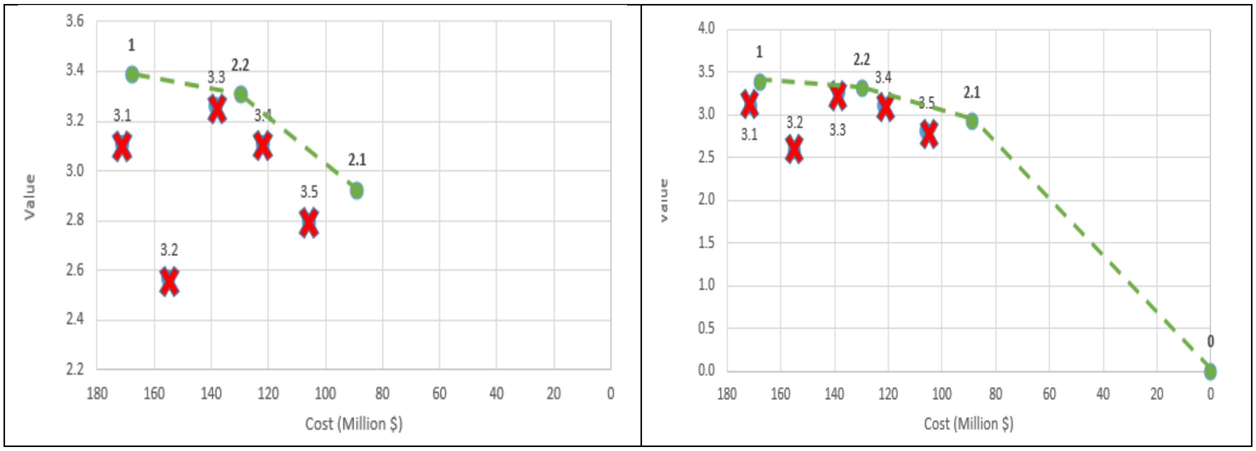

Figure 29 Plot Aggregate Value against Cost for 9 scenarios

From the graph, it can be seen that additional cost is required to get higher value. Evaluation of provisional decision will be performed by compare scenario value that have same cost range at US$ 160-180 million. For example, highest cost is needed for scenario 1 and scenario 3.1. However, scenario 1 has higher value than scenario 3.1. Therefore, scenario 1 is preferable. Same step is performed to other scenarios then conclude three scenarios that have the highest value that are scenario 1, scenario 2.2 and scenario 2.1. If we draw lines from scenario 1 to scenario 2.1 (green lines), we could define the efficient frontier. Every scenario that is located below efficient frontier is not worth to be considered further.

Table 30 Scenario that is located at efficient frontier for Total Value and Cost

Scenario	Total Value/Benefit	Total Cost (Million $)
1	3.38	167.94
2.2	3.31	129.82
2.1	2.92	88.85

To decide the best alternative between each scenario, further evaluation can be performed as follow:

- First evaluation to be performed will be based decision maker preference between value and cost. If the decision maker has much concerned about value, then scenario 1 will be the choice. Alternatively, if the focus is to keep cost low, then scenario 2.1 is the choice. Based on KPI that have been discussed, cost is one of the component that need to minimized. Therefore, scenario 2.1 is the best alternative due to has the lowest cost. Scenario 2.1 cost is 52% lower than scenario 1 and 68% lower than scenario

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- Second evaluation is method that is proposed by Edwards and Newman (Multi Attribute Evaluation, 1986). The method proposed to evaluate the need of additional cost for each additional point of value between option. Evaluation result can be seen below:

Table 31 Evaluation with Edward and Newman Method for Total Value and Cost

			Scenario 1		Scenario 2.2	
			Cost (Million $)	Value	Cost (Million $)	Value
			167.94	3.38	129.82	3.31
Scenario 2.1	Cost (Million $)	88.85	79.09	0.46	40.97	0.38
	Value	2.92	$171.36 Million/point		$106.53 Million/point	
Scenario 1	Cost (Million $)	167.94			38.11	0.08
	Value	3.38			$495.49 Million/point	

From above table, cost needed for one additional point to move between scenario can be evaluated. To have additional point of value, range of additional cost will be $106.53 Million to $495.49 Million. Therefore, it still preferable to choose scenario 2.1 due to the magnitude of additional cost that is needed.

- Third evaluation is performed by choose one of the attribute that relatively easy to evaluate in monetary terms. It can be seen that scenario 2.1 still the best option. Scenario 2.1 has the highest profit with the lowest cost

Table 32 Scenario that is located at efficient frontier for Profit and Cost

Scenario	Profit (Million $)	Total Cost (Million $)
1	4.18	167.94
2.2	8.83	129.82
2.1	13.38	88.85

After various analysis on the remaining choice that is located at efficient frontier line, it can be concluded that scenario 2.1 is the best option. Action in scenario 2.1 is to continue phase 3 of LLP project only to 4 platforms that have positive NPV namely MWP-C, SWP-J, MWP-S, MD-1. Implementation action for scenario 2.1 will be performed in chapter 4.

8. Sensitivity analysis

The last step of SMART is sensitivity analysis. In sensitivity analysis one of the weight of an attribute will be changed into zero (0) and then the aggregate value will be recalculated to evaluate the stability of the choices when the level of importance for particular attributes is changed.

In this research, five attributes will be grouped into two. First group consist of profit, development cost and production cost. Second group consist of production and regulatory compliances. Group is created based on different objectives between government and contractor. Contractor have main objectives to maximize profit and minimize cost. On the other side, government have objectives to maximize hydrocarbon production and realization of project that already stated in POD document.

Table 33 Sensitivity Analysis on Profit, Operating Cost and Development Cost

Weight Factor	0.0	0.0	0.0	0.57	0.43		
Scenario	Profit	Operating Cost	Development Cost	Production	Regulatory Compliance	Total Value	Cost (Million $)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	2.86	2.57	5.43	167.94
2.1	0.00	0.00	0.00	1.14	1.71	2.86	88.85
2.2	0.00	0.00	0.00	2.29	2.14	4.43	129.82
3.1	0.00	0.00	0.00	2.29	2.14	4.43	171.13
3.2	0.00	0.00	0.00	1.71	1.71	3.43	152.95
3.3	0.00	0.00	0.00	1.71	2.14	3.86	138.20
3.4	0.00	0.00	0.00	1.71	1.71	3.43	121.80
3.5	0.00	0.00	0.00	1.14	1.71	2.86	105.65

Table 34 Sensitivity Analysis on Production and Regulatory Compliance

Weight Factor	0.56	0.28	0.17	0.0	0.0		
Scenario	Profit	Operating Cost	Development Cost	Production	Regulatory Compliance	Total Value	Cost (Million $)
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.56	0.28	0.17	0.00	0.00	1.00	167.94
2.1	1.67	0.83	0.50	0.00	0.00	3.00	88.85
2.2	1.11	0.56	0.33	0.00	0.00	2.00	129.82
3.1	1.11	0.28	0.17	0.00	0.00	1.56	171.13
3.2	1.11	0.28	0.17	0.00	0.00	1.56	152.95
3.3	1.67	0.56	0.33	0.00	0.00	2.56	138.20
3.4	1.67	0.56	0.50	0.00	0.00	2.72	121.80
3.5	1.67	0.56	0.50	0.00	0.00	2.72	105.65

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Table 35 Sensitivity Analysis Summary

Scenario	Base Case	Profit + Development Cost + Operating Cost = 0	Production + Regulatory = 0
0	0.00	0.00	0.00
1	3.38	5.43	1.00
2.1	2.92	2.86	3.00
2.2	3.31	4.43	2.00
3.1	3.10	4.43	1.56
3.2	2.56	3.43	1.56
3.3	3.26	3.86	2.56
3.4	3.10	3.43	2.72
3.5	2.79	2.86	2.72

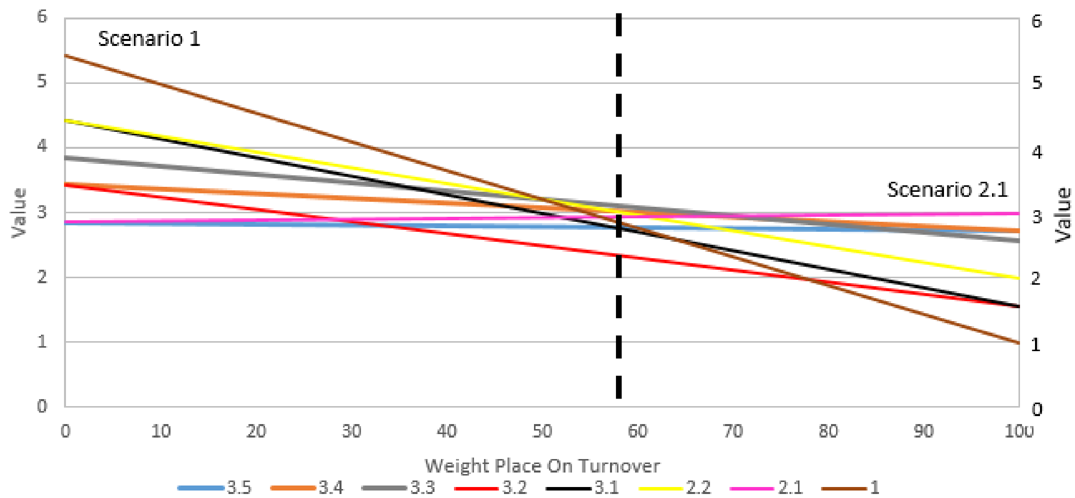

Figure 30 Sensitivity Analysis

From sensitivity analysis, it can be seen if focus is given to production and regulatory, scenario 1 will have superior benefit value compare to other scenario. Scenario 1 action is to continue perform LLP compressor to all platform without concern to profit and cost. In case focus is given to profit and cost, scenario 2.1 will have the highest value. This result is in line with evaluation in step 7 that focus to profit and cost. Therefore, as long as weight of total turnover for profit and cost is higher than 59%, scenario 2.1 will be the most attractive option.

3.5. Summary

Several scenario is generated to find the best course of action for phase 3 of LLP project. To ensure alternative is driven by company value, a set of attributes is extracted from company

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KPI. As the result, nine scenarios is generated. To find the best alternative, SMART method is use to compare aggregate benefit for each scenario compare to cost that is required.

Based on provisional decisional plot, an efficient frontier line can be created. There are three best scenarios namely scenario 1 (install LLP compressor to all platforms target), scenario 2.1 (install LLP compressor to platform that have positive NPV) and scenario 2.2 (install LLP compressor that have positive NCF). Further evaluation is performed to choose the best option. Scenario 2.1 is concluded as the best option for phase 3 LLP compressor project. The conclusion is based on decision maker preference to cost over value, high additional cost that is needed to have additional point for aggregate benefit and comparison to attribute that have monetary value.

Sensitivity analysis is performed by group attributes into two group, first group is profit, development cost and production that are the main concern of the company. Second group is production and regulatory compliance that are the main concern of government agency. Scenario 2.1 will be the most attractive option as long as weight of total turnover for profit and cost is higher than 59%.

Based on above analysis and evaluation, writer suggest scenario 2.1 as the best option for phase 3 LLP project that will be performed in three offshore fields

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Chapter IV – Conclusion and Implementation

4.1. Conclusion

Study objectives in general is to evaluate and propose best alternative of action for next phase of LLP compressor project. Focus on this study is phase three that initially planned for eight offshore platforms. This study also covers a number of issues raised in Chapter 1:

"Why pilot LLP compressor project has higher liquid rate than estimation?"

Kepner-Tregoe method is used to find to root cause of problem that is encountered in pilot project. Analysis is started with problem statement, problem definition, possible cause identification and testing. There are four possible causes that could become the root cause namely reservoir behavior, liquid transfer pump capacity, access inside well to isolate liquid source and liquid rate measurement. Reservoir behavior and access inside well are viewed as causes that is not uncontrollable while liquid transfer capacity and liquid rate measurement considered as controllable cause.

As liquid transfer pump capacity is defined based on liquid rate measurement that is assumed based LP operating condition therefore inaccuracy of liquid measurement become the root cause of high liquid rate issue in pilot project. Based on this finding, accurate liquid measurement is executed for each platform target with offload operation. Offload operation is performed to mimic LLP operating condition.

"What is the impact of the pilot project failure on the success of the next phase of LLP compressor project?"

Impact of liquid rate issue in pilot project is evaluated in term of surface and subsurface aspects. There is two impact in term of surface impact, first impact is higher cost due to additional equipment, range of additional cost for phase three is +16 to +22%. Second impact is delay of project execution of around two years due to needs of re-study of engineering aspect and well observation. Subsurface impact is evaluated with material balance method and conclude lower expected production gain in the range of -19% to -43%

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"What are the criteria to evaluate the best alternative for next phase of LLP compressor project?"

Value-Focus Thinking suggests that value need to be defined prior to alternative construction. Key Performance Indicator (KPI) comprise of several parameters that related to company performance. Eight parameters in KPI that have strong and direct relation to LLP compressor project are economic profit, EBITDA, production cost, development cost, oil production volume, gas production volume, POD/OPLL realization and QR/WS study. Those parameters than grouped into 5 criteria that are profit, production cost, development cost, production and regulatory compliance. For each criterion, new attributes are assigned to aligned with project objectives. In the end, they are 5 attributes that will be used to defined best alternative of LLP project namely NPV, production cost, development cost, production and regulatory compliance.

"What is the best course of action that will be implemented for next phase of LLP compressor Project?"

Nine scenarios are generated based on attributes as value reference. Evaluation of all scenarios is performed with SMART approach. Based on efficient-frontier line that is drawn in the plot of aggregate value against cost, it is concluded three best scenarios. Further evaluation to three best scenarios have concluded that scenario 2.1 as the best option. Action in scenario 2.1 that will be performed is to install LLP compressor to four offshore platforms that have positive NPV. Platforms name are MWP-C, SWP-J, MWP-S, MD-1. Sensitivity analysis is performed based on weight of turnover to two group that represent company and government perspective. Proposed scenario will still be the best option as long as weight of total turnover for company perspective is higher than 59%.

SMART method proposal to define best scenario for phase 3 of LLP compressor project have been discussed with manager of subsurface development area 2. Area 2 is responsible for

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subsurface development of three offshore gas field namely Peciko, Sisi Nubi and South Mahakam. Approval can be seen at figure 31 based on email correspondence

Dear Mas Prayudi,

I am in full agreement with your explanations below. Please proceed to continue the discussion with SHU and SKK Migas.

Thanks and Regards,

Bayu Handoko

Pjs Mgr SDA2

Subject: SMART method to decide next step for LLP Project in Offshore Fields

Dear Manager SDA2,

Pilot project at SWP-G have issue related to high liquid rate with magnitude 8-10 times higher than estimation.
Analysis to root cause has found that liquid rate estimation deviation is happened due to improper liquid measurement at offload condition

Campaign of well observation to have proper liquid measurement for platform targets that is located in 3 offshore fields have been performed. Due to the scale of operation in three fields, the activity need 1.5 years to be completed.
Well observation result show that same issue of high liquid rate is also found in the future platforms target

Surface analysis and subsurface analysis show increase of cost due to need of additional equipment to handle higher liquid rate and decrease of profit due to decreasing production gain.
Latest economic evaluation show negative NPV at several platforms.

Notes : NCF = Net Cash Flow and NPV = Net Present Value

Peciko			Sisi Nubi			South Mahakam		
Platforms	NCF	NPV	Platforms	NCF	NPV	Platforms	NCF	NPV
MWP-C	+	+	MWP-S	+	+	JM-1	-	-
SWP-J	+	+	WPS-2	+	-	MD-1	+	+
			WPN-2	+	-			
			WPN-3	-	-			

Based on PESTEL analysis, solely depend on profit evaluation is no longer enough.
Political and Social-Culture factor analysis show Government of Indonesia have vision to reach 12 BCFD by 2030 to fulfill natural gas demand that have continuously increase since 2006
Legal factor analysis also indicate contractor responsibility to fulfill job scope in POD document.

Therefore, Value-Focus Thinking and SMART method is proposed to find the best alternative for future LLP compressor project
Value-Focus Thinking is used to select criteria in company KPI (Key Performance Indicator) that is related to business situation and LLP project
Based on chosen attributes, nine scenario are generated and further evaluation with SMART (Simple Multi Attribute Rating Technique) method is performed to choose the best scenario

Component	Attributes	Unit	Value	Weight (%)
Profit	NPV (Net Present Value)	Million $	10	26%
Cost	Production Cost	Million $	5	13%
	Development Cost	Million $	3	8%
Production	Total Volume Production	Kboe	12	31%
	Maximum Production Rate	MMscfd		
Regulatory Compliance	Completed Platform	Numbers	9	23%
	Project Completion Year	Year		
TOTAL			39	100%

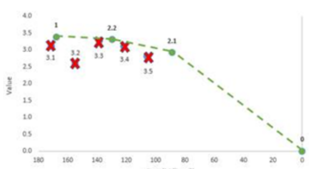
Scenario 0 - Cancel Phase 3 LLP compressor project to all offshore platforms target

Scenario 1 - Perform Phase 3 LLP compressor project to all offshore platforms target in the same year

Scenario 2 - Perform Phase 3 LLP compressor project only to the selected platform
- **Scenario 2.1** - Perform to platforms with positive NPV
- **Scenario 2.2** - Perform to platforms with positive NCF

Scenario 3 - Perform Phase 3 LLP compressor project in sequence
1st Sequence : Platforms with Positive NPV
2nd Sequence : Remaining Platforms
- **Scenario 3.1** - New LLP compressor after observe phase 1 and phase 2 result. Better gain assumption
- **Scenario 3.2 to 3.5** - LLP compressor reutilization. **3.2** - 4 platforms, **3.3** - 3 platforms, **3.4** - 2 platforms, **3.5** - 1 platforms

Provisional-Decision plot is cross plot between total value and total project cost. Total value for each scenario is calculated with SMART method and Total cost project is based on estimation from Project team
From the plot, efficient frontier line (green line) can be drawn to define best alternative. Three scenario namely scenario 1, scenario 2.1 and scenario 2.2 is located at efficient-frontier line will be evaluated further.
Other scenario that is located below efficient-frontier will be no longer considered



Another evaluation step is performed to choose the best scenario from three best alternative based on preference to cost over value, evaluation of additional cost for each additional value and use attribute with monetary term as main value
Finally, after running proper evaluations as mentioned, the best scenario for LLP compressor future project is scenario 2.1. Action in scenario 2.1 is to continue LLP compressor project to 4 platforms namely MWP-C, SWP-J, MWP-S and MD-1

I would like to get your comment and validation related the evaluation result from this method before continue to the discussion with Sub Holding Upstream and SKK MIGAS

Best Regards,
Prayudi Noverri

Figure 31 Method Validation from Decision Maker (Source PHM Internal Document)

4.2. Recommendation

- Based on decision analysis using the SMART approach, it is recommended to the management of PT Pertamina Hulu Mahakam to execute the third phase of LLP compressor installation on 4 offshore platforms, namely MWP-C, SWP-J, MWP-S, and MD-1.
- Gas price and equipment cost have to be reviewed periodically if option of LLP compressor is still open for remaining four offshore platforms. Gas price incremental and cost reduction of LLP compressor and related equipment will be essential factor to open again LLP compressor option
- Evaluation to other techniques such as surfactant injection, velocity string or downhole liquid pump to improve production from remaining four platforms have to be performed. New techniques have to be simpler and have lower cost in order to have better NPV than LLP compressor installation

4.3. Implementation Plan

Refer to study that already performed, LLP compressor will be installed in four platforms. MWP-C and SWP-J is located at Peciko Fields, MWP-S is located at Sisi-Nubi Fields and MD-1 is located at South Mahakam. LLP compressor installation need major modification to existing platform. In term of project scope, it will require engineering study, material procurement, fabrication and installation of LLP compressor and the support system. In general, planning for proposed scenario for phase 3 of LLP compressor project as follow:

1. Well observation and subsurface evaluation. Well observation is performed to have good measurement of expected liquid rate at LLP operating condition. Subsurface evaluation is performed with material balance method that also use well observation data. In this research, well observation and subsurface evaluation have been completed in Q2 2022.
2. Front End Engineering Design (FEED) for structural, piping, electrical, instrument and control system, and process in 4 platforms. This step is expected to be completed in Q2 2023.
3. Contract and procurement will be started after FEED is completed in Q2 2023. The contract process will need 6 months to be completed.

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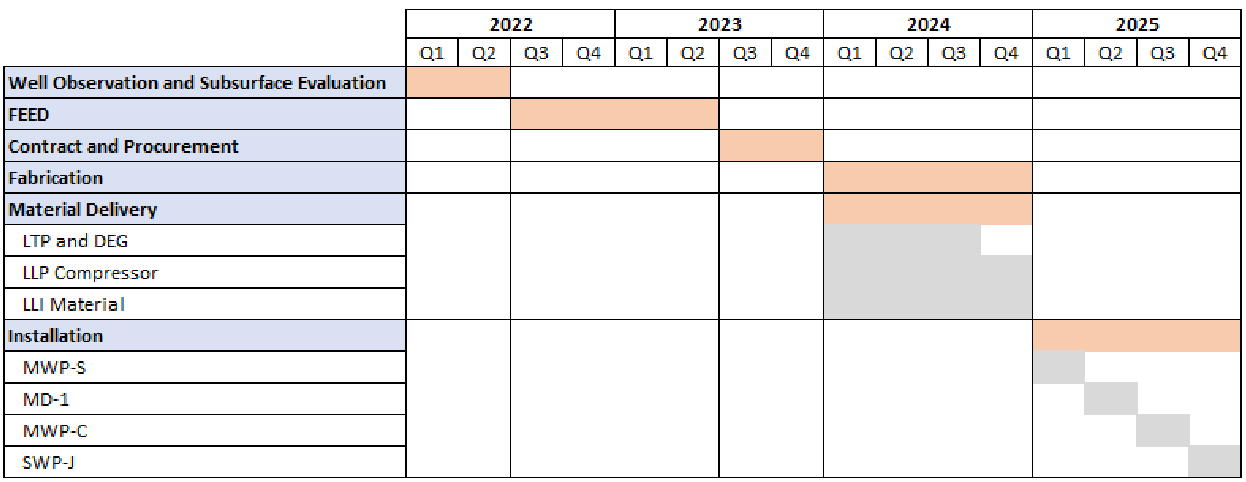
4. Material and equipment delivery that is expected to be started in Q1 2024 after the vendors have been appointed. There will be three major deliveries that have different completion duration. Liquid transfer pump and Diesel Engine Generator will need 9 months to complete delivery. LLP compressor and Long lead item delivery such as valve, instrument system is expected to be completed in 12 months.
5. Fabrication stage for deck extension and additional production manifold also started in Q1 2024. This stage will need 12 months for completion
6. Installation stage will need 3 months and to be performed in series. Order will depend on expected cumulative production from each platform target. Order of installation will be, first order is MWP-S, second order is MD-1, third order is SWP-J and last order is MWP-C. This stage will need 12 months for completion

Table below shows a proposed plan for how to carry out this project based on the steps that have been described above.

Table 36 Implementation Plan



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