MAINTENANCE STRATEGY FOR AGING FACILITIES OF OIL AND GAS COMPANY

FINAL PROJECT

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ABSTRACT

This study aims to develop a functional maintenance management strategy that goes beyond its traditional role as a cost center or merely a support function, positioning it as a dynamic profit source for NSO. The strategy focuses on optimizing equipment efficiency, reliability, and longevity, addressing challenges related to asset aging. By adopting a proactive and value-based maintenance model, this strategy seeks to minimize downtime and costs, reduce loss production opportunities, enhance operational performance, and ultimately contribute to the company's profitability.

The methodology involves comprehensive external and internal analysis. External analysis includes PESTEL, Porter's Five Forces, and consumer analysis, while internal analysis encompasses resource analysis, Porter's Value Chain framework, core competency analysis, and VRIO analysis. The findings from these analyses are synthesized into a SWOT analysis, followed by a TOWS matrix to determine alternative strategies, which are then translated into actionable implementation plans.

The main findings propose four strategic solutions: first, risk-based maintenance management using CMMS, which includes maintenance planning, execution, controlling and monitoring, and evaluation. Second, the development of a superior maintenance organization involves forecasting maintenance workload, capacity planning, organizational structuring (centralized, decentralized, or hybrid), and identifying in-house and outsourced maintenance work. Third, enhancing workforce skills through the development of skill matrices, emphasizing safety and regulatory compliance, continuous training and skill development, and regular evaluations to adapt to changing requirements. Fourth, developing strategic partnerships with suppliers through synergy in joint procurement with fellow PSCs, both with subsidiary entities under the Sub Holding Company and with other PSCs, as well as seeking synergy opportunities with state-owned enterprises and their affiliates.

The study concludes that a structured, risk-oriented approach, comprehensive planning, workforce skill enhancement, and strategic collaboration can transform maintenance management into a sustainable profit source. Given the dynamic nature of the industry, companies must regularly review and adjust their maintenance strategies. This approach aligns with asset integrity management systems based on continuous improvement principles, ensuring maintenance strategies remain optimal and responsive to evolving challenges. Consequently, maintenance management becomes not only a profit source but also a crucial pillar of operational sustainability.

Keywords: reliability, availability, loss production opportunity (LPO), AIMS, RCM, RBI.

STRATEGI PEMELIHARAAN PADA FASILITAS TUA DI PERUSAHAAN MINYAK BUMI DAN GAS

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ABSTRAK

Penelitian ini bertujuan untuk mengembangkan strategi manajemen pemeliharaan fungsional yang melampaui peran tradisionalnya sebagai pusat biaya atau sekadar fungsi pendukung, dan memposisikannya sebagai sumber keuntungan dinamis bagi NSO. Strategi ini berfokus pada optimasi efisiensi, keandalan, dan umur panjang peralatan, serta mengatasi tantangan terkait penuaan aset. Dengan mengadopsi model pemeliharaan yang proaktif dan berbasis nilai, strategi ini berupaya meminimalkan waktu henti dan biaya, menurunkan kehilangan peluang produksi (loss production opportunity), meningkatkan kinerja operasional, dan pada akhirnya berkontribusi pada profitabilitas perusahaan.

Metodologi penelitian melibatkan analisis eksternal dan internal yang komprehensif. Analisis eksternal mencakup PESTEL, Lima Kekuatan Porter, dan analisis konsumen, sedangkan analisis internal mencakup analisis sumber daya, kerangka Rantai Nilai Porter, analisis kompetensi inti, dan analisis VRIO. Hasil analisis ini disintesiskan ke dalam analisis SWOT, diikuti dengan matriks TOWS untuk menentukan strategi alternatif yang kemudian diterjemahkan ke dalam rencana implementasi yang dapat ditindaklanjuti.

Temuan utama penelitian mengusulkan empat solusi strategis: pertama, manajemen pemeliharaan berbasis risiko menggunakan CMMS, yang meliputi perencanaan pemeliharaan, eksekusi pemeliharaan, pengendalian dan pemantauan, serta evaluasi pemeliharaan. Kedua, pengembangan organisasi pemeliharaan yang unggul melalui perkiraan beban pemeliharaan, perencanaan kapasitas, penataan organisasi (terpusat, terdesentralisasi, atau hibrid), dan identifikasi pekerjaan pemeliharaan in-house dan outsourced. Ketiga, peningkatan keterampilan tenaga kerja melalui pengembangan matriks keterampilan, penekanan pada keselamatan dan kepatuhan terhadap peraturan, pelatihan berkelanjutan dan pengembangan keterampilan, serta evaluasi rutin untuk beradaptasi dengan perubahan persyaratan. Keempat, pengembangan kemitraan strategis dengan penyedia barang dan jasa melalui sinergitas dalam pengadaan bersama dengan sesama KKKS, baik dengan entitas anak perusahaan di bawah Sub Holding Company maupun dengan KKKS lain, serta mencari peluang sinergitas dengan BUMN dan perusahaan afiliasinya.

Penelitian ini menyimpulkan bahwa pendekatan yang terstruktur, berorientasi risiko, perencanaan menyeluruh, peningkatan keterampilan tenaga kerja, dan kolaborasi strategis dapat mengubah manajemen pemeliharaan menjadi sumber keuntungan yang berkelanjutan. Mengingat sifat industri yang dinamis, perusahaan harus secara berkala meninjau dan menyesuaikan strategi pemeliharaannya. Pendekatan ini selaras dengan sistem manajemen integritas aset berdasarkan prinsip perbaikan berkelanjutan, memastikan strategi pemeliharaan tetap optimal dan responsif terhadap tantangan yang terus berkembang. Dengan demikian, manajemen pemeliharaan tidak hanya menjadi sumber keuntungan tetapi juga merupakan pilar penting keberlanjutan operasional perusahaan.

Kata Kunci: keandalan, ketersediaan, potensi kehilangan produksi (LPO), AIMS, RCM, RBI.

VALIDATION PAGE

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FOREWORD

First and foremost, I would like to express my deepest gratitude to God Almighty for His blessings and guidance, which have enabled me to complete this research successfully.

I would also like to extend my heartfelt thanks to my family. To my wife, Mey Corry Siagian, and my daughter, Audrey Samantha Lumban Gaol, thank you for your unwavering support, patience, and understanding. Your love and encouragement have been my greatest source of strength throughout this journey.

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Bandung, August 2024

Esron Hadinata Lumban Gaol

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LIST OF ABBREVIATIONS AND SYMBOLS

AI	:	Artificial Inteligent
AKHLAK	:	*Amanah, Kompeten, Harmonis, Loyal, Adaptif, and Kolaboratif* (Trustworthy, Competent, Harmonious, Loyal, Adaptive, and Collaborative)
APDN	:	*Apresiasi Produk Dalam Negeri* (Appreciation of Domestic Products)
APBN	:	*Anggaran Pendapatan dan Belanja Negara* (State Budget)
AIMS	:	Asset Integrity Management System
ALARP	:	As Low as Reasonably Practicable
APO	:	Aceh Production Operation
BdM	:	Breakdown Maintenance
BOT	:	build-operate-transfer
BUMD	:	*Badan Usaha Milik Daerah* (regional-owned enterprise)
BPMA	:	*Badan Pengelola Migas Aceh* (Aceh Oil and Gas Management Agency)
CM	:	Corrective Maintenance
CMMS	:	Computerized Maintenance Management System
CMS	:	Corrosion Management System
CO2	:	Carbon Dioxide
CoF	:	Consequences of Failure
CNG	:	Compressed Natural Gas
ECR	:	Equipment Criticality Rangking
EMP	:	PT. Energi Mega Persada
EMR	:	Energy and Mineral Resources
ERP	:	Enterprise Resources Planning
EMOI	:	Exxon Mobil Oil Indonesia
FIMS	:	Floating System Integrity Management
H2S	:	Hydrogen Disulfide
HDI	:	Human Development Index
ICP	:	Indonesian Crude Price

IoT	:	Internet of Things
IIoT	:	Industrial Internet of Things
KPI	:	Key Performance Indicator
KPI	:	PT. Kilang Pertamina Intenational
LIMS	:	Lifting Integrity Management System
LMAN	:	*Lembaga Manajemen Aset Negara* (The National Asset Management Agency)
LNG	:	Liquefied Natural Gas
LPG	:	Liquefied Petroleum Gas
MMBTU	:	million British thermal units
MMSCF	:	Millions of Standard Cubic Feet
MOI	:	Mobil Oil Indonesia
MORE	:	maximize oil recovery effort
MR	:	Material Requisition
MRP	:	Material Requirement Planning
MTOE	:	Millions of tonnes of oil equivalent
NGL	:	Natural Gas Liquefaction
NSB	:	North Sumatera B
NSO	:	North Sumatera Offshore
OCM	:	Operating committee meetings
OEM	:	original equipment manufacturer
OEE	:	Overall Equipment Effectiveness
PAG	:	PT. Perta Arun Gas
PCE	:	Production Critical Equipment
PdM	:	Predictive Maintenance
PEMA	:	PT. Pembangunan Aceh
PERTAGAS	:	PT. Pertamina Gas
PGE	:	PT. PEMA Global Energi
PGN	:	PT. Pertamina Gas Negara

PHE	:	PT. Pertamina Hulu Energi
PHR	:	PT. Pertamina Hulu Rokan
PI	:	Participating Interest
PIMS	:	Pipeline Integrity Management System
PM	:	Preventive Maintenance
PNCE	:	Production Non-Critical Equipment
PO	:	Purchase Order
PoF	:	Probability of Failure
PR	:	Purchase Requisition
PSC	:	Production Sharing Contract
RO	:	Release Order
RxM	:	Prescriptive Maintenance (another name for Proactive Maintenance)
SCE	:	Safety Critical Equipment
SCM	:	Supply Chain Management
SFIMS	:	Surface Facilities Integrity Management System
SHU	:	Sub-Holding Upstream
SIMS	:	Structural Integrity Management System
SKKNI	:	*Standar Kompetensi Kerja Nasional Indonesia* (Indonesian National Work Competency Standards)
SNCE	:	Safety Non-Critical Equipment
SOE	:	State-Owned Enterprise
SRU	:	Sulphur Recovery Unit
SSOP	:	*Sistem sinergi optimasi produksi* (Production optimization synergy system)
SWOT	:	Strengths, Weaknesses, Opportunities and Threats
TCM	:	technical committee meetings
TKDN	:	*Tingkat Komponen Dalam Negeri* (Local Content Level)
WA	:	Working Area
WO	:	Work Order
WTP	:	water treatment plant

[redacted] INTRODUCTION

1.1. Background

The oil and gas industry is one of the industrial sectors that faces significant risks and uncertainties. Moreover, this business encounters challenges associated with the highly dynamic fluctuations in global oil and gas prices. Changes in the prices of oil and gas worldwide are influenced not only by supply and demand factors but also by currency fluctuations, geopolitical instability, futures market participants, and several other factors (Yan, 2012). Figure 1.1 illustrates how oil prices respond to various geopolitical situations and economic events from 1970 to 2020.

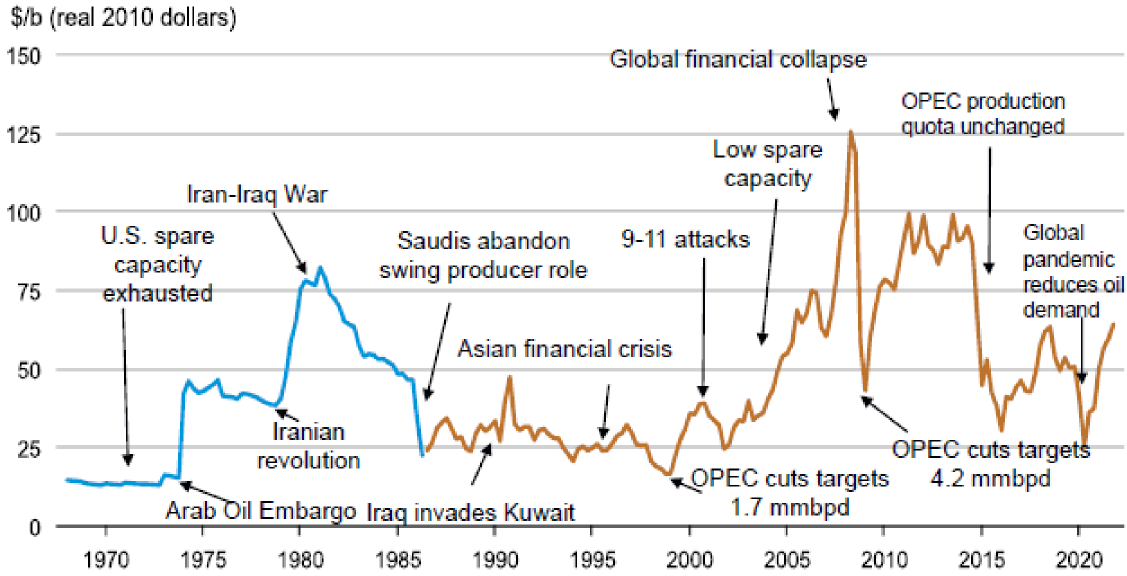


Figure 1.1. The volatile of oil prices as the global geopolitical and economic situation
(Source: U.S. Energy Information Administration)

Fluctuations in oil prices can have a significant impact on the financial performance of companies. Research conducted by Bagirov and Mateus (2019) on oil companies listed in Western Europe, as well as by Dayanandan and Donker (2011) on oil companies in North America, consistently concludes that return on equity is highly sensitive to changes in oil and gas prices. To address the challenges of dynamic fluctuations in oil and gas prices, companies strive to optimize costs and allocate resources efficiently in operational activities to reduce production costs.

Production costs, also known as lifting costs, encompass all expenses related to oil and gas production activities divided by the total barrels of oil equivalent produced. These costs include labor, repairs and maintenance, raw materials, inventory, fuel consumption, taxes, and insurance (Gallun, Nichols, Wright, & Stevenson, 2001). Within the operational cost structure, repair and maintenance costs play a crucial role. Mobley (2002) estimates maintenance costs range from 15-60% of total production costs, depending on the industry type. In the petrochemical refinery sector, Joel McGlynn and Frank Knowlton (2011) note that maintenance costs are categorized into direct costs (28% of total operational costs) and hidden costs, influenced by factors such as safety, environmental compliance, legal aspects, service disruptions, and shareholder impacts.

Maintenance costs in the oil and gas industry exhibit variability among fields due to several factors. First, the nature of combustible or explosive products requires complex equipment maintenance strategies to maintain equipment and facility integrity. Additionally, products may contain chemicals posing risks to health, safety, equipment, or the environment. For instance, gas production in some fields, containing impurities such as hydrogen sulfide (H2S) and carbon dioxide (CO2), requires extra attention. H2S is highly toxic, even at low concentrations. Inhalation of H2S can cause respiratory irritation, pulmonary edema, and in severe cases, even death. Exposure to higher concentrations can result in immediate loss of consciousness and respiratory failure. Meanwhile, concentrated CO2 can threaten human health, increase fire danger, and contribute to global warming. Poor ventilation can lead to CO2 accumulation, requiring strict safety measures. Additionally, corrosion caused by CO2 can damage equipment. In gas refining facilities, ensuring the gas meets quality standards before sale is essential, adding to operational and maintenance expenses for oil and gas companies. The complexity of refining facilities correlates directly with increased operational and maintenance costs.

The second factor impacting maintenance costs is the developmental stage of oil and gas production fields, as depicted in Figure 1.2. These fields typically progress through three stages: initial development, mature operations, and advanced recovery. During the primary recovery phase, where natural reservoir pressure facilitates oil and gas extraction, basic equipment like pumps and separators suffice. However, as production declines, secondary recovery methods such as water or gas injection become necessary, leading to the installation of additional infrastructure like injection wells and pumps. Subsequently, in the mature stage, operators may employ tertiary recovery techniques like enhanced oil recovery involving steam or chemical injection, necessitating specialized equipment and facilities. These advanced methods not only increase operational complexity but also raise maintenance requirements for sophisticated equipment such as steam generators and injection pumps.

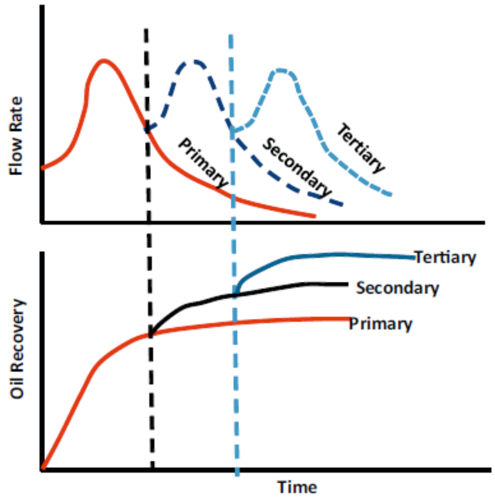


Figure 1.2. Typical production profile of an oil field due to production recovery phase
(Source: Ahmed & Meehan (2012))

The third factor contributing to maintenance challenges is equipment aging. Over time, equipment undergoes wear and tear, making maintenance more complex. While reaching the end of its service life doesn't necessarily render equipment economically obsolete, it does require special attention to maintenance practices. Notably, manufacturers often discontinue maintenance services or recommendations for equipment beyond its service age. Therefore, extending the service life of aging equipment demands meticulous maintenance planning and execution.

The choice of an appropriate maintenance strategy holds the key to managing maintenance activities effectively, offering various benefits to the company. These advantages include heightened cost efficiency and effectiveness in maintenance operations, ensuring uninterrupted production by enhancing the availability and reliability of facilities and equipment, meeting health, safety, and environmental requirements, and complying with relevant regulatory standards.

1.2. History of Oil and Gas Exploitation in North Aceh

1.2.1. Arun NGL Was the Biggest NGL Producer in the world

The history of oil and gas exploration and exploitation in North Aceh began in 1968 with the signing of a production-sharing contract (PSC) between Pertamina and Mobil Oil Indonesia (MOI) which later become Exxon Mobile Oil Indonesia (EMOI) after merger with Exxon in 1999. Subsequent exploration efforts by MOI in 1971 led to the identification of gas reserves in Block B, encompassing the Arun Field, South Lhoksukon A (SLS-A), and South Lhoksukon D (SLS-D), followed by the discovery of gas reserves in the North Sumatra Offshore (NSO) Block in 1972.

This discovery prompted the development of production facilities in Lhoksukon by MOI, including condensate and liquefied natural gas (LNG) facilities under PT. Arun Natural Gas Liquefaction (Arun NGL), to fulfill LNG sales contracts with Japanese and American buyers, signed in December 1973. Arun NGL, a joint venture between Pertamina (55% shares), Exxon Mobil (30% shares), and Japan Indonesia LNG Company (15% shares), was established in 1974 to process natural gas produced by MOI into LNG, while utilizing condensate as a by-product.

Adapting to increased demand and rising gas production, Arun NGL expanded its production capacity, initially with 3 trains in 1978 and later 6 trains in 1994, with a production capacity of 4.5 million tons per year and 14 million tons per year, respectively. Additionally, Arun NGL expanded its operations by establishing a liquefied petroleum gas (LPG) plant in 1987.

As gas production from Block B declined, MOI initiated the development of the NSO Block, an offshore gas field located approximately 102 km from the Arun NGL facilities. Exploitation activities in the NSO Block began in 1998 with the construction of oil and gas platforms (offshore facilities), subsea gas pipelines, and a sulphur recovery unit (SRU) in the Arun NGL plant area.

Arun NGL held the distinction of being the world's largest LNG producer from the 1980s to the 1990s. However, declining gas production led to the discontinuation of LNG production at the Arun NGL refinery in 2015, with assets returned to the state and managed by the National Asset Management Agency (LMAN).

1.2.2. Post Arun NGL stopped

After the complete cessation of Arun NGL operations, the Government of Indonesia recognized the necessity of initiatives to bolster national energy security, particularly in the provinces of Aceh and North Sumatra. To spearhead these efforts, the Government, through the Ministry of State-Owned Enterprises (SOEs), designated PT. Pertamina (Persero) as a SOE to lead the Arun Plant revitalization project, which is coupled with the construction of a gas pipeline from Arun to Belawan.

This comprehensive revitalization endeavor encompasses three distinct projects: the LNG plant revitalization project, the condensate terminal revitalization project, and the LPG Plant revitalization project.

1) The LNG Plant Revitalization Project

   Also known as the LNG Hub and Regasification Terminal Project, has the primary goal of repurposing the LNG Plant facilities of the Arun NGL. The key transformations involve converting the existing export terminal into an import terminal receiver and repurposing the liquefaction plant into a regasification plant. To overcome the complexity of this project, PT. Pertamina (Persero) entrusts this responsibility to its subsidiary, PT. Pertamina Gas (Pertagas). Recognizing the scale and special nature of this project, Pertagas took a strategic approach by establishing a subsidiary solely dedicated to overseeing and implementing the revitalization efforts. So, in March 2013, PT. Perta Arun Gas (PAG) was officially established. PAG is purposefully structured and equipped with the necessary resources, including skilled personnel and financial support, to effectively manage the intricacies of targeted revitalization projects. The timeline for this project indicates that it officially commenced in March 2013 and successfully transitioned into operational status in February 2015. This project signifies a strategic effort to adapt and optimize existing infrastructure, aligning it with the evolving needs of the energy landscape and enhancing the overall efficiency and functionality of the Arun NGL facilities.

2) The LPG Terminal Revitalization Project

   The LPG terminal revitalization project, commonly referred to as the LPG Transshipment Project, is designed to repurpose the LPG Storage Tank into an LPG Hub to address domestic demand. This strategic initiative is undertaken by PT. Pertamina Patra Niaga, a subsidiary of the PT. Pertamina (Persero). The essence of this project lies in transforming the existing LPG Storage Tank into a crucial hub that facilitates the efficient management and distribution of LPG to meet the growing demands within the domestic market. By optimizing storage and transshipment capabilities, PT. Pertamina Patra Niaga aims to enhance the accessibility and availability of LPG, contributing to the fulfillment of domestic energy needs.

3) The Revitalization of the Condensate Tanks Project

   The revitalization of the condensate tanks project addresses the optimization of existing infrastructure. Currently, out of the four condensate storage tanks with a capacity of

500,000 barrels each, only one is in use by shippers around the Arun NGL Plant to temporarily store condensate or oil products before shipment. The project's primary objective is to fully utilize all four tanks, thereby enhancing storage capacity to accommodate larger oil and condensate products. Executed as a collaborative effort, the project involves the expertise of PT. Pertamina Marketing and Trading in partnership with PT. Pembangunan Aceh (PEMA). This joint venture aims to maximize the efficiency of condensate storage and shipment processes, contributing to improved operational capabilities and flexibility within the Arun NGL facility.

On the upstream side, following the cessation of Arun LNG operations, EMOI relinquished its participant interest in Block B and Block NSO on September 30, 2015. This transfer occurred three years earlier than the block contract's scheduled expiration in 2018. Pertamina, acting through its subsidiary Pertamina Hulu Energi (PHE), assumed full participating interest (PI) in these two blocks. Subsequently, PHE established two subsidiaries, PHE-NSB to oversee Block B and PHE-NSO to manage NSO. PHE managed both blocks until the expiration of the origin block's contract on October 3, 2018.

In line with Government Regulation No. 23 of 2015, the management of oil and gas blocks within Aceh's onshore and territorial sea (up to 12 nautical miles) falls under the jurisdiction of the Aceh Oil and Gas Management Agency (BPMA). When the contract period for oil and gas blocks expires, priority is given to Regional Owned Enterprises (BUMD) for the transfer. Given that Block B is situated onshore, the Aceh Government has shown a keen interest in managing it. To address the Aceh Government's current lack of readiness in managing Block B, BPMA has appointed PHE-NSB to oversee the block for an initial six-month period, which can be extended until a new PSC is signed with a BUMD. The Aceh Government's goal for autonomous management of WA within its authority was realized on May 17, 2021, as BPMA transferred the management rights of Block B to PT. Pembangunan Aceh (PEMA), a regional-owned enterprise. On the other hand, because the NSO Block extends beyond the 12 nautical mile limit, the management of this block is overseen by SKK Migas, who have designated PHE-NSO to continue with the Production Sharing Contract under the gross split scheme from October 2018 until October 2038.

1.3. Company Profile

Starting from October 1, 2015, PHE-NSO and PHE-NSB were tasked with supervising Block NSO and Block NSB. Initially operating independently, both entities fell under the

Aceh Production Operation (APO) Field's management, overseen by a Field Manager. Then, on May 17, 2021, PHE-NSB transferred its PI in Block B to PEMA. In collaboration with PT. Energy Mega Persada (EMP), PEMA formed a new entity called PT. PEMA Global Energy (PGE) to take charge of managing Block B. Following this transition, the management of Block B separated from PHE, leading to the renaming of the APO Field to NSO Field.

1.3.1. Vision and Missions

PHE-NSO operates as a subsidiary and business unit of PHE, aligning its vision, mission, values, and corporate strategy with those of the parent company. PHE has established a vision to be a world-class oil and gas company. To realize this vision, the Company has outlined a mission to professionally manage operations and business portfolios in the upstream oil and gas sector, ensuring high profitability and delivering added value for stakeholders.

1.3.2. Corporate Culture Values

The Company adopts key values that are in line with the values of the Holding Company. The Holding Company's values, in turn, are based on the core values of human resources of SOE. The key values include:

1. Trustworthy; upholding the trust given
2. Competence; learning and developing capabilities continuously
3. Harmony; caring and respecting the differences
4. Loyal; dedicating and prioritizing the nation and state interests
5. Adaptive; continuously innovate and have enthusiasm in driving or facing change
6. Collaborative; building synergistic cooperation

1.3.3. Business Policy and Strategy

To achieve its vision and mission, the Company has established three corporate strategies:

1. Managing existing assets in the working area or existing oil and gas blocks through exploration or by utilizing the latest technology.
2. Exploring new ventures by seeking out new oil and gas blocks with substantial oil and gas potential.
3. Establishing strategic partnerships that involve sharing risks, costs, and technology.

In addition to these corporate strategies, the Company has defined four business strategies:

1. Managing maintenance activities, repairs, and modifications of facilities, overseeing operational infill development drilling and well work, handling planned shutdown activities, minimizing unplanned shutdowns, and setting targets for, monitoring, and optimizing oil and gas production.
2. Implementing the Asset Integrity Management System (AIMS) to regulate preventive and corrective actions in operating, preserving, and maintaining the reliability of production facilities in the field.
3. Production optimization synergy system (SSOP) and maximize oil recovery effort (MORE).
4. Organizing Operating committee meetings (OCM), technical committee meetings (TCM) and special workshops with partners.

1.3.4. Business and Product

According to the Company's Article of Association, PHE's core business activities encompass the exploration, production, and development of oil and gas. Additionally, the SHU Company engages in diverse business activities, including portfolio management, upstream oil and gas services, oil and gas support services, distribution and logistics services, and energy.

Specifically, within the PHE-NSO business unit, the Company focuses on oil and gas production, with natural gas and condensate as the primary products. Throughout 2022, all products produced were sold to consumers, which are also companies affiliated with the Holding Company. The sales distribution followed the structure outlined in Table 1.1.

Table 1.1. Distribution of oil and gas product in 2022

Product	Customer	Sales		Market Share
Condensate	PT Kilang Pertamina Internasional	17,200.00	Barrels	100%
Natural Gas	PT. Pertagas Niaga	1,887.14	MMSCF	62.08%
	PT. PGN	1,087.66	MMSCF	35.78%
	PT. PGN City Gas	65.20	MMSCF	2.14%

1.3.5. Area Operation

NSO operates two production facilities situated in distinct locations. The production wells are located on offshore platform facilities, while the gas processing facilities are situated at onshore facilities, formerly recognized as the Arun NGL Plant. For a visual representation of the Company's work area and distribution, see Figure 1.3.

Figure 1.3. The Company's working area

1.3.6. Organization Structure

In 2020, PT. Pertamina (Persero) and its subsidiaries underwent a significant organizational transformation aimed at enhancing agility, focus, and accelerating the development of world-class business capabilities. This transformation involved the transition to a holding company structure and the establishment of six sub-holdings, as illustrated in Figure 1.4. As the Holding Company, PT. Pertamina (Persero) focuses on portfolio management activities, fostering business synergies across the Pertamina Group, and actively advancing new business development. Additionally, Holding Company plays a crucial role in supporting national programs, thereby contributing to the broader goals of energy security and economic development in Indonesia. This reorganization is designed to streamline operations, improve strategic focus, and drive innovation, positioning the Company to better navigate the dynamic and competitive energy sector.

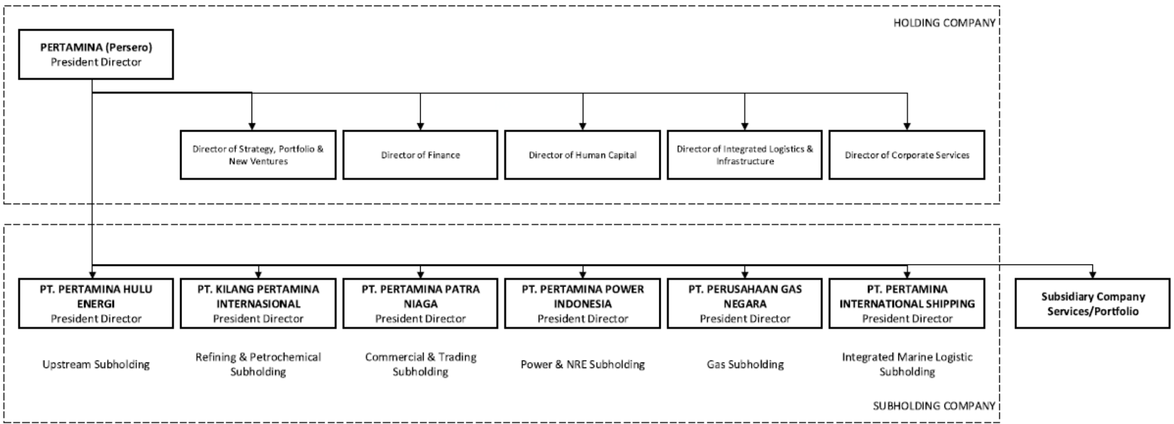


Figure 1.4. Organization Structure of Holding and Sub-Holding Company

Concurrently, each sub-holding within Holding Company is dedicated to driving operational excellence. This commitment involves developing economies of scale, fostering constructive collaboration within their respective business areas, expediting business development, enhancing existing capabilities, and increasing flexibility in partnerships and funding. The overarching goal of these efforts is to ensure greater profitability for the Company. PHE has been designated as the leading company within the Sub-Holding Upstream (SHU). Following this designation, PHE acquired the entire portfolio of Holding Company involved in the upstream oil and gas industry.

To streamline portfolio management, 34 subsidiaries specializing in oil and gas exploration and production—out of a total of 65 subsidiaries within the PHE portfolio—are organized into five Regionals and 17 Zones based on geographical proximity. Each regional has a designated company responsible for overseeing the portfolio within that region, with other subsidiaries transforming into business units under the leadership of these regional companies.

The organizational structure between the SHU Company and its subsidiaries is outlined in Figure 1.5. Specifically, PT. Pertamina Hulu Energi NSO as entity company or NSO Field as unit business is clustered under Zone 1 and managed by PT Pertamina Hulu Rokan (PHR) as the company appointed to manage Zones 1, 2, 3 and 4 or called as Regional 1 Company, as illustrated in Figure 1.6. Within this structure, field teams primarily focus on operations, while supporting teams are centralized in Zone 1, as depicted in Figure 1.7. This reorganization aims to enhance operational efficiency, foster strategic alignment, and improve overall performance in the upstream segment of Holding Company.

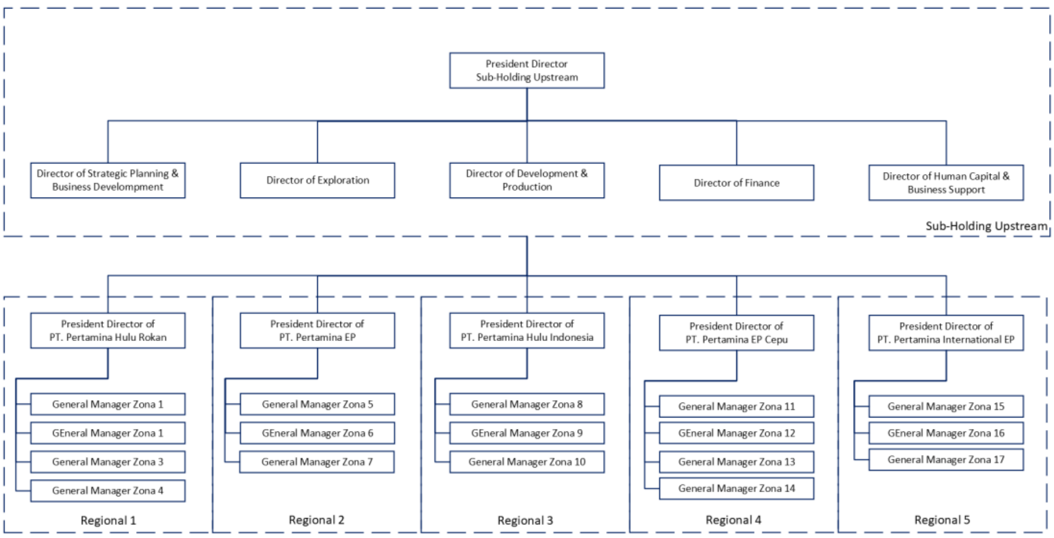


Figure 1.5. SHU Organizational Structure

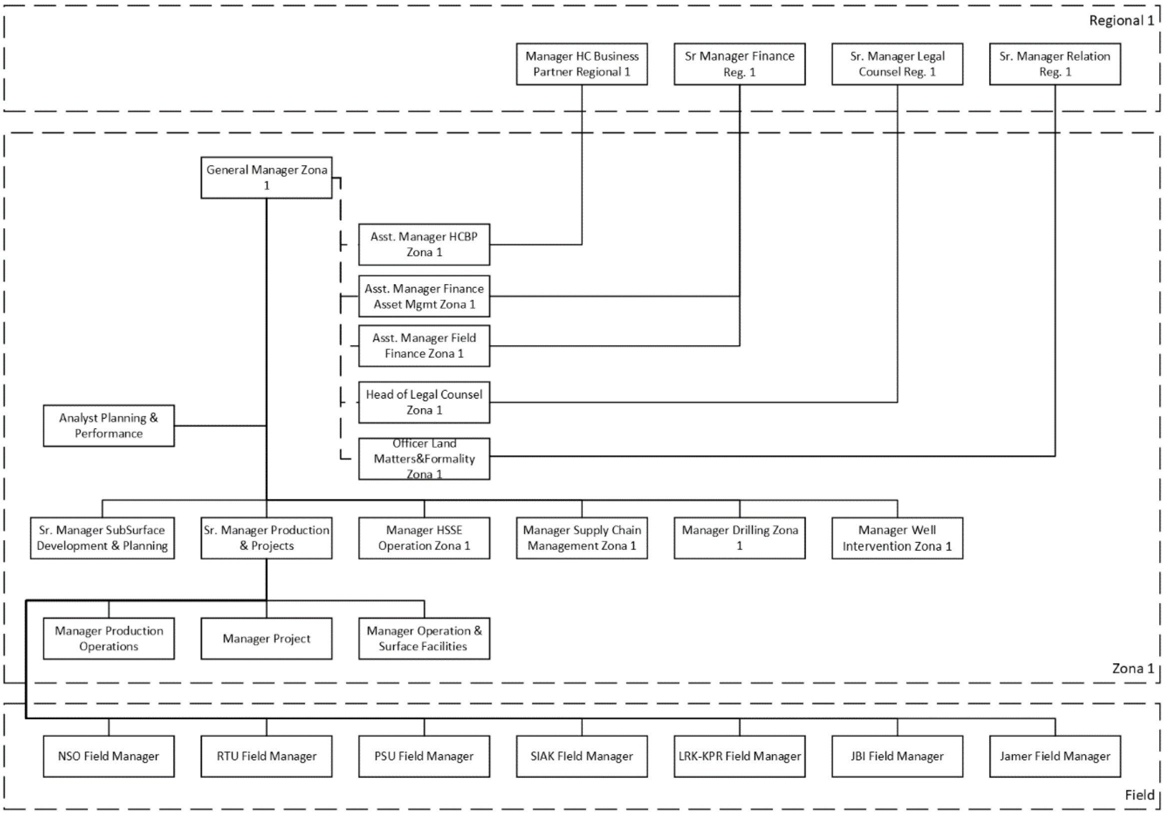


Figure 1.6. Zone 1 Organization Structure

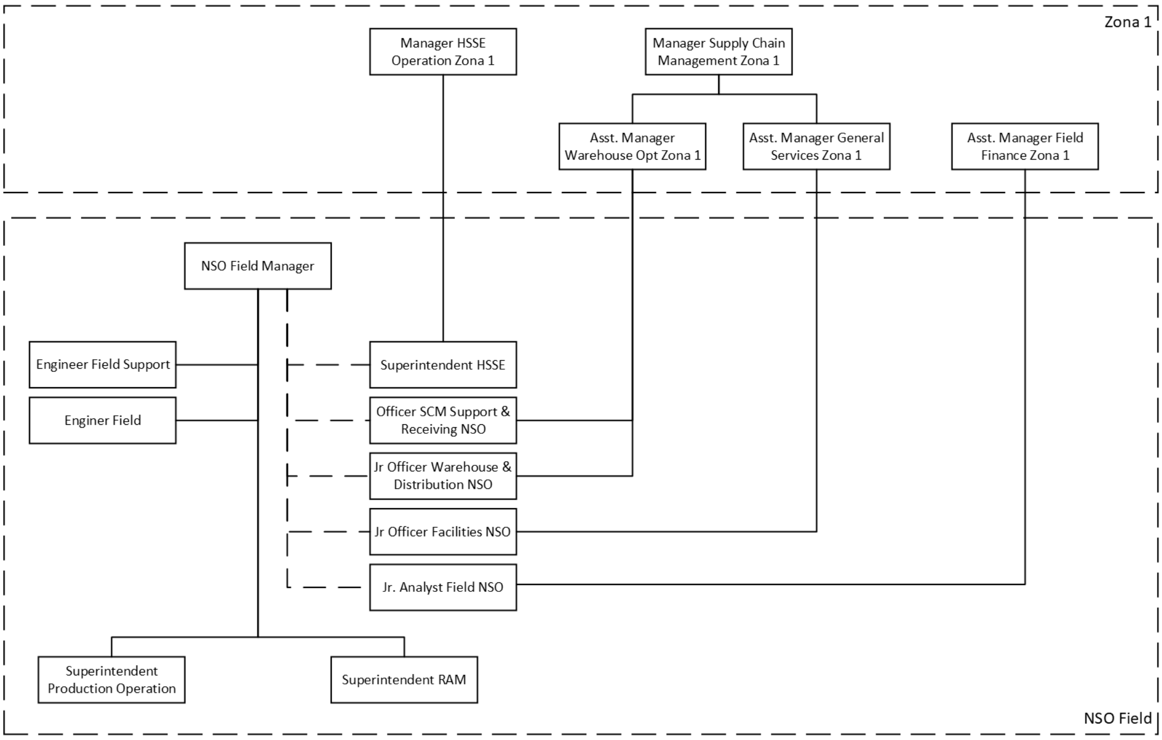


Figure 1.7. NSO Field Organization Structure

1.4. Maintenance Management

1.4.1. Managed Assets

The assets managed by the Company currently originate from the acquisition of blocks from previous PI holders. The management of these assets, particularly in the NSO and Block B blocks, has exhibited dynamic changes, attributed to alterations in PI and company initiatives aimed at optimizing efficiency. On October 1, 2015, EMOI transferred the management of these blocks, inclusive of all assets utilized in oil and gas exploration and production activities in the NSO block and Block B, to PHE-NSO and PHE-NSB (unifed as APO Field). The operational office for managing APO Field is situated in Lhoksukon.

Simultaneously, there was a transfer of all Arun NGL operations to PAG, encompassing the operation of EMOI's onshore facility assets as the prior operator of the NSO block, with PHE-NSO assuming the role of the new operator. However, PHE-NSO did not immediately take over the operation of the gas treating unit, condensate recovery unit, and sulfur recovery unit facilities at the Arun Plant due to the absence of an organization to manage these facilities. The operation of these facilities was conducted collaboratively with PAG under an operation and maintenance service contract. The transfer of operation and maintenance for these facilities occurred in 2018, coinciding with the extension of the new block contract.

Although the onshore facilities (in Arun Plant) have been transferred to the Company, these facilities cannot function without supporting facilities such as power supply, potable water, seawater, steam boiler, air instrument plant, nitrogen gas plant, fire protection system, maintenance shop including tools and equipment. The management of these supporting facilities still relies on PAG. In 2021, another change in PI for Block B led to the transfer of block management to PGE. Consequently, the Company's operational office was relocated to Lhokseumawe. Due to the marginal condensate production of the Company's in comparison to PGE, the operation of condensate recovery facilities is no longer feasible under the management of the Company. Consequently, in April 2023, the Company handed over the operation of the condensate recovery facility in Arun Plant to PGE. The Company's current operational block diagram can be seen in Figure 1.8.

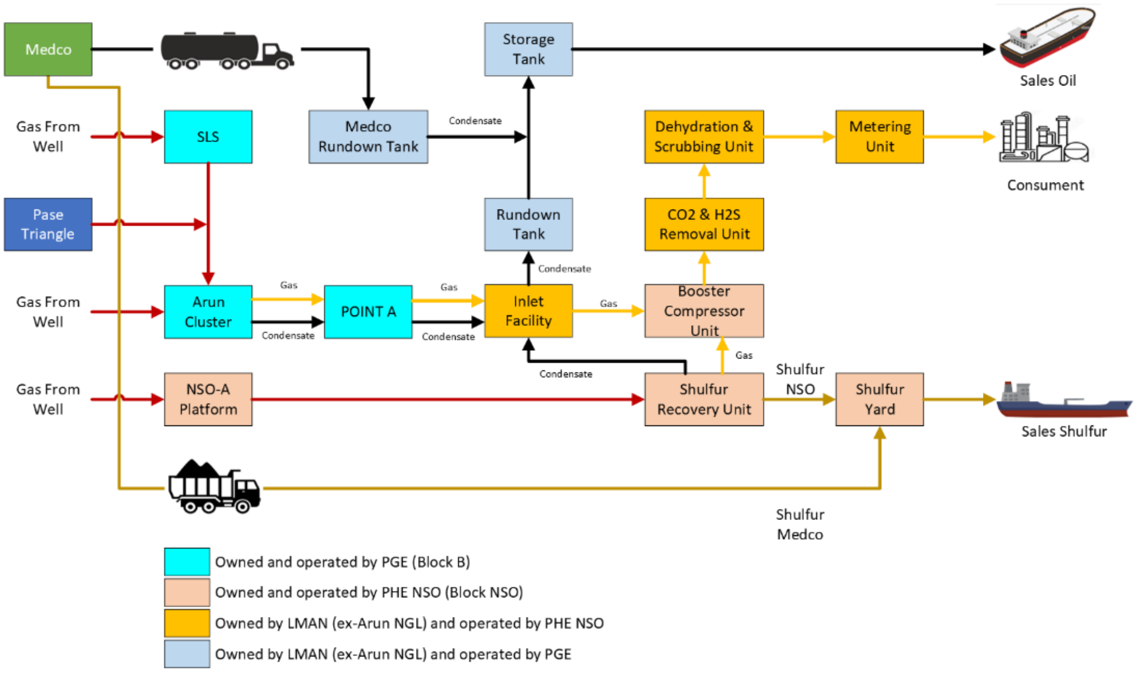


Figure 1.8. Operation Block Diagram PHE-NSO

Each transfer or acquisition of assets involves a comprehensive change in the management of all aspects, encompassing physical assets, knowledge assets, data, materials, and labor. However, the process of acquiring the NSO blocks from EMOI faced challenges, experiencing less than smooth transitions. Many data related to maintenance management, such as equipment data and maintenance programs, were not adequately handed over. Regarding labor, EMOI only transferred personnel at the operator, technician, and the highest supervisory levels. Skilled workers, engineers, and managerial levels were withdrawn and reassigned to other EMOI working areas. The transferred manpower decreased over time, and during the management handover of Block B to PGE, a significant portion of the workforce was transferred to PGE, along with all equipment and facilities utilized for maintenance activities.

Similarly, in the acquisition of part of the Arun NGL facility, there was a transfer of part of the workforce. However, since PAG executed the acquisition of the Arun NGL facility first, the workers received by the Company had already undergone screening by PAG. PAG retained talented workers at the operator, technician, or engineer levels, while no managerial level workers were included in the transfer. Another advantage in the early acquisition of the Arun NGL facility by PAG was that PAG had secured all facilities and equipment used for maintenance activities. In contrast, the Company only obtained the heavy equipment maintenance shop facility with minimal equipment.

1.4.2. Maintenance Performance

From 2015 to 2018, PAG managed the operation and maintenance of the gas treating unit facilities, condensate recovery units, and sulfur recovery units through an operation and maintenance contract. During this period, the Company focused on the operation and maintenance of production facilities on the platform. Since acquiring these facilities from PAG in 2018, the Company has continued the existing maintenance program. However, the maintenance strategy for onshore production facilities relies on a breakdown or corrective maintenance approach. Equipment has not been registered in the computerized maintenance management system (CMMS), and a scheduled maintenance program is absent. Maintenance activities are initiated based on work orders from the operational team.

In contrast, the maintenance strategy for platform facilities includes a preventive maintenance (PM) program. The equipment list is registered in the CMMS, with schedules and task lists for each PM activity well-defined. While PM implementation is effective, the program has not been reviewed for the suitability of maintenance tasks under current conditions, and a scheduled predictive maintenance (PdM) program is still lacking.

The Company lacks a spare parts management program due to the absence of a robust maintenance strategy. The warehouse manages remaining stock transferred from EMOI and Arun NGL, along with materials and raw materials for production operations. Material or spare part fulfillment for maintenance relies on existing stock; if unavailable, spot purchasing is conducted.

The Company maintenance organization is part of the Reliability, Availability, and Maintenance (RAM) function, led by a Superintendent. The RAM workforce comprises both organic and outsourced labor. Organic workers are selected and hired by SHU Company, while business units cannot revise the organizational structure and hire organic workers. Meanwhile, the outsourced labor comes from the transfer of labor from acquisitions of EMOI blocks and the Arun NGL facilities. Since the Company's inception, there has been no system to evaluate the needs and qualifications of the RAM workforce. The workforce composition is dynamic, with a high rate of organic labor rotation and a decreasing outsourced workforce due to asset management transfer (handover of Block B and condensate facilities to PGE) and natural terminations as workers reach retirement age.

Effective maintenance management is crucial for ensuring uninterrupted company operations. Inadequate maintenance strategies and delayed detection of equipment failures can severely impact both production and safety. The current conditions experienced by the Company highlight deficiencies in its maintenance management. This inefficiency is evident from several critical incidents encountered by the Company. Equipment failures have caused unplanned shutdowns, leading to high LPO numbers from 2021 to 2023, as shown in Table 1.2.

Table 1.2. LPO due to unplanned shutdown from 2021 to 2023

Year	LPO (BOE) Accumulated
2021	365,568.88
2022	120,590.87
2023	136,517.86

1.4.3. Gap Analysis of Maintenance Management

As a contractor for SKK Migas, a gap analysis in maintenance management is crucial to assess the Company's current practices against the ideal standards set forth by SKK Migas in their Work Guidelines. SKK Migas Work Guidelines No. PTK-041/2018 defines seven key maintenance components: organizational structure and leadership, execution management, materials management, change management, documentation and information systems, key performance indicators (KPIs), and benchmarking. The gap analysis involves comparing each of these maintenance components against the standards defined by SKK Migas. This process helps identify areas where the Company's maintenance practices may deviate from the established guidelines, highlighting areas for improvement. The findings of this analysis are presented in Table 1.3, providing a clear reference point for future maintenance improvement initiatives.

Table 1.3. Gap analysis of the Company's maintenance management

Component	Requirement as PTK 041	Current Situation
Organization structure and Leadership	• Have a maintenance organizational structure and a job description for each position.	• The maintenance team organization is established, but there are still vacant positions. Job descriptions for each position are available.
	• Define competencies, determine targets, integrate maintenance processes and procedures, optimize resources and evaluate maintenance and implement continuous improvement programs.	• Competencies for each position have not been clearly defined. Annual maintenance targets are set at the beginning of the year, and maintenance processes and procedures exist but are not consistently followed. There have been no evaluations of

Component	Requirement as PTK 041	Current Situation
		maintenance management or efforts toward continuous improvement.
	• Evaluation of the skills, competencies and performance of maintenance program implementers	• There has been no evaluation of the skills, competencies, or performance of maintenance program implementers.
Execution Management	• Establish a maintenance work program • Plan the availability of resources, materials, equipment and priority scale • Plan maintenance work and align with simultaneous operation (SIMOP) • Accounting for the impact of maintenance on operations	The maintenance program for offshore facilities has adopted planned maintenance but has not been reviewed since the acquisition from EMOI. Meanwhile, onshore facilities continue to rely on breakdown maintenance. This reliance on reactive maintenance results in low planning effectiveness and suboptimal availability of resources, materials, equipment, and priority determination. Additionally, it leads to unpredictable LPO, causing unexpected downtimes and disruptions in production, ultimately affecting overall operational efficiency and performance.
Material Management	• Has a system to control materials to ensure smooth maintenance • Has critical parts of major equipment • The material procurement mechanism refers to applicable regulations	The Company has a system for procuring and managing stock materials in the warehouse, including spare parts. However, due to the poorly planned maintenance program, the management of spare parts, including critical components for major equipment, is inadequate.
Management of Change	Have a system that manages change management (changes in processes, technology, safety system equipment, engineering documents, changes in repair frequency, changes in maintenance work, changes in material specifications and spare parts).	The company already has change management guidelines, but they only apply to changes in operational patterns and design capacity. However, these guidelines do not cover changes in repair frequency, maintenance work, or material and spare part specifications.
Documentation and Information Systems	Manage data and documents related to maintenance programs, including: • Engineering master data including data sheets, design data dan OEM manuals; • Technical drawings, including P&ID, Piping Flow Diagrams (PFDs), equipment drawings, and one-line diagrams; and • Data integrity and reliability, including RBI, FMEA, criticality rankings, Key Performance Indicator (KPI), Root Cause Failure Analysis (RCFA), procedures,	The data management system related to maintenance activities is poorly managed, remains scattered, and has never been evaluated. This fragmented approach hinders effective tracking, analysis, and utilization of maintenance data, ultimately impacting the efficiency and reliability of maintenance operations.

Component	Requirement as PTK 041	Current Situation
	inspection results, condition monitoring, and analysis.	
Key Performance Indicator	Have a maintenance performance assessment system using KPIs.	KPI targets for maintenance activities are already in place, but they solely concentrate on ensuring reliability and equipment availability, overlooking the effectiveness of the maintenance activities themselves.
Benchmarking	Implement benchmarking and use it as input for continuous improvement.	Benchmarking for the continuous improvement of maintenance activities has never been conducted.

1.5. Business Issues

Based on the gap analysis of the company's maintenance management, it can be concluded that several aspects of the maintenance management are inadequate. The following are some of the challenges faced by the company's maintenance function.

1. The organizational structure for the maintenance team is established, but some positions remain vacant, and job descriptions are available.
2. Competencies for each position are not clearly defined
3. While annual maintenance targets are set, the processes and procedures are inconsistently followed.
4. There has been no evaluation of skills, competencies, or performance of the maintenance team.
5. The execution management reveals that the offshore maintenance program has not been reviewed since the acquisition from EMOI, and onshore facilities rely on breakdown maintenance, resulting in low planning effectiveness and resource availability.
6. Material management is hampered by inadequate planning, leading to ineffective management of spare parts and critical components.
7. Change management guidelines exist but are limited to operational pattern and design capacity changes, neglecting repair frequency, maintenance work, and material specifications. Documentation and information systems are poorly managed, scattered, and unevaluated, affecting the efficiency and reliability of maintenance operations.

8. KPI targets focus solely on reliability and equipment availability, overlooking maintenance effectiveness.
9. There has been no benchmarking for continuous improvement in maintenance activities.

This poor maintenance management is further exacerbated by the aging condition of the equipment. As elucidated, a significant portion of the equipment under management was acquired from EMOI and part of the Arun Refinery. The facilities on the platform and SRU have been operational since 1998, amounting to approximately 24 years. Conversely, the gas treating unit and condensate recovery unit facilities were established in 1974. Devising maintenance strategies for aging equipment necessitates a distinct approach compared to newer equipment, posing a notable challenge.

1.6. Research Question and Objective

Based on business issues in functional maintenance, the following are the questions in this research.

1. How can maintenance strategies be developed to increase maintenance efficiency and effectiveness and improve and maintain equipment reliability and availability?
2. What steps are being taken to implement this functional maintenance strategy?

The objectives of this research are as follows:

1. To formulate a functional maintenance strategy that aligns with the requirements outlined in PTK 041.
2. To develop an action plan to achieve these functional strategies.

1.7. Research Scope and Limitation

This research focuses specifically on a business unit within an oil and gas company, with the proposed solutions tailored to that particular unit. Applying these solutions to other business units or sectors may be inappropriate or may require modifications to suit the specific circumstances of those units or sectors.

[redacted] BUSINESS ISSUE EXPLORATION

The RAM function within the Company holds primary responsibility for overseeing maintenance management. Building upon the analysis of maintenance management challenges outlined in Chapter 1, the objective of this research is to formulate a functional maintenance strategy that aligns with and supports the achievement of company goals. A functional strategy, as defined by Weelen & Hunger (2012), refers to a strategy at the functional level aimed at maximizing resource productivity within a functional area to realize company and/or business unit goals and strategies.

2.1. Literature Review

Implementing best practices in maintenance management plays a vital role in enhancing equipment reliability and availability, leading to significant reductions in costs and production losses (Duarte & Scarpin, 2023). Effective maintenance practices address the root causes of efficiency loss, ensuring that equipment operates smoothly and without unexpected downtimes. This is particularly important in continuous production environments, where the goal is to maintain uninterrupted operations, minimize risks, and uphold high-quality standards (Ruschel, Santos, & Loures, 2017). In such settings, even minor disruptions can lead to substantial productivity losses and increased operational costs, highlighting the necessity of a robust maintenance management strategy.

Maintenance management strategy is a type of strategy that falls within the functional strategy cluster in the strategy hierarchy (Wandebori, 2019). This research uses two approaches to formulate functional maintenance strategies. The first approach involves formulating generic strategies using Porter's generic competitive strategies analysis (Porter, 1985). These generic strategies provide a foundational framework for developing alternative strategies and subsequent action plans. The second approach, known as alternative strategies, utilizes TOWS matrix analysis which was first introduced by Heinz Weihrich (1982). The TOWS Matrix illustrates how a corporation can align its internal strengths and weaknesses with external opportunities and threats to generate four potential strategic alternatives, as shown in Figure 2.1.

INTERNAL FACTORS (IFAS) / **EXTERNAL FACTORS (EFAS)**	**Strengths (S)** List 5 – 10 *internal* strengths here	**Weaknesses (W)** List 5 – 10 *internal* weaknesses here
Opportunities (O) List 5 – 10 *external* opportunities here	**SO Strategies** Generate strategies here that use **strengths** to take **advantage** of **opportunities**	**WO Strategies** Generate strategies here that take **advantage** of **opportunities** by **overcoming weaknesses**
Threats (T) List 5 – 10 *external* threats here	**ST Strategies** Generate strategies here that use **strengths** to **avoid threats**	**WT Strategies** Generate strategies here that **minimize weaknesses** and **avoid threats**

Figure 2.1. Formulating Alternative Strategies Using TOWS Matrix

Sources: (Weelen & Hunger, 2012)

External opportunities and threats are assessed using the PESTEL framework to analyze the company's environment, complemented by an analysis of industry competition through Porter’s Five Forces framework. Additionally, consumer behavior analysis is conducted to identify factors influencing consumer decisions to use the product and to determine whether these factors represent opportunities or threats for the company in the future.

Internal strengths and weaknesses are identified by analyzing the company’s resources, capabilities, core competencies, and competitive advantages. Resource analysis aims to evaluate the assets the company utilizes in its operational activities. Capability analysis examines the role of various company functions in operations, leveraging Porter’s Value Chain framework. Subsequently, the effectiveness of resources and capabilities is analyzed to determine their potential to become core competencies in maintenance activities. Using the VRIO framework, core competencies are assessed to identify which ones can serve as competitive advantages, supporting the company’s operations compared to its competitors.

2.2. Research Framework

The process of developing a maintenance functional strategy commences with conducting external analysis to identify opportunities and threats, alongside internal analysis to ascertain strengths and weaknesses. These findings are then synthesized into a SWOT analysis. The next step involves using the TOWS matrix analysis to determine the optimal maintenance functional strategy solution, which is subsequently translated into an implementation plan. These sequential steps can be structured into a comprehensive framework, as illustrated in Figure 2.1.

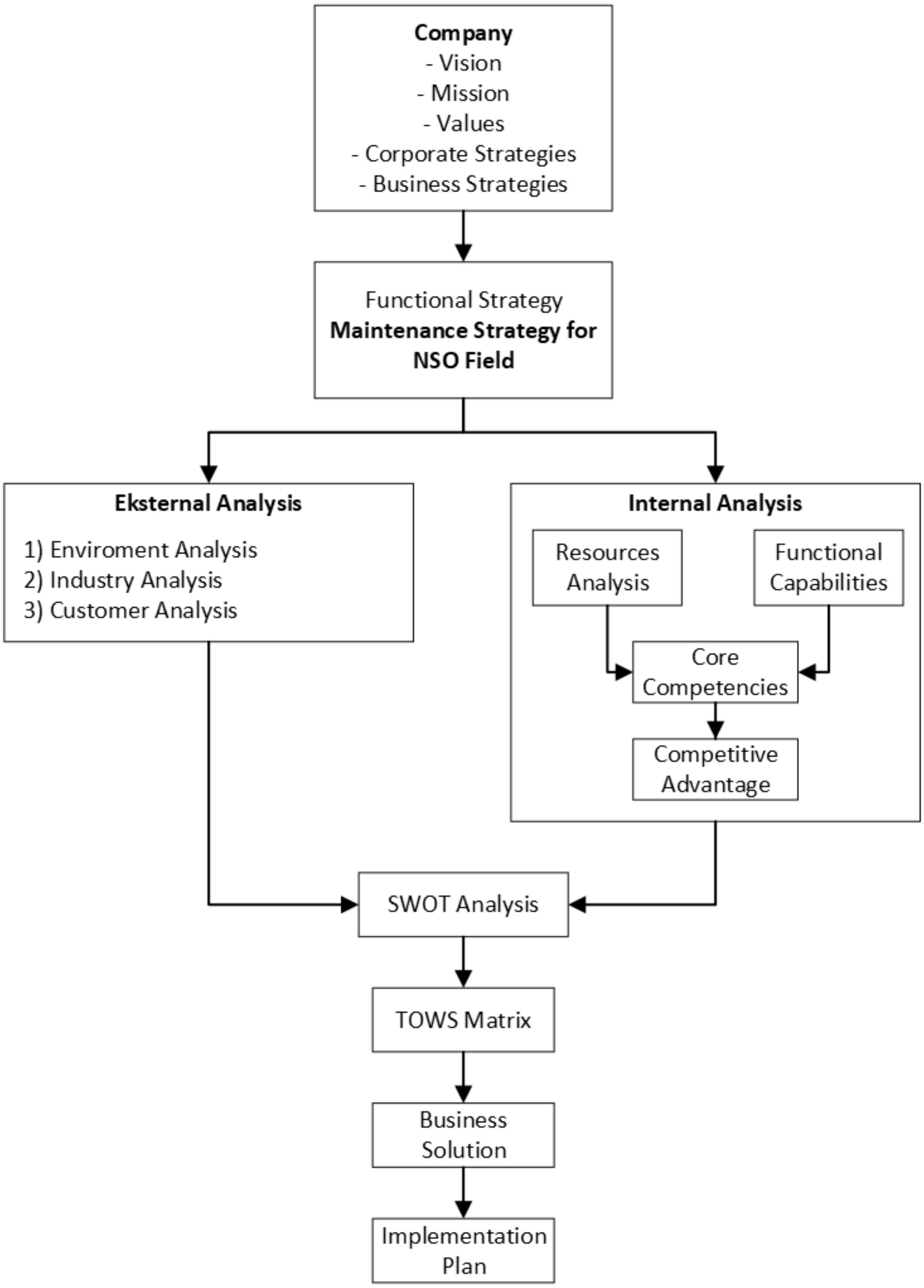


Figure 2.2. Research framework in formulating the maintenance functional strategy

2.3. Research Methodoly

2.3.1. Research Design

The research adopts a qualitative approach, which involves collecting and analyzing non-numerical data to understand concepts, opinions, or experiences. Various data sources are used to gain a comprehensive view of the company's situation.

2.3.2. Data Collection

Internal data, including formal documents and company reports, highlight company-specific challenges and opportunities. External data, which includes information from official national and global institutions, as well as analysis of current national and global conditions, provides context for company operations.

2.3.3. Data Analysis Method

A comprehensive literature review was conducted to explore existing research and theoretical frameworks relevant to the topic. This multifaceted approach, combining multiple strategic management frameworks, ensures a thorough and nuanced understanding of the company and its operating environment. It allows for a comprehensive analysis that considers both internal capabilities and external conditions, providing a robust basis for strategic decision-making.

2.4. External Factor Analysis

External analysis, often referred to as environmental analysis, is a critical step in developing a maintenance functional strategy. This analysis involves examining the factors and conditions outside the organization that can impact its operations and performance. The primary goal is to identify opportunities and threats in the external environment.

2.4.1. Environmental Analysis

Environmental analysis, integral to strategic management, entails a systematic examination of external factors influencing an organization's performance and strategy. These factors, categorized as political/legal, economic, socio-cultural, technological, and environmental, offer insights into potential opportunities and threats. By evaluating them, organizations anticipate changes, identify strategic opportunities, and mitigate risks. Staying attuned to these factors enables adjustments in corporate strategy, enhancing competitiveness and long-term sustainability.

1) **Political/Legal**

Article 33, paragraph 3 of the 1945 Constitution asserts that the management of oil and gas exploration and exploitation, classified as vital natural resources affecting people's livelihoods, falls under state control. Consequently, the oil and gas industry in Indonesia experiences significant state involvement, manifested through government policies and laws/regulations. Moreover, the Company's status as a subsidiary of a SOE amplifies political and legal influence on its operations. Several political and legal policies impact the Company's operational activities, extending to its maintenance endeavors.

a) In the 2018 extension of the NSO block contract, a pivotal shift occurred in the type of production sharing contract (PSC) from a cost recovery scheme to a gross split scheme. The fundamental distinction between these two contract schemes lies in the methodology of revenue sharing between the government and the contractor. The cost recovery scheme entails revenue distribution from net revenue, calculated after deducting operating costs (operational costs are the burden of the state). On the other hand, the gross split scheme divides revenue based on gross production, where all operating costs are fully borne by the contractor. This transition brought about adjustments to various rules, impacting aspects such as the approval process for work plans and budgeting, both for investing work programs and operating work programs. Additionally, changes were introduced in the implementation of procurement guidelines by SKK Migas, regulations concerning tax matters, and other pertinent areas. From the Company's standpoint, as all operating costs are now the Company's responsibility, efficient cost management becomes imperative under the gross split scheme to maximize profits.

b) Each proposed work plan and budget within the Company undergoes a comprehensive approval process involving both the SHU Company, acting as the portfolio controller, and SKK Migas, serving as the representative of the nation overseeing oil and gas activities in Indonesia. With the adoption of the gross split scheme in the Company's block contract, the level of state control in approving work programs and budgets has seen a notable shift. Unlike the more rigorous oversight characteristic of the cost recovery scheme, the emphasis in the gross split scheme is placed more on production targets. This adjustment reflects a nuanced approach, where state scrutiny aligns with the specific dynamics of the chosen contract scheme, particularly emphasizing production goals.

c) Government support for effective maintenance activities in the oil and gas industry is evident in Regulation No. 16 of 2020 by the Minister of Energy and Mineral Resources (EMR). This regulation outlines the Strategic Plan of the Ministry of EMR for the years 2020-2024, providing detailed insights through the Decree No. 145.K/11/DJM/2020 issued by the Director General of Oil and Gas. Within this decree, it is articulated that a key strategy to uphold and enhance oil and gas production involves mitigating the loss of production opportunities. This is achieved through the rigorous implementation of maintenance activities, aimed at boosting the reliability and availability of equipment and production facilities while minimizing unplanned shutdowns. The government's emphasis on these measures underscores a commitment to optimizing production efficiency in the oil and gas sector.
d) State backing for the advancement of the domestic industry is evident in various regulations aimed at optimizing the utilization of locally produced goods and services. This directive extends to the oil and gas industry and its ancillary sectors. According to SKK Migas Work Guideline No. 066/SKKMA0000/2021/S4, contractors under the PSC Gross Split scheme are mandated to prioritize the use of domestic products sourced from providers listed in the Domestic Product Appreciation (APDN) book and/or on Local Content Level (TKDN) lists issued by Ministries/Government Agencies. This regulation underscores the government's commitment to fostering the growth of domestic industries by promoting the utilization of locally produced goods and services within the oil and gas sector.
e) Regulation No. 05 of 2015 by the Minister of EMR addresses the mandatory adherence to 35 competency standards within the realm of oil and gas business activities. This regulation explicitly references several Decrees of the Minister of Manpower and Transmigration that govern the Indonesian National Work Competency Standards (SKNNI). The integration of these competency standards underscores a commitment to ensuring the highest levels of proficiency and competence in the oil and gas industry, aligning with national workforce standards and regulations.

2) Economic

The oil and gas industry serves as a pivotal economic driver both nationally and regionally. At the national level, the Company plays a crucial role as a contributor to state revenue within the State Budget (APBN). Being active in the oil and gas sector, the Company contributes significantly to tax revenue from the oil and gas industry and shares in the state revenue generated from natural resources in the sector. Moreover, as a subsidiary of a SOE, the Company also contributes to state revenue through dividend payments.

Similarly, at the regional level, upstream oil and gas activities play a vital role in enhancing the local economy. According to a study by the Ministry of EMR (2016), the presence of upstream oil and gas activities in a region leads to increased economic growth. This is evidenced by a rise in economic activity, higher per capita income for the population, an upswing in Gross Regional Domestic Product per capita, and a boost in employment opportunities. The symbiotic relationship between the oil and gas industry and regional economic development underscores the industry's broader impact beyond national borders.

3) Socio-cultural

The correlation between the presence of a company in an area and the socio-cultural development of that area is evident in their reciprocal relationship. The presence of the Company, along with other related companies, creates an increased demand for skilled labor, which in turn encourages the growth of educational institutions in the vicinity. This phenomenon is clearly visible in Lhokseumawe, where, since the development of oil and gas production in North Aceh by EMOI followed by the construction of an LNG plant by Arun NGL, there has been a significant increase in the Human Development Index (HDI) of Lhokseumawe City.

This is reflected in the average length of schooling for residents of Lhokseumawe, which ranks fourth highest in Aceh Province. According to Figure 2.2, the average length of schooling increased from 10.88 years in 2018 to 11.22 years in 2022. This figure is still above the provincial average for Aceh, which was 9.09 years in 2018 and 9.44 years in 2022.

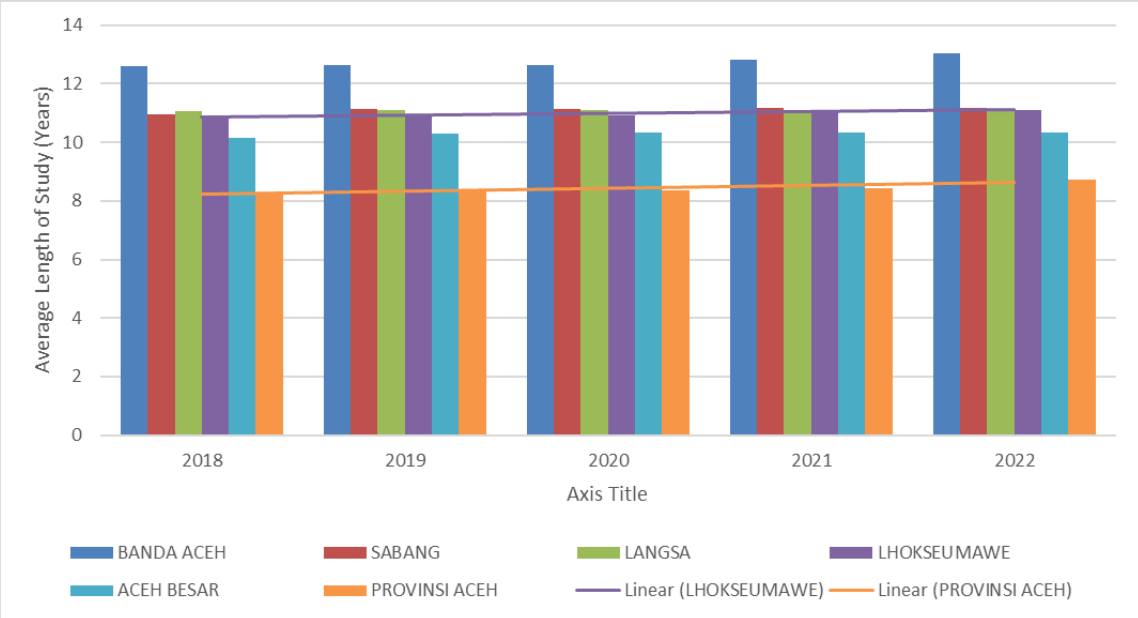


Figure 2.3. Human Development Index in the Five Highest Cities in Aceh Province
(Source: BPS)

The elevated HDI of Lhokseumawe City is closely tied to the proliferation of educational institutions in the area where the Company operates. According to data from the Ministry of Education and Culture (Pusdatin Kemendikbudristek, 2023), Lhokseumawe City boasts 21 colleges, while North Aceh, as a district adjacent to the city, has 7 (refer to Appendix 1). Collectively, these two regions account for 14.8% of the total number of universities in Aceh Province. Notably, Lhokseumawe City has the second-highest number of colleges, following Banda Aceh City, the provincial capital.

The increase in the average length of schooling indicates improvements in the educational system driven by the presence of major companies in the area. The demand for more skilled and educated labor due to the presence of these companies encourages the local population to pursue higher education. This demonstrates how the presence of a company not only impacts the local economy but also significantly influences social and cultural aspects, creating a positive cycle that supports the overall development of the region.

From the Company's perspective, the improvements in socio-cultural conditions, particularly the heightened educational levels of residents in the Company's environment, yield tangible benefits. The Company benefits from a high-quality workforce, as current employees and locally hired contract workers are graduates of local institutions. This symbiotic relationship underscores the positive impact of the Company's presence on the educational and socio-cultural landscape of the region.

4) Technological

The integration of technology in industries is focused on expediting processes, simplifying operations, and enhancing efficiency. Maintenance management activities, in particular, have greatly benefited from various technologies, with CMMS being one of the most commonly used information systems. CMMS facilitates the streamlined management of extensive equipment, covering tasks such as asset register management, maintenance strategy and planning, scheduling, manpower allocation, and monitoring and reporting.

As technological advancements progress, the industrial landscape has entered the era of Industry 4.0, also known as the fourth industrial revolution. Industry 4.0 involves the automation of industrial processes through the incorporation of artificial intelligence with data analysis and machine learning capabilities. Key technologies supporting Industry 4.0 include the Internet of Things (IoT), cloud computing, big data analytics, Artificial Intelligence (AI), and machine learning. Within the oil and gas industry, especially in maintenance activities, the adoption of Industry 4.0 technologies presents an opportunity to enhance the efficiency and precision of maintenance operations.

Notable Industry 4.0 technologies applicable to maintenance include the Industrial Internet of Things (IIoT), machine learning, and augmented reality. The IIoT can facilitate real-time monitoring and PdM by connecting various sensors and devices across the maintenance ecosystem. Machine learning can be used to analyze large volumes of data to predict equipment failures and optimize maintenance schedules. Augmented reality can provide maintenance personnel with real-time, hands-on guidance and visualizations, improving the accuracy and speed of repairs.

Implementation of these technologies can utilize existing technologies in the market or involve the creation of bespoke technological solutions tailored to the specific needs of the Company. Adopting Industry 4.0 technologies can transform traditional maintenance practices into proactive and predictive maintenance models, ultimately reducing downtime, extending equipment life, and increasing overall operational efficiency.

5) Environmental

The oil and gas industry has inherent risks of environmental pollution arising from both routine operations and uncontrolled product releases. This is particularly relevant for the Company, where the gas produced contains impurities, especially H2S and CO2. H2S is a toxic compound that emits an unpleasant odor at low levels and can be fatal if inhaled at higher concentrations, exacerbating environmental concerns. Simultaneously, CO_2 emissions contribute to the industry's carbon footprint and broader environmental impacts.

In the context of inadequate maintenance practices, these risks are further heightened. Frequent equipment or system failures can lead to uncontrolled emissions of H_2S and CO_2. The impact of this pollution not only causes environmental damage but also poses a serious threat to the Company's sustainability. Consequences range from reputational damage and regulatory sanctions to the potential revocation of operational permits.

Therefore, robust and comprehensive maintenance practices are critical to ensuring operational integrity and mitigating the environmental risks inherent in the oil and gas industry. By proactively managing maintenance, the Company can maintain operational continuity and broader environmental well-being, aligning with global efforts to promote sustainable and responsible industrial practices.

2.4.2. Industry Analysis

An industry is a collective of companies sharing similar products or services, such as oil and gas, textiles, transportation, or banking services. The primary objective of a company within an industry is to achieve profitability through effective competition. Consequently, crafting a successful competition strategy becomes a pivotal factor in securing a competitive edge. Identifying the appropriate competition strategy hinges on evaluating the Company's strengths concerning five competitive forces outlined by Porter (1980): the threat of new competitors, the threat of substitutes, the bargaining power of buyers, the bargaining power of suppliers, and the rivalry among existing competitors. These forces collectively impact a company's profitability by influencing factors like price, cost, and required investments (Porter, 1985).

As depicted in Figure 2.3, Porter elucidates that the degree of pressure, whether characterized as high or low, emanating from these competitive forces can be perceived as either a threat or an opportunity for the Company. These forces, acting as constraints, fundamentally shape the operational landscape for companies, influencing their capacity to generate profits. The ability to discern and navigate these forces effectively is pivotal for companies striving to strategically position themselves within their respective industries. Navigating this dynamic realm of competition necessitates a keen understanding of the threat-opportunity spectrum posed by factors like the threat of new competitors, substitutes, the bargaining power of buyers and suppliers, and the rivalry among existing competitors. This strategic awareness is indispensable for companies seeking not only to survive but to thrive amid the intricacies of industry competition.

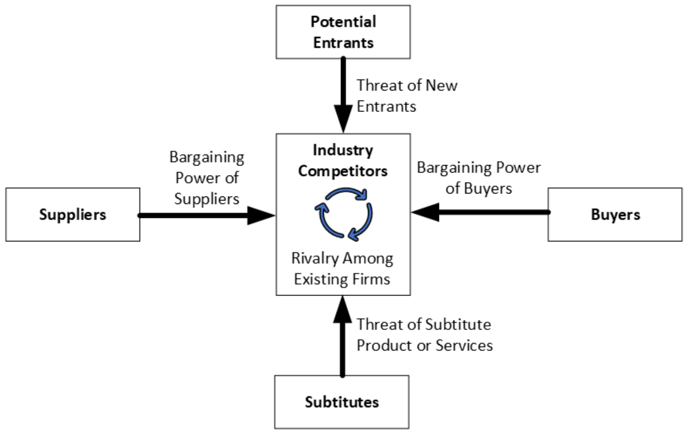


Figure 2.4. Porter's five forces
(Source: Porter (1980))

1) Threat of new entrants

The threat of new entrants in the upstream oil and gas industry is relatively low due to several high barriers to entry. Firstly, acquiring PI to manage an oil and gas block involves stringent compliance with numerous regulations and obtaining various permits and licenses, which presents a significant obstacle. Secondly, the financial requirement for such acquisition demands substantial capital investment, making it difficult for new entrants to penetrate the market. Additionally, the inherently high-risk nature of the oil and gas industry necessitates advanced expertise, extensive experience, and sophisticated technology, further deterring potential new entrants.

From a maintenance management perspective, the threat of new entrants replacing the existing maintenance function is virtually non-existent. The maintenance function operates within a dedicated business unit, ensuring a focused and efficient approach to addressing maintenance-related challenges. The specialized skills and knowledge required for effective maintenance management in the oil and gas sector make it unlikely for new entrants to replace these functions. While companies may choose to outsource certain maintenance activities to third-party service providers, this is a strategic decision based on thorough internal analysis considering factors such as cost-effectiveness, expertise, and operational efficiency, rather than a competitive threat from new entrants.

In summary, the threat to new entrants in the maintenance strategy segment of the oil and gas industry is low, primarily due to the specialized nature of maintenance functions and the typically focused approach within established business units.

2) Bargaining power of suppliers'

The bargaining power of suppliers in maintenance activities encompasses both the suppliers of materials and services. Suppliers of materials, such as spare parts, consumable materials, tools, and equipment, are categorized based on their replaceability: substitutable and non-substitutable materials. Substitutable materials, like pipes, valves, and fittings, can be replaced with other materials of similar specifications or even with different specifications. The Company has not mandated the use of specific brands or original equipment manufacturer (OEM) parts, thereby maintaining high bargaining power when selecting these materials due to the availability of multiple interchangeable options.

Conversely, non-substitutable materials, often associated with specific technologies, copyrights, or systems using certain protocols (e.g., turbomachinery, DCS, and SCADA), grant suppliers higher bargaining power. This power is amplified when manufacturers distribute products through a limited number of agencies or sole agents, such as Trakindo for Caterpillar™ or Indoturbine for Solar Turbine™.

The bargaining power of service suppliers, including third-party maintenance, troubleshooting, inspection, supervision, construction, and installation services, is generally low. Indonesian laws and regulations support the proliferation of supporting companies in the oil and gas industry, fostering a competitive environment among service providers. This competition gives the Company significant leverage. However, the bargaining power of service providers increases when specialized services requiring unique tools or expertise (e.g., underwater survey services) are involved, or when there is limited competition among service providers.

In summary, the overall bargaining power of suppliers for maintenance functions is moderate. The Company holds substantial influence in selecting substitutable materials and services within a competitive market but faces reduced influence when dealing with non-substitutable products/services monopolized by specific suppliers/distributors.

3) Bargaining power of buyers/consumers

In the Company business unit, the maintenance function is responsible for managing all production facilities, starting from the wellhead, distribution pipes, production processing facilities, fire protection systems, and drilling rig facilities, as well as office and residential facilities. Apart from carrying out maintenance, the maintenance function also operates utility facilities such as power plants and water treatment plant (WTP) facilities.

The bargaining power of consumers over functional maintenance can be analyzed from two perspectives: direct consumers and final consumers. Direct consumers are the Company's internal stakeholders, the functions responsible for operating the equipment. Considering that the maintenance function has full control over maintenance management, including determining maintenance strategies, planning, implementation, as well as controlling and evaluating maintenance activities, internal consumers of the maintenance function have low bargaining power in maintenance activities. Their authority is limited to generating notifications if anomalies are detected during operations or if modifications are required to existing designs. As a result, internal consumers have very low bargaining power regarding maintenance activities.

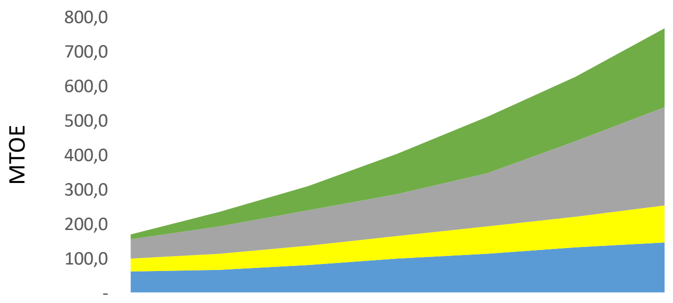
For the final consumers, who are the buyers of oil and gas products, the situation is different. For oil/condensate products, the only consumer is KPI, which has low bargaining power due to the high demand for crude oil products that far exceeds national supply. This reduces consumers' options for alternative sources. Gas products are sold to meet local needs, with consumers including Pertagas Niaga, PLN, PGN, and PGN Gas City. The bargaining power of gas buyers is influenced by purchasing volume and the existence of alternative suppliers. Currently, gas supplies for regional demands come from oil and gas companies in North Aceh, such as the Company and PGE, as well as gas from LNG regasification carried out by PAG. The availability of natural gas is limited, and its price is still lower than regasified LNG, making the Company's gas products more attractive to consumers and reducing their bargaining power to switch to other sources.

In summary, the bargaining power of buyers in the context of functional maintenance is low. Internally, user functions have low bargaining power due to centralized strategic control and maintenance planning. Externally, buyers of oil and gas products also have low bargaining power due to supply-demand dynamics and competitive pricing.

4) Threat of Substitution

Gas and condensate products are predominantly used by consumers as energy sources, though certain industries employ them as raw materials. The energy market, however, is not confined to oil and gas alone; numerous alternative energy sources are increasingly available, particularly from renewable sources such as solar, wind, and hydroelectric power. The growing availability and adoption of these alternatives pose a significant threat to companies in the oil and gas sector. Global initiatives to reduce carbon emissions and the implementation of carbon taxes by governments worldwide are accelerating this shift towards renewable energy.

However, the 2018 Indonesian Energy Outlook (Secretariat General of the National Energy Council, 2018) reveals a complex transition. While the projected composition of the energy mix indicates a decrease in reliance on oil and gas from 49.32% in 2025 to 33.03% in 2050, and an increase in environmentally friendly energy from 17.3% in 2025 to 29.78% in 2050, the absolute demand for oil and gas is expected to rise. Specifically, petroleum demand is projected to grow from 66.2 million tonnes of oil equivalent (MTOE) in 2025 to 148.1 MTOE in 2050, reflecting an annual growth rate of 4.95%. Similarly, gas demand is anticipated to increase from 50.1 MTOE in 2025 to 105.9 MTOE in 2050, with an annual growth rate of 4.46%. Projections of the energy mix from 2017 to 2050 are detailed in Figure 2.4.



	2017	2025	2030	2035	2040	2045	2050
Oil	63,0	66,2	80,8	98,2	115,9	132,9	148,1
Gas	36,1	50,1	58,2	66,4	76,2	88,8	105,9
Coal	56,9	78,7	100,5	122,1	156,8	218,7	286,0
Green Energy	13,0	40,8	73,2	117,6	165,4	190,5	229,0

Figure 2.5. Source of energy outlook
(Source: The National Energy Council)

From a maintenance management perspective, the primary objective is to ensure the reliability and availability of production equipment and facilities, thereby guaranteeing production continuity. Changing roles in maintaining reliability and availability may involve utilizing third-party equipment or facilities through various schemes such as rental agreements, operation and maintenance agreements, build-operate-transfer (BOT) models, or service-based contracts. The selection of these options is a strategic business decision made after comprehensive studies and considerations, and thus is not considered a threat to the functional role of maintenance.

In summary, while the short-term threat of substitution is low, the long-term threat is likely to increase as global energy markets transition to renewable sources. This transition necessitates strategic adaptation to maintain competitiveness and ensure sustainable operations.

5) Rivalry among existing competitors

Competition among existing competitors can be seen from the supply and demand relationship of the products offered by competitors. For condensate/petroleum products, suppliers are identified as all national oil and gas companies that distribute their products for domestic use, and demand is the aggregate consumption of petroleum products on a national scale. Since Indonesia has become a net importer of petroleum where the amount of demand on a national scale is greater than the total national product, all petroleum products produced by national oil and gas companies can be absorbed by the domestic market. This causes competition among competitors to be quite low. On the other hand, the only consumer of the Company's petroleum products is KPI, which is the sister company to the SHU Company. The affiliation synergy policy of the Holding Company provides benefits for the Company, where the Company's products receive priority in terms of absorption compared to other oil and gas companies.

For gas products, because gas products are closely related to the distribution chain, competition analysis among competitors is carried out only in the same distribution chain area. Gas sources for distribution in one distribution chain come from two main sources; gas produced by oil and gas company and gas from LNG regasification by PAG. In terms of price, natural gas produced by oil and gas companies is cheaper than gas from re-gasified LNG. Because consumers are more inclined to cheaper gas, gas products produced by oil and gas companies are preferred, while re-gasified LNG is used as a floating supply.

Just like petroleum products, rivalry among existing competitors for natural gas products is also low with the following explanation:

- Existing consumers are now able to absorb all products produced by existing gas producers.
- The price of natural gas products is a price determined by the government under the Ministry of EMR.
- Gas products are commodity goods that have little product differentiation.
- High switching cost in differentiating product.

Although competition with competitors is low where any gas products produced can be absorbed by the market and companies cannot determine their own prices, to be able to provide the greatest possible profit, the maintenance function has a role in maintaining the reliability and availability of production facilities to maintain production continuity and suppress LPO. Managing maintenance should be done as effectively and efficiently as possible.

2.4.3. Consumer Analysis

Understanding consumer behavior is crucial for determining the maintenance strategy within the oil and gas sector. By comprehending how consumers interact with products and services, companies can tailor their maintenance approaches to ensure optimal reliability and availability of production facilities. Factors such as usage patterns, demand fluctuations, and preferences influence maintenance schedules, resource allocation, and technology investments. By aligning maintenance strategies with consumer needs and market dynamics, companies can enhance operational efficiency, minimize downtime, and maintain a competitive edge in the industry.

Consumers Identify

In accordance with the Constitution of the Republic of Indonesia, natural resources including oil and gas belong to the state and are used for the greatest prosperity of the people. This principle prioritizes meeting domestic needs. Since 1994, Indonesia has experienced a decline in oil production that is inversely proportional to the increase in consumption. As a result, since 2004, Indonesia's status has changed from a net exporter to a net importer. This shift is illustrated in Figure 2.5.

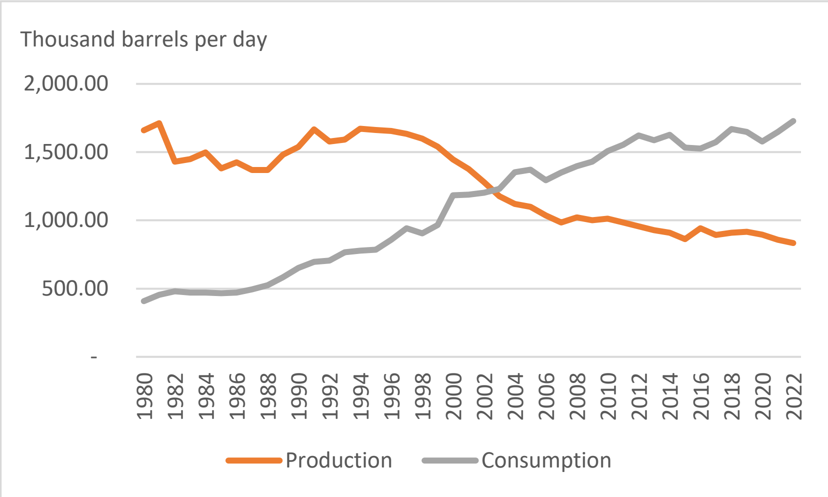


Figure 2.6. Indonesian Oil Consumption and Production from 1980-2022
(Source: U.S. Energy Information Administration)

To increase national energy security and meet domestic oil needs, the Indonesian government has implemented various strategies. One significant measure is Minister of EMR Regulation Number 08 of 2017. Article 17 paragraph 2 in this regulation states that contractors in the Gross Split PSC scheme must allocate production which is the state's share plus 25% of the contractor's share to cover domestic needs. The state, through the Letter of the Minister of EMR Number 5543/13/MEM.M/2014 dated September 1, 2014, has appointed PT. Pertamina (Persero) through KPI to manage all crude oil/condensate that constitutes the state's share.

As a subsidiary of a SOE, the Company is also obliged to support the Holding Company's program to maintain national energy security. The Company sells condensate products, which are the contractor's share, for the domestic market. Given that the Holding Company is an integrated energy company that also has subsidiaries in the oil refining sector, synergy among subsidiaries and affiliated companies is crucial. All condensate products that belong to the company are sold to KPI, which is the sole consumer of the condensate products produced by the company.

The distribution of natural gas presents unique challenges. Although converting natural gas into LNG, CNG, or LPG offers flexibility in packaging and shipping, this conversion process incurs additional costs that can ultimately increase the selling price and impose financial burdens on consumers. Distribution of natural gas through pipelines remains the most efficient method.

Natural gas sales can be conducted in two ways, direct sales from the producer to the consumer and sales through distribution companies. In direct sales, the gas product is delivered to the endpoint through independent pipelines built by the producer or through the gas pipeline network owned by the PGN Group, which will incur a toll fee. In this method, the responsibility for finding customers lies with the producer. In the second method, delivery is made at the available gas pipeline network point, while finding end consumers is the distributor's responsibility. Currently, the company's consumers for gas products include Pertagas Niaga (market share 62.08%), PGN (35.78%), and PGN City Gas (2.14%), all of which are sister companies under Subholding Gas.

Consumers Behavior

Consumer behavior in the oil and gas sector in Indonesia is influenced by several key factors, including government regulations, market dynamics, pricing mechanisms, and the quality and availability of products. These factors shape the demand patterns and purchasing decisions of consumers in both the industrial and domestic segments.

1) Government regulation

   Governments influence consumer behavior in the oil and gas market through a variety of regulatory measures designed to ensure energy security, protect the environment, and promote economic stability. These regulations include taxes and subsidies, which can respectively discourage or encourage fuel consumption by affecting prices. Environmental regulations, such as emissions standards and carbon pricing, aim to reduce greenhouse gas emissions and promote cleaner energy use, indirectly shaping consumer choices. Fuel efficiency standards for vehicles and appliances mandate higher efficiency, reducing overall energy demand. Additionally, incentives for renewable energy and electric vehicles encourage a shift away from fossil fuels. Information and labeling requirements help consumers make informed decisions about their energy consumption. Investments in public transportation and urban planning can reduce reliance on personal vehicles, further decreasing oil and gas usage. Trade policies also impact fuel prices and availability, affecting consumer behavior. Collectively, these regulatory approaches guide consumers towards more efficient and sustainable energy practices, ultimately influencing the overall demand for oil and gas.

2) Market dynamics

Market dynamics significantly influence consumer behaviors in the oil and gas sector through various mechanisms such as supply and demand fluctuations, price volatility, geopolitical events, technological advancements, and market competition. Supply disruptions due to natural disasters or geopolitical conflicts can reduce oil availability, leading to higher prices and prompting consumers to reduce usage or seek alternatives. Economic growth increases demand and prices, while recessions have the opposite effect. Price volatility, with sudden spikes or long-term trends, can lead consumers to cut back on non-essential travel or invest in fuel-efficient technologies and alternative energy sources. Geopolitical instability and international trade policies add uncertainty, influencing consumers to be more cautious with energy consumption. Technological advancements in extraction and production can increase supply and lower prices, while efficiency improvements and the rise of renewable energy and electric vehicles offer consumers more choices, reducing dependence on traditional fossil fuels. Additionally, growing environmental awareness and economic considerations drive consumers towards cleaner and more cost-effective energy solutions. These market dynamics collectively shape consumer behavior, leading to shifts in consumption patterns and investments in sustainable energy technologies.

3) Pricing mechanisms

Oil and gas prices exert a profound influence on consumer behavior across various aspects of daily life and economic decision-making. When prices surge, consumers often respond by curtailing non-essential travel, carpooling, or switching to public transportation to mitigate the impact of higher fuel costs. Similarly, households facing escalating heating or electricity bills may adopt measures like adjusting thermostat settings or investing in energy-efficient upgrades to conserve energy. Such price fluctuations can ripple through the economy, fueling inflation and diminishing disposable income, prompting consumers to trim spending on discretionary items. In the long term, sustained high prices catalyze investments in fuel-efficient vehicles and alternative energy sources like solar or wind power, altering consumption patterns and driving a gradual shift towards more sustainable practices. Government interventions, such as subsidies or incentives for energy-efficient technologies, also play a pivotal role in shaping consumer responses to price volatility. Ultimately, oil and gas prices not only dictate immediate consumption choices but also influence broader lifestyle adjustments, market dynamics, and policy frameworks as societies strive to navigate the complexities of energy sustainability and economic resilience.

The price of oil and gas in Indonesia is determined by the government. For crude oil, the Indonesian Crude Price (ICP) index formula refers to the Regulation of the Minister of EMR Number 29 of 2021. And ICP price movements are strongly influenced by world oil price movements. For comparison, the average price of ICP with WTI and Brent can be seen in Figure 2.6. In this graph it can be seen that ICP price movement are influenced and in line with world oil prices represented by WTI dan Brent index.

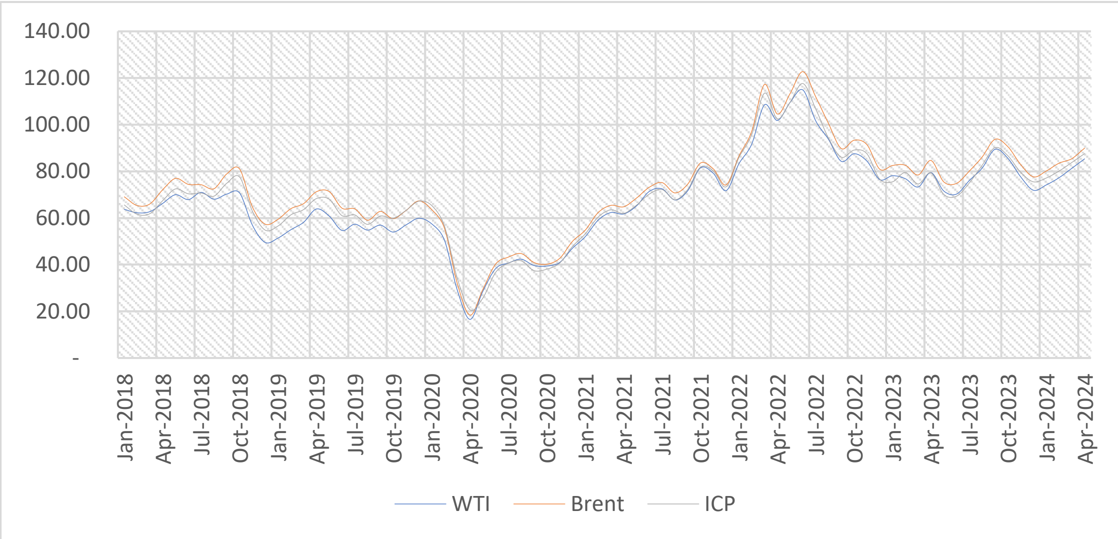


Figure 2.7.Crude price comparison between WTI, Brent and ICP
(Source: U.S. Energy Information Administration and Ministry of EMR)

Just like crude oil, the price of natural gas is also determined by the government. Here are some regulations related to natural gas pricing and consumers who are entitled to certain prices.

a) Presidential Regulation No. 40 of 2016 amended by Presidential Regulation No. 212 of 2020 explains that the price of natural gas to users engaged in industry and the provision of electricity for public interest is not more than US$ 6 / MMBTU with the handover point at the user's plant gate.
b) Regulation of the Minister of EMR No. 58 of 2017 as amended by Regulation of the Minister of EMR No. 14 of 2019 which regulates the price of natural gas from business entities holding oil and gas commercial business licenses for the supply of electricity and industry, households and small customers and the provision of fuel gas for transportation.

c) Government Regulation Number 48 of 2019 which regulates the formula of contributions and the amount of contributions for gas transportation business activities.
d) BPH Migas Regulation No. 34 of 2019 which regulates the procedure for calculating natural gas transportation rates through pipelines and economic useful life in accordance with supply availability.
e) Regulation of Minister of EMR Number 8 of 2020 which sets gas prices at US$ 6 / MMBTU at end-user plant gates for 7 industrial sectors, regulates the provision of incentives for distribution business entities and regulates the role of BPH Migas.
f) Decree of the Minister of EMR Number 89 of 2020 which explains certain natural gas users and prices in the industrial sector.
g) Regulation of the Minister of EMR Number 10 of 2020 which regulates the price of natural gas for industries used for electricity generation is no more than US $ 6 / MMBTU at the plant gate.
h) Decree of the Minister of EMR Number 91 of 2020 which sets the price of natural gas at the plant gate for business in electric/power generation.
i) Decree of the Minister of EMR Number 91.K / MG.01 / MEM. M/2023 which sets certain natural gas users and certain natural gas prices in the industrial field.

Since the price of petroleum and gas products refers to the price set by the government, both producers and consumers do not have power to decrease or increase the price of oil and gas.

4) Quality

Crude oil and gas produced usually contain impurities in the form of water (generally containing salts), other gases (such as CO2, H2S, N2) and solids (such as sand, scale, dirt, mud and corrosive materials in production facilities such as pipes). These impurities if not properly separated on the producer side will be lost on the consumer side, affect product quality on the consumer side, or can even affect the reliability or service life of consumers. Impurities that exceed the design specifications of consumer equipment can accelerate the life of equipment or even damage the equipment. For example, CO2 gas is a gas that is corrosive to certain metal materials, CO2 levels exceeding a certain limit will shorten the service life of pipes or other equipment. For these considerations, consumers usually require limits on impurities allowed in petroleum and gas products.

These impurities limitations are contained in the contract of sale and purchase agreement between the company and the consumer.

5) Certainty of supply

Generally, consumers using oil and gas products as raw materials and energy sources. To meet their operational needs, consumers expect certainty of continuity of supply to petroleum and gas products. Unplanned shutdown is an unexpected event on the consumer side and can affect consumer perception of the company.

In terms of price, the Company cannot make efforts to be able to influence product prices. However, in terms of quality and continuity, operational and maintenance functions have a fairly high role. The firm's operations functional manage all resources including in operating equipment or production facilities in producing, processing, and selling oil and gas to consumers. To be able to retain consumers and maintain their perception, the Company must ensure that managed production facilities can be operated in accordance with design capacity through good operational and maintenance practices.

2.5. Internal Factor Analysis

Internal factor analysis aims to find the strengths and weaknesses of the Company (or functional maintenance in the context of functional strategy) through the analysis of core competencies obtained from the analysis of resources and capabilities of the company and functional. By knowing the resources and capabilities that have the most strategic importance or which are functional superior competencies, then assess how functional can utilize these superior competencies into competitive advantages both against competitors and in fulfilling business and corporate strategies.

2.5.1. Resource Analysis

Company resources are all assets, capabilities, organizational processes, company attributes, information, knowledge, etc. which are controlled by the company and used to formulate and implement strategies with the aim of increasing the efficiency and effectiveness of the company (Barney, 1991). These resources are grouped into 3 categories: tangible assets, human assets and intangible assets (Weelen & Hunger, 2012; Grant, 2018).

1) **Tangible Assets**

Tangible assets are physical and measurable assets that an organization owns. These assets have a physical form and can be used to produce goods or services, support operations, and generate revenue. Tangible assets can be financial (such as cash, budget, borrowability, repayment ability) or physical (buildings, equipment, inventory). The following will explain the tangible assets owned by company related to managing maintenance management.

a) Financial Assets

Financially, the Company’s maintenance function operates with a dedicated maintenance budget, serving as a pivotal cost center responsible for executing and managing maintenance programs essential for the company's operational integrity. Endowed with both the capability and authority, the maintenance function meticulously plans and proposes annual maintenance programs and budgets, aligning them with the Company's broader work program and budget. These proposals undergo rigorous scrutiny and approval processes from the SHU Company and SKK Migas to ensure compliance with strategic objectives and regulatory standards. Despite having a designated budget, the maintenance function lacks unilateral authorization for expenditures or payments. Instead, approvals must be obtained from leaders at the business unit manager level or higher, in accordance with specified expenditure/payment authorization limits, ensuring prudent financial management. As a subsidiary of PHE, internal company funding sources play a crucial role in covering operational and investment costs. These funds, derived from the company's operational activities and contributions from the SHU Company overseeing the upstream oil and gas business portfolio, underpin various needs, including daily operations, facility maintenance, and new project investments. This intricate financial framework underscores the maintenance function's strategic importance, ensuring operational efficiency while adhering to robust financial controls and compliance standards.

b) Workshop Building and Infrastructure

The maintenance workshop/building and supporting infrastructure are tangible assets that play an important role in supporting the company's maintenance and repair activities. Ideally these assets provide the physical space and facilities necessary to perform activities such as assembly, fabrication, or maintenance effectively and efficiently. However, currently the maintenance functional is facing challenges in optimizing and managing workshops/maintenance buildings dedicated to maintenance activities efficiently. At the beginning of the transition of Block B and NSO operators from EMOI to PHE, the workshop/maintenance building used by APO Field was an ex-EMOI asset in Lhoksukon. However, since Block B was acquired by PGE, the entire NSO Field team including the maintenance team moved from Lhoksukon to the ex-Arun NGL refinery which has belonged to LMAN since Arun NGL was terminated. Previously, the building was used as a transportation equipment and heavy equipment workshop during the Arun NGL era.

The equipment and supporting facilities owned by the building are dedicated to transportation workshops and maintenance of heavy equipment, some of which are no longer usable, such as overhead cranes that are damaged, jib cranes that are no longer installed, air compressors that have not been maintained for a long time, etc. Adapting the layout of this building to accommodate all maintenance teams or sub-functions under PHE requires strategic use of the available area. The building layout needs to be modified to align with the specific needs of the current maintenance function. Investments in tools and equipment that you don't already own must be made. In addition, supporting equipment that is integrated into the building, such as the equipment previously mentioned, needs to be repaired and maintained to increase the capability and effectiveness of maintenance facilities.

c) Tools and equipment

Functional maintenance utilizes and maintains tools and equipment for executing maintenance activities. Some of these tools and equipment are already available in the workshop building, a legacy from the Arun NGL period. The remaining items are acquired through investments, rentals, or service contracts with third parties. Outsourcing maintenance to a third party is typically considered when specific tools or equipment, and/or the qualifications of maintenance functional personnel, are unavailable or not suitable for certain maintenance activities, such as overhaul maintenance or the repair of electric motors.

To enhance the functional capability of maintenance in conducting repairs and inspections, a comprehensive analysis of tool and equipment needs, coupled with an assessment of maintenance workforce skills, is essential. Additionally, an economic analysis comparing in-house maintenance with outsourcing options is crucial. If the evaluation demonstrates that, with the current skills or through skills enhancement, it is more cost-effective to conduct maintenance and inspections independently rather than outsourcing, then the procurement of necessary tools and equipment becomes justifiable. For instance, the maintenance function currently oversees a substantial amount of equipment like pumps and electric motors, where bearing replacement is a frequent maintenance task. However, due to the lack of equipment and workforce capabilities, this bearing replacement work is outsourced to a third party. By investing in tools and equipment and providing training to the workforce, the maintenance function can achieve efficiency by independently performing bearing replacement work.

d) Spare part and consumable material

Spare parts refer to equipment components that are replaced upon reaching the end of their service life, while consumable materials are materials that are depleted during maintenance activities, such as welding wire, oxygen, propane, etc. The functional warehouse is responsible for managing spare parts and stock items, while consumable materials fall under the purview of the maintenance function. Due to the prevalence of reactive maintenance in the maintenance program, and the lack of implementation of PM or PdM, the management of spare part materials has not been optimal. The absence of input from the functional maintenance team has hindered the warehouse's ability to strategically purchase and efficiently manage min-max stock levels.

As of now, the management of spare parts materials for maintenance needs does not align with company guidelines for stock material management. This discrepancy is attributed to the inadequate identification of maintenance activity planning, preventing the creation of a material requirements plan that serves as input in the Material Requirements Planning (MRP) program.

2) Intangible Asset

a) Corporate culture or values

The Company adheres to the AKHLAK values, which stand for *Amanah* (Trustworthy), *Kompeten* (Competent), *Harmonis* (Harmonious), *Loyal* (Loyal), *Adaptif* (Adaptive), and *Kolaboratif* (Collaborative). These values are derived from the Ministry of SOE and are cascaded down from Holding Company to SHU

Company and further to companies in Business Units. These values serve as guiding principles for the company's operational activities, promoting trust, competence, harmony, loyalty, adaptability, and collaboration among its employees and stakeholders. The adoption of these values reflects the company's commitment to maintaining high ethical standards and fostering a positive organizational culture.

b) Integrated CMMS and ERP

In maintenance management, the company has implemented a CMMS that is seamlessly integrated with the company's Enterprise Resources Planning (ERP). User accounts and authorizations have been established for each superintendent within the operating unit, ensuring a structured and secure access system. This integration enhances the efficiency and coordination of maintenance activities by providing a centralized platform for planning, scheduling, and tracking maintenance tasks, contributing to streamlined operations and improved decision-making processes.

c) Corporate Working Guidance

In adhering to best practices in the oil and gas industry, the company has developed various guidelines, organizational governance structures, and individual governance protocols within its corporate governance framework. These regulations are strategically overseen at the Regional and SHU levels, extending to all production units, including PHE-NSO. Specifically, regarding maintenance activities, the company has instituted a set of rules, including:

- Maintenance Guidelines
- Guidelines for Standardization of Production Facility Integrity Management Programs
- Process Safety and Asset Integrity Management System (PSAIMS) Guidelines
- Standardization of Corrosion Management Systems
- Standardization of Floating Integrity Management System (FIMS) Methodology
- Standardization of Pipeline Risk Assessment Methodology for Pipeline Integrity Management System (PIMS)
- Standardization of Reliability Management System (RMS) Methodology - Electrical Equipment and Instruments
- Standardization of Reliability Management System (RMS) Methodology - Rotating Equipment

- Standardization of Surface Facility Integrity Management System (SFIMS) Methodology - Static and Piping
- Standardization of Structure Integrity Management System (SIMS) Methodology
- etc.

d) Culture

The oil and gas industry is inherently high-risk, necessitating the establishment and adherence to various standards, codes, rules, guidelines, and procedures to mitigate operational risks. Within the company, the consistent application of these standards and codes has evolved into a ingrained habit and cultural norm among the workforce. This commitment to a 'safety-first' culture is particularly evident in maintenance management practices.

e) Motivation

The reliability and availability of production equipment and facilities serve as KPIs for the President Director of the SHU Company, and these targets cascade down through various levels to the operational unit manager. Throughout the company, there is a shared understanding among all employees regarding the impact of equipment failure on production. It has become a standard operating procedure within the units that any disruptions, especially those leading to production halts, must be addressed promptly, regardless of time and cost constraints. The maintenance function team is prepared to respond immediately, even outside regular working hours.

3) Human Assets

a) Organization

The Company places significant emphasis on upholding equipment reliability and availability to ensure sustained production across its operating units. This commitment is evident in the maintenance organization structure spanning from the Sub Holding Company, Regional, and Zone levels down to the Field or Operational Unit level. At the Field level, the maintenance organization primarily oversees the implementation phase of the maintenance program. Moving up to the Zone level, the focus shifts to strategic maintenance activities such as executing Turn-Around projects and negotiating Long-Term Contract Agreements, blanket contracts, and other high-value contracts. Meanwhile, maintenance organizations at the regional level are dedicated to formulating maintenance strategies and policies. At the SHU level, the maintenance function is geared towards coordination, integration with portfolio management, and standardization efforts.

The company has structured its maintenance team organization into three sub-functions, each grouped based on similar skill sets: Maintenance Planning, Mechanical Maintenance, and Electrical and Instrumentation Maintenance. Within the Maintenance Planning sub-function, responsibilities include preparing maintenance program plans, planning maintenance contracts, overseeing and evaluating maintenance activities, reporting on maintenance activities, and managing materials and spare parts for maintenance tasks. The Mechanical Maintenance sub-function is further divided into teams specializing in various mechanical maintenance areas, including rotating mechanical, static mechanical, scaffolding, painting, and civil & multicraft teams. The rotating mechanical maintenance team, for instance, comprises smaller teams focusing on pump and turbine maintenance, engine maintenance, and hoist and heavy equipment operation. Similarly, the static maintenance team is subdivided into shop maintenance and field maintenance teams. Within the Electrical and Instrumentation Maintenance sub-function, there are distinct electrical and instrumentation maintenance teams, each further divided into shop maintenance and field maintenance teams. This organizational structure is visualized in Figure 2.7.

[redacted]

Figure 2.8. Organization structure of maintenance functional PHE-NSO

b) Manpower

Maintenance Functional personnel comprise core workers, encompassing both permanent and contract employees, as well as outsourced employees categorized by their employment status. The core workforce is centrally appointed and placed by either the Sub Holding Company or Regional Company. As depicted in Figure 2.8., the maintenance team is overseen by a first-line manager, the Superintendent, who directly supervises two senior line maintenance supervisors and one planner. Each line maintenance supervisor oversees a team of two technicians. Clear job descriptions are assigned to each position. Presently, two out of the eight positions are vacant: Maintenance Performance and Planner, and Senior Supervisor Electrical and Instrument.

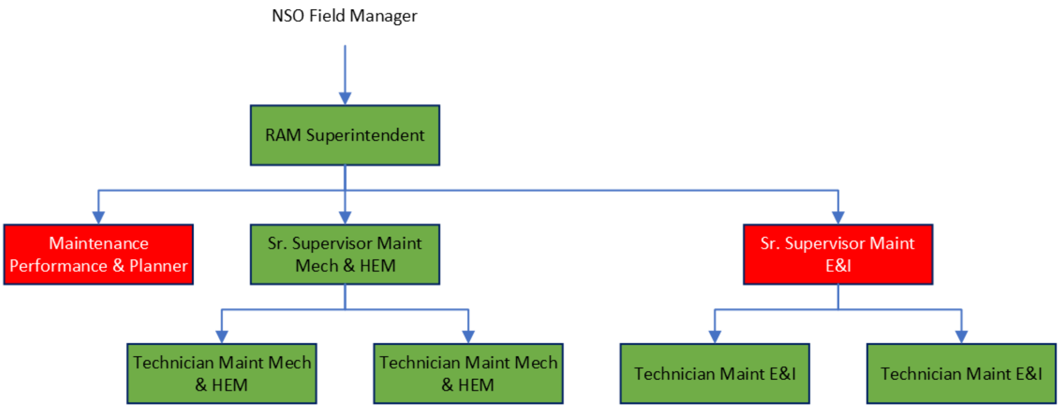


Figure 2.9. Core position in Maintenance Organization

In addition to the core workforce, the Functional Maintenance Organization receives support from outsourced workers who aid in carrying out tasks alongside the core team. Initially, this workforce was recruited through labor contract innovations, a result of acquiring offshore facilities from EMOI and onshore facilities from PAG. These outsourced workers operate based on directives from the core workforce and lack well-documented job descriptions for individual positions. To date, there has been no workload analysis or evaluation of labor requirements since the transition of contract labor from the former company.

c) Skill/know how

Functional maintenance encompasses diverse competencies within the planning and execution divisions. In the planning division, the team is competent in drafting contracts, identifying spare parts for each piece of equipment, and conducting transactions in SAP. This includes creating purchase requests for materials and services, maintenance requests using notifications, work orders, and closing work orders.

The hard competencies within the maintenance executor groups are categorized into five essential groups, each playing a pivotal role in maintaining various aspects of the company's facilities, thereby enhancing the overall reliability and efficiency of the production process.

i. Mechanical Rotating Group: This specialized group concentrates on the maintenance and repair of rotating machinery, encompassing pumps, turbines, and compressors. Their expertise is vital in managing dynamic mechanical components subjected to wear and tear due to continuous rotation.
ii. Mechanical Static Group: Focusing on stationary mechanical components, this group oversees equipment such as pressure vessels, heat exchangers, and pipelines. Their proficiency lies in ensuring the integrity and reliability of these non-moving structures.
iii. Electrical Group: Tasked with electrical systems and components, including motors, switchgear, and control systems, this group is responsible for sustaining the electrical functionality of diverse equipment and guaranteeing a secure and efficient power supply.
iv. Instrumentation Group: Specializing in the maintenance of instrumentation and control systems, this group ensures the precision and reliability of measuring and control devices. This includes managing sensors, transmitters, and control valves critical for effective process control.
v. Civil & Structure Group: Focused on the structural aspects of facilities, this group addresses buildings, platforms, and other infrastructure. They ensure the integrity of civil structures, including foundations and support systems, enabling them to withstand environmental conditions.

Each of these groups contributes uniquely to the maintenance and upkeep of specific components, collectively fortifying the company's operational reliability and optimizing the production process.

d) Communication and Collaboration

Effective communication is a cornerstone in the maintenance management system within the company, fostering collaboration and ensuring a seamless flow of information. Communication channels are well-established and utilized across different levels, from the team within the business unit to interactions with the Zone, Regional, and SHU. Various platforms facilitate communication, ensuring a comprehensive and efficient exchange of information.

i. Town Hall Meetings: Large-scale meetings provide a platform for addressing broader topics and disseminating essential information to a wider audience.

ii. Memorandums and Circulars: Official written communication methods are employed for conveying important updates, policies, and guidelines.
iii. Warrants: Formal documents are issued to authorize specific actions or convey official instructions, ensuring clarity and accountability.
iv. Emails: As a common mode of communication, emails are employed for both formal and informal exchanges, providing a written record of correspondences.
v. Broadcasting: Leveraging broadcasting systems allows for the dissemination of information to a larger audience efficiently.
vi. Information Technology Tools: Utilization of information technology is integral, with online meetings and folder sharing facilities enhancing collaborative efforts.
vii. WA Group: For smaller, more focused teams, instant messaging platforms like WhatsApp groups facilitate quick and direct communication.
viii. SharePoint: Collaborative platforms like SharePoint enhance document sharing and team collaboration, streamlining work processes.
ix. Online and Offline Meetings: The combination of online and offline meetings accommodates diverse preferences and ensures effective communication regardless of the team's location.

This diverse array of communication channels caters to different needs and preferences, fostering a well-connected and informed maintenance management system within the company.

e) Motivation

The maintenance functional personnel exhibit a uniform understanding of the paramount importance of maintaining equipment reliability for ensuring uninterrupted production. This shared commitment is evident in their dedication to completing every improvement activity and their willingness to initiate or continue work beyond regular working hours. This collective sense of responsibility underscores the team's commitment to the overall efficiency and continuity of production processes.

2.5.2. Capabilities Analysis

Organizational capability refers to a company's ability to effectively utilize its resources to achieve its objectives. The synergy between various resources, working collectively rather than in isolation, maximizes productivity and leads to the successful production of the desired final product (Weelen & Hunger, 2012). This collaborative approach is particularly crucial in maintenance activities, where multiple functions within an organization must interact to ensure effective and efficient operations.

The functional capability of maintenance involves executing maintenance activities aligned with a comprehensive maintenance work program. This necessitates collaboration with other functional roles within the organization, highlighting the importance of interfunctional relationships. The value chain analysis in maintenance activities illustrates these relationships and the interconnected roles within the organizational structure.

To analyze the value chain within maintenance activities, Porter's value chain framework is employed. This strategic tool categorizes a company's activities into primary and support activities, providing a structured approach to understanding where value is created and identifying potential areas for cost minimization. Primary activities encompass inbound logistics, operations, outbound logistics, marketing and sales, and service, while support activities comprise infrastructure, human resource management, technology, and procurement. Figure 2.9. illustrates this framework, offering insights into the various functions engaged in the maintenance value chain.

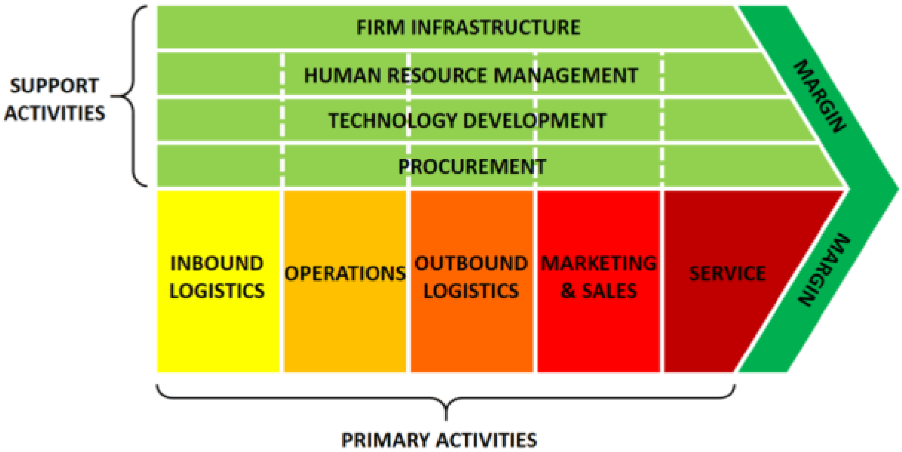


Figure 2.10. Potters' Value Chain Framework
(Source: Porter (1985)

1) Primary Activity

a) Inbound Logistic

In the realm of maintenance activities, inbound logistics entails efficiently managing both stock and non-stock materials essential for operational needs. Stock materials encompass regularly kept, standardized items, managed through ongoing inventory control processes to ensure availability for consistent demand and mitigate supply chain disruptions. The Warehouse Functional unit oversees the management of stock materials, including spare parts and raw materials crucial for ongoing operations. These materials are received from suppliers and temporarily housed at the warehouse, serving as a central transit point before distribution to end users.

In contrast, non-stock materials are procured on an ad-hoc basis for specific projects or orders, avoiding inventory storage and managed with just-in-time delivery, being ordered and used as needed without being stored as inventory. The responsibility for managing non-stock materials often falls to the user function within organizations, ensuring seamless integration into operational workflows without burdening centralized inventory management systems.

The timely availability of spare parts is facilitated by an Inventory Management System (IMS) administered by the Functional Warehouse. The IMS relies on inputs from the Maintenance Functional unit, which compiles a Bill of Material (BoM) and Master Schedule (MS) based on maintenance planning programs. These documents are integrated into Material Requirement Planning (MRP) by the Functional Warehouse to ensure necessary materials are available when needed. Stock levels of spare parts are managed using the min/max level method to maintain optimal inventory without overstocking.

Effective management of inbound logistics necessitates close collaboration between the Functional Warehouse and Functional Procurement units. This collaboration is vital for maintaining optimal stock levels through Supply Chain Management (SCM), integrated into the ERP system. SCM ensures a smooth flow of materials from suppliers to the warehouse and eventually to end users, while ERP integration facilitates real-time data sharing and coordination across the organization.

An integrated approach to inbound logistics yields several benefits, including the timely availability of spare parts and materials, minimized downtime, and enhanced maintenance efficiency. By leveraging IMS and integrating it with SCM and ERP systems, organizations can streamline processes and improve overall operational efficiency, supporting their capability to meet operational objectives and sustain a competitive edge.

b) Operation

The relationship between operational and maintenance functions is crucial for an organization's efficiency and effectiveness, characterized by interdependence and cooperation. The operational function is responsible for ensuring that all company resources involved in production activities perform their roles effectively, including the operation of equipment and facilities. Meanwhile, the maintenance function aims to keep equipment and facilities in optimal condition, prevent breakdowns, and ensure smooth operations. Both functions share the goal of maximizing productivity and efficiency, with operations focusing on high output and maintenance on equipment reliability. Therefore, regular communication and collaboration between these functions are essential for scheduling maintenance with minimal disruption. The interplay between these functions in the organization is illustrated in the utilization and maintenance of production equipment or facilities, as depicted in Figure 2.10.

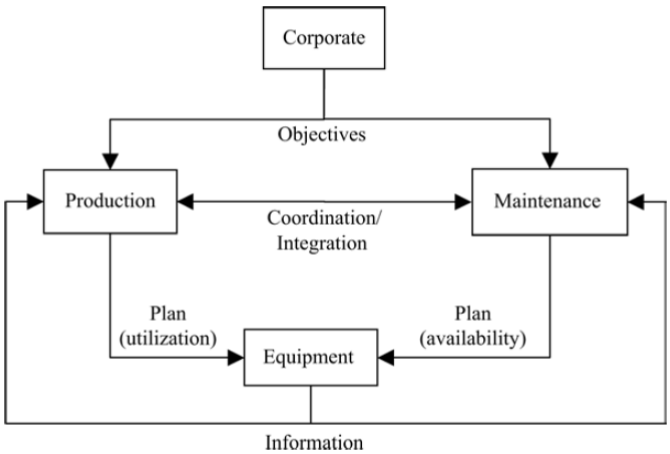


Figure 2.11.Operation and Maintenance Interrelation in Maintenance Management
(Source: Al-Turki (2011))

PM and PdM programs heavily rely on feedback from operations to optimize equipment performance. When equipment malfunctions or deviates from its design specifications, the operational function is responsible for submitting repair requests or issuing notifications for corrective actions. This information is then communicated to the maintenance function, highlighting the collaborative relationship between these two essential functions in maintaining the reliability and performance of production equipment.

The primary responsibility of the maintenance function is to ensure that production equipment and facilities operate according to their design or specified operational parameters. This involves a range of activities, including inspections, corrective maintenance (CM), breakdown maintenance (BdM), preventive maintenance (PM), predictive maintenance (PdM), and proactive maintenance (RxM). Before starting maintenance tasks, maintenance planners evaluate the necessary resources, such as spare parts, consumables, equipment, and labor. If spare parts and consumables are considered stock items, planners create a Material Request (MR) for the warehouse function. In cases where spare parts are not stocked items, a Purchase Request (PR) is made for materials and submitted to the procurement function. If the evaluation indicates the need for outsourced labor, planners will create a PR for services if a service contract is not available or a Release Order (RO) if a service contract is already in place.

Once the maintenance requirements plan is fulfilled, planners create a Work Order (WO) and submit it to the maintenance execution division. The maintenance execution group then proceeds with the planned maintenance activities or oversees the work if performed by third parties. After completing each maintenance activity, the work order must be closed with technical completion (TeCo). If unplanned maintenance work occurs, the maintenance execution group can create a new notification, providing insights to the planning team for future improvements. This comprehensive process ensures the systematic and efficient management of maintenance activities within the company.

Thus, the interconnection between operational and maintenance functions through close communication and collaboration, along with a structured maintenance process, is crucial for maintaining organizational efficiency and effectiveness in achieving production goals.

c) Outbound Logistic

In the context of the maintenance management, outbound logistics involves the delivery and performance of maintenance services, which are essential for ensuring the optimal functioning of production equipment and facilities. These services are evaluated through KPIs such as reliability, availability, Overall Equipment Effectiveness (OEE), Loss Production Opportunity (LPO), and maintenance costs. Reliability and availability metrics measure how consistently and efficiently equipment performs without failures and how much time it is operational, respectively. High reliability and availability indicate effective maintenance practices that minimize downtime. OEE is a composite metric that assesses how well equipment is utilized by considering its availability, performance efficiency, and quality rate. High OEE reflects optimal equipment performance due to timely and effective maintenance.

LPO measures the potential production loss caused by equipment downtime during maintenance activities. Minimizing LPO is crucial for maintaining high production levels and ensuring maintenance activities are scheduled and executed with minimal operational disruption. Maintenance costs include both direct costs, such as labor and spare parts, and indirect costs, like downtime and reduced productivity. Effective maintenance management aims to keep these costs within budget while maintaining high service quality.

The maintenance functional's outbound logistics also involves timely responses to maintenance requests, effective scheduling of preventive and corrective maintenance, and efficient execution of repair tasks. Continuous monitoring of maintenance activities using KPIs helps assess service effectiveness, supporting data-driven decision-making and continuous improvement. Implementing a feedback loop to refine maintenance strategies based on performance data ensures recurring issues are addressed, and preventive measures are developed.

Overall, effective outbound logistics in the maintenance department optimize equipment performance, manage costs, and drive continuous improvement. This holistic approach aligns maintenance activities with the company's operational goals, ensuring sustained productivity and operational excellence.

d) Marketing & Sales

In the context of internal customers within the company, traditional marketing and sales strategies may not be directly applicable. Instead, a tailored approach focused on implementing a maintenance strategy campaign would be more suitable. This campaign aims to enhance internal communication and awareness surrounding maintenance strategies, promoting best practices and emphasizing the vital role of each functional unit in contributing to the overall success of maintenance activities.

The maintenance strategy campaign would involve various initiatives aimed at fostering understanding and alignment across all internal stakeholders. Workshops and training sessions could be organized to educate employees about the importance of maintenance strategies, imparting knowledge about different maintenance methodologies, and highlighting the significance of proactive maintenance approaches. These sessions would not only increase awareness but also empower employees to actively participate in maintenance-related initiatives.

Regular communication channels, such as newsletters, intranet updates, and team meetings, would be utilized to disseminate information about ongoing maintenance projects, success stories, and upcoming initiatives. By keeping internal stakeholders informed and engaged, these communication channels would ensure that everyone is aligned with the maintenance strategy and understands their role in its execution.

Furthermore, fostering a culture of continuous improvement and collaboration would be integral to the success of the maintenance strategy campaign. Encouraging cross-functional collaboration and knowledge sharing would facilitate the implementation of innovative maintenance practices and the identification of opportunities for optimization.

Overall, the maintenance strategy campaign aims to create a shared understanding of maintenance goals and objectives among internal stakeholders, driving collective efforts towards achieving maintenance excellence within the company. By promoting internal awareness and alignment, the campaign sets the stage for enhanced efficiency, reliability, and sustainability of maintenance activities, ultimately contributing to the company's overall success.

e) Service (After Maintenance)

Within the framework of Porter's Value Chain Analysis, primary activities of services are crucial for providing exceptional after-sales support and customer service. Similarly, in the maintenance management of a company, where the customer for maintenance services is internal, the principles of service provision remain paramount. Post-repair or maintenance, the maintenance guarantee persists, ensuring continued operational efficiency. Maintenance activities inherently demand continuous efforts, necessitating collaboration between functional operations and maintenance teams. Following repairs, the operational team meticulously monitors equipment performance, promptly generating corrective maintenance notifications if further issues arise during this monitoring phase. Simultaneously, the maintenance planning team evaluates equipment performance post-servicing, conducting a thorough examination of reports provided by the implementation team during maintenance work. Subsequently, based on these findings, the maintenance planning team issues work orders to ensure efficient follow-up actions are taken. This collaborative and cyclical process is instrumental in maintaining equipment in optimal condition, thus enhancing the overall effectiveness of maintenance activities within the company's operational framework.

2) Support Activity

a) Firm infrastructure

The company has made strategic investments in comprehensive infrastructure to facilitate seamless operations across all elements within the maintenance activities value chain. A key component of this infrastructure is the implementation of SAP as an Enterprise Resource Planning (ERP) system, which significantly enhances cross-functional capabilities by integrating various aspects of the maintenance process.

SAP's Material Management (MM) module plays a pivotal role in efficiently managing inventory, purchasing, Material Requirement Planning (MRP), and master data, ensuring optimal stock levels and streamlined procurement processes. The Finance Controlling (FICO) module oversees and manages the company's financial processes comprehensively, ensuring financial transparency and control.

For maintenance-specific functions, SAP's Plant Maintenance (PM) module is employed, providing robust capabilities to manage asset registers, bill of materials (lists of spare parts), maintenance strategy, planning, and execution. This module enables effective asset management, maintenance planning, and execution, contributing to enhanced equipment reliability and operational efficiency.

Additionally, the Human Resources (HR) module within SAP plays a crucial role in managing various aspects related to personnel, including payroll processing, organizational management, time management, workforce planning, and training and event management. This comprehensive HR module ensures efficient management of workforce resources, enabling the organization to optimize staffing levels and enhance employee productivity.

The integrated infrastructure provided by SAP ensures synchronized and efficient operation of maintenance activities throughout the organization. By leveraging SAP's capabilities, the company can streamline processes, improve data accuracy, and enhance decision-making, ultimately driving operational excellence and competitive advantage.

b) Procurement

In the realm of maintenance activities, the Supply Chain Management (SCM) function assumes a vital role in overseeing the procurement process. This encompasses the management of both just-in-time (JIT) procurement of materials/services and the procurement of materials for the inventory management system. The procurement procedures are tailored to match the nature of the goods or services being procured.

For non-stock goods, materials, or services, the typical process involves the initiation of a Purchase Requisition (PR) by the functional maintenance team. This empowers them to kick-start the procurement process and acquire the necessary materials or services promptly.

Conversely, regarding the procurement of materials for inventory, PR generation is orchestrated by the functional warehouse. This differentiation in the procurement process ensures a systematic approach, guaranteeing that materials are procured and managed efficiently, whether for immediate use in maintenance activities or for storage purposes.

Collaboration between the maintenance functional and warehouse functional is paramount to maintaining an effective and well-coordinated supply chain. This collaboration fosters seamless coordination and optimization of procurement activities, ultimately bolstering the organization's ability to meet maintenance needs promptly and efficiently.

c) Human resources management (HRM)

Functional Human Resource Management (HRM) plays pivotal roles and assumes critical responsibilities within the organization, focusing on various aspects of workforce management. One of its key responsibilities is the recruitment and placement of core workers, aligning their roles with the company's organizational structure to ensure optimal functionality and efficiency. Additionally, functional HRM oversees the recruitment of supporting service workers or outsourced workers, utilizing either volume-based contracts or man-month rates. It's important to note that the management of outsourced workers under product-based or service-based contracts falls under the purview of user functions.

Beyond recruitment, functional HRM is actively involved in managing training and development programs, fostering continuous learning and skill enhancement among the workforce. This includes designing and implementing training initiatives tailored to the specific needs of employees, ensuring they have the necessary skills and knowledge to excel in their roles. Furthermore, the department is responsible for knowledge management (KM), ensuring the effective capture, organization, and dissemination of valuable organizational knowledge. This involves implementing systems and processes to document and share best practices, lessons learned, and other critical knowledge assets across the organization.

Assessment of organizational capabilities is another crucial responsibility handled by functional HRM. This involves evaluating the collective skills, competencies, and capacities within the organization, identifying strengths and areas for improvement. The insights gleaned from these assessments inform strategic decision-making and workforce planning efforts, enabling the organization to align its human capital with its business objectives effectively. The multifaceted role of functional HRM contributes significantly to the overall human resource strategy and effectiveness within the company, ensuring that the organization's workforce remains a key driver of its success.

d) Technology development

The Information Technology (IT) function within the organization plays a fundamental role in ensuring the efficient flow of information, thereby enhancing productivity and facilitating decision-making processes. A key aspect of this responsibility involves the adoption and management of Enterprise Resource Planning (ERP) systems, particularly through platforms like SAP, which have been instrumental in streamlining business process information flow.

The IT function's duties extend to both software and hardware management, encompassing the maintenance and optimization of ERP system performance. This includes overseeing user account administration to guarantee secure access and maintain data integrity, thus safeguarding sensitive organizational information.

In addition to ERP systems, IT is also tasked with managing supporting devices such as email servers and web servers. Furthermore, it oversees the implementation and maintenance of supporting applications, including electronic tender applications, digital attendance systems, and electronic correspondence tools. Moreover, IT ensures the availability and functionality of virtual collaboration software, facilitating online meetings and file sharing to enhance communication and collaboration among employees.

A crucial aspect of IT's role is ensuring real-time synchronization of information across ERP data to prevent misinformation and maintain data consistency. By fulfilling these diverse responsibilities, the IT function significantly contributes to the seamless and effective functioning of the organization's information flow and technological infrastructure, thereby supporting overall operational efficiency and decision-making capabilities.

2.5.3. Core Competencies

Core competencies refer to a set of capabilities that transcend divisional boundaries within a firm and represent areas where the firm excels (Weelen & Hunger, 2012). Moreover, competence, as defined by Weelen & Hunger, is the corporate capability derived from coordination and integration between functions within an organization. Through the analysis of coordination and integration among functions within a single operational unit, as well as between different operational units and with Zones, Regional Company, SHU Company and Holding Company, several competencies of the company are obtained in relation to the management of maintenance activities.

1) Optimizing Maintenance Management with Integrated CMMS and ERP Solutions

The company utilizes a CMMS in the form of the SAP-PM (Plant Maintenance) module within SAP, which has been seamlessly integrated with other SAP modules to enhance maintenance management processes. Specifically, this integration includes the SAP-MM (Material Management) module for managing materials or spare parts and the SAP-FICO

(Finance and Controlling) module for handling financial transactions related to maintenance activities.

The maintenance management process begins with the creation of work orders (WOs). These WOs can originate from notifications by user functions for unplanned maintenance or automatic generated notifications for scheduled PM or PdM. This ensures that all maintenance tasks are promptly and accurately recorded, facilitating effective maintenance planning and execution.

To meet the material needs for maintenance activities, the SAP-PM module interacts with the SAP-MM module. For stock items, material reservations (MR) can be made directly through the WO, which are then processed by the warehouse function. For non-stock materials, a purchase requisition (PR) is generated via the WO and processed by the procurement function into a purchase order (PO). Upon receipt of the materials or spare parts, a goods receipt (GR) is carried out, followed by the payment process managed through the SAP-FICO module.

When maintenance services from third parties are required, the WO generates a service requisition (SR). This SR is further processed by the procurement function into a PO. Once the third-party maintenance work is completed, it is closed with service acceptance (SA) in the SAP-MM module. This ensures that all third-party services are accurately tracked and managed.

Budget considerations and payments are seamlessly integrated with the SAP-FICO module. Budgets within the maintenance cost center may be temporarily blocked during the PR or SR stages and are released after the creation of the GR or SA. This integration allows for real-time budget tracking, cost analysis, and comprehensive reporting. SAP-FICO enables detailed financial oversight, helping to ensure that maintenance activities are cost-effective and within budget.

The integration of CMMS with ERP solutions through SAP modules streamlines and optimizes maintenance management processes. By linking the PM, MM, and FICO modules, the company can efficiently manage work orders, material procurement, and financial transactions related to maintenance. This integrated approach ensures that maintenance tasks are carried out promptly, materials are managed effectively, and financial processes are handled accurately, ultimately enhancing the overall maintenance management system and contributing to operational efficiency and cost savings.

2) Enhancing Maintenance Management Through Asset Integrity Strategies

Asset integrity refers to the ability of an asset—whether equipment, infrastructure, or systems—to effectively, efficiently, and safely perform its designated function throughout its intended lifecycle. This encompasses maintaining the physical condition, reliability, and functionality of the asset while ensuring compliance with regulatory and operational standards. The primary focus is on preventing failures, upholding safety, and optimizing the asset's performance and lifespan through various inspection, maintenance, and management strategies. The SHU Company has established working guidelines that integrate the asset integrity approach as the core principle for implementing maintenance management. Pertamina Hulu Energi (PHE) has strategically committed to adopting a standardized AIMS program for its production facilities across all operating units. This standardization involves the use of risk-based inspection (RBI) and reliability-centered maintenance (RCM) methodologies to create continuous improvement programs. The goal is to ensure that equipment operates within safe operating limits, consistent with the overarching principle of asset integrity. By embracing these strategies, the company ensures that its assets are maintained in optimal condition, enhancing reliability, safety, and performance. The integration of RBI and RCM methodologies, along with standardized practices and continuous improvement programs, creates a robust framework for effective maintenance management. This approach not only prevents failures and upholds safety but also optimizes the performance and lifespan of assets, contributing to the overall operational efficiency and success of the company.

3) Streamlining Inventory Control Through Centralized Stock Management

Maintenance activities are fundamental for ensuring that equipment functions optimally, encompassing a range of tasks such as inspection, cleaning, adjustment, and part replacement. To carry out these activities effectively, it's crucial to procure the necessary materials in a timely and efficient manner. The company emphasizes adherence to principles of good corporate governance (GCG) in all its operations, including material procurement for maintenance purposes.

The procurement process for maintenance materials typically involves a tender process, where providers of goods and services submit bids. However, to further enhance efficiency, effectiveness, and accountability, the company has implemented centralized material management at the SHU Company level. This centralized approach offers several key advantages:

a. Increased Effectiveness

   Centralized procurement of stock materials helps prevent redundant and repeated purchases. By consolidating purchasing decisions at the SHU Company level, the company can leverage economies of scale, potentially reducing costs associated with material procurement.

b. Optimization of Stock Materials

   Centralized management allows for better optimization of material stock by facilitating transfers between different business units or subsidiaries within the organization. This flexibility enables the company to improve resource allocation and minimize excess inventory, thereby reducing carrying costs and improving overall efficiency.

c. Material Resource Planning (MRP)

   Material stock management adopts the Material Resource Planning (MRP) method, a systematic approach that helps reduce inventory costs by ensuring that materials are procured and managed efficiently. MRP involves forecasting demand, scheduling procurement activities, and maintaining optimal inventory levels to meet maintenance requirements without overstocking.

By adopting centralized material management practices, the company aims to streamline the procurement process, reduce costs, and optimize the utilization of stock materials across its business units and subsidiaries. This approach aligns with principles of good governance, emphasizing transparency, accountability, and regulatory compliance in all procurement activities. Additionally, centralized materials management supports the organization's broader strategic goals by enhancing operational efficiency and resource allocation, ultimately contributing to improved maintenance outcomes and overall performance.

4) Optimizing Maintenance Operations with Strategic Contract-Based Management

Optimizing maintenance operations through strategic contract-based management involves leveraging the commonalities shared among subsidiaries and operating units within the SHU Company to enhance efficiency in the procurement of repair services.

These entities often operate within the same industry, exhibit similar operation patterns, and utilize comparable facilities and equipment. Recognizing this shared context presents an opportunity for collaborative efforts in procuring repair services.

Pooling resources and jointly procuring repair services across subsidiaries or operating units can yield several advantages:

a. Increased Effectiveness

   Collaborative procurement ensures that repair services meet the collective needs of the subsidiaries or operating units, leading to more effective outcomes in addressing common challenges. This strategic approach allows for a more comprehensive and tailored response to maintenance requirements.

b. Efficiency from Scale

   By combining resources and procurement efforts, there is potential for efficiency gains due to increased scale. This can result in cost savings, better negotiation terms with service providers, and optimized utilization of resources.

c. Streamlined Processes

   Joint procurement enables the standardization and streamlining of procurement processes across subsidiaries or operating units. This consistency simplifies administrative tasks, reduces redundancies, and enhances overall procurement efficiency.

d. Knowledge Sharing

   Collaborative procurement fosters a platform for knowledge sharing among subsidiaries or operating units. Insights and lessons learned from collective experiences can inform decision-making processes and contribute to continuous improvement in the procurement process.

Adopting a collaborative approach to procurement of repair services aligns with the shared characteristics and objectives of the subsidiaries or operating units within the SHU. This strategy aims to optimize efficiency, achieve cost savings, and enhance overall effectiveness in meeting common maintenance requirements. By leveraging synergies and pooling resources, the organization can realize tangible benefits in maintenance operations while maximizing value across the SHU.

5) Fostering Growth in an Integrated Learning Organization

Fostering growth in an integrated learning organization entails embedding a culture of continuous learning and adaptability into its core operations. In such organizations, learning becomes an intrinsic part of daily practices, processes, and systems, rather than a separate or occasional activity. Key characteristics and principles associated with integrated learning organizations include:

a. Continuous Learning Culture

   Cultivating an environment where learning is ongoing for all employees, integrated into their daily work routines.

b. Knowledge Sharing

   Committing to sharing knowledge across teams and departments through collaborative platforms and mechanisms, facilitating the exchange of insights, best practices, and lessons learned.

c. Adaptability and Flexibility

   Valuing adaptability and embracing change, encouraging employees to be flexible and responsive to new challenges while swiftly adapting to market trends and emerging technologies.

d. Learning Systems and Technologies

   Leveraging modern learning management systems (LMS), technology-enabled training, and digital resources to provide accessible and personalized learning experiences.

e. Leadership Support

   Actively promoting a learning culture, with leaders leading by example, prioritizing professional development, and encouraging employees to seek learning and skill development opportunities.

f. Performance and Learning Alignment

   Aligning learning objectives with organizational goals and individual performance expectations, ensuring employees understand how their learning efforts contribute to personal growth and organizational success.

g. Feedback and Reflection

   Valuing feedback and reflection, establishing regular feedback loops to assess the effectiveness of learning initiatives and encouraging employees to reflect on their learning experiences.

h. Cross-Functional Collaboration

Encouraging collaboration across departments or teams, allowing employees from different areas to share knowledge and expertise.

i. Learning from Events

Viewing mistakes as opportunities for learning and improvement, fostering a culture of psychological safety where employees feel comfortable taking risks and learning from their experiences.

j. Strategic Alignment

Aligning learning initiatives with strategic priorities, investing in developing skills and competencies critical to achieving long-term organizational goals.

k. Measurable Outcomes

Measuring learning outcomes and using KPIs to assess the impact of learning initiatives on individual and organizational performance.

An integrated learning organization is characterized by a holistic approach to learning that permeates all aspects of the organization. It values continuous improvement, collaboration, and adaptability, creating an environment where employees are empowered to learn, grow, and contribute to the overall success of the organization.

2.5.4. Competitive Advantages

According to Barney (1991), core competencies can serve as a source of competitive advantage for a firm if they meet four critical criteria; valuable, rare, inimitable and organized.

1) Valuable

Core competencies must contribute significantly to the company's value proposition. They should enable the company to deliver products or services that meet customer needs better than competitors, leading to increased customer satisfaction, market share, or profitability.

2) Rare

Core competencies should be distinctive and difficult for competitors to replicate. They might stem from unique combinations of skills, technologies, or resources that are not readily available to others in the industry.

3) Inimitable (Difficult to Imitate)

Competitors should find it challenging to imitate or reproduce the core competencies of the firm. This could be due to complex processes, proprietary technologies, or specialized knowledge that is hard to acquire or duplicate.

4) Organized (Exploitable)

The organization must be structured and aligned to effectively leverage its core competencies. This involves having the right talent, processes, systems, and culture in place to support the development and deployment of these competencies across the organization.

Figure 2.11 likely represents the interplay and relationship among these criteria. It serves as a visual representation of how these criteria collectively contribute to the competitive advantage derived from core competencies. Core competencies meeting these four criteria can form the basis for a sustained competitive advantage. Identifying, developing, and leveraging such competencies are crucial aspects of strategic management.

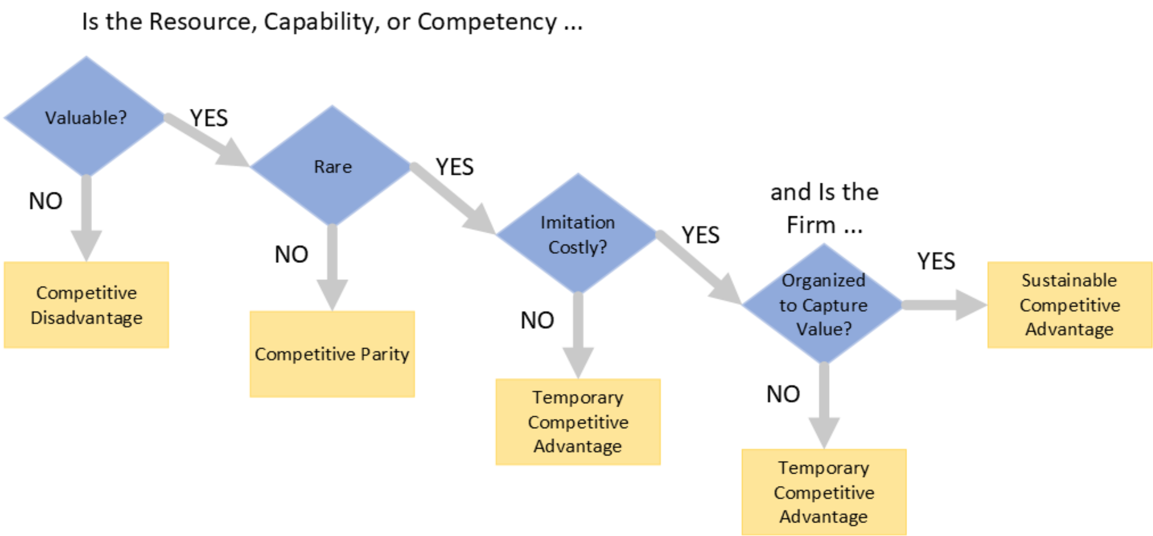


Figure 2.12. Revealing Competitive Advantage by Applying VRIO Framework
(Source: Rothaermel (2021))

Tracing core competencies using the VRIO framework can be concluded as follows.

1) Optimizing Maintenance Management with Integrated CMMS and ERP Solutions

Optimizing maintenance management with integrated CMMS and ERP solutions offers significant advantages by streamlining processes, improving efficiency, and reducing costs. These systems provide a centralized platform for managing work orders, materials procurement, budgeting, and financial tracking, thereby optimizing overall maintenance operations. While CMMS and ERP systems are commonly used in various industries, the integration of these systems specifically for maintenance management is relatively rare. Many companies may lack the technical capabilities or resources to effectively implement such integrated solutions, making this an uncommon but valuable asset. Replicating integrated CMMS and ERP solutions involves considerable investment in technology infrastructure, software customization, and extensive employee training. Competitors may find it challenging to replicate the exact system and processes without similar levels of resources and expertise, making this capability difficult to imitate. The successful implementation and integration of CMMS and ERP solutions into the company's maintenance management processes demonstrate the organization's capabilities and commitment to innovation. This reflects a structured and forward-thinking approach to maintenance management, highlighting the company's ability to leverage advanced technologies for operational excellence.

2) Enhancing Maintenance Management Through Asset Integrity Strategies

Enhancing maintenance management through asset integrity strategies aims to improve the reliability and performance of equipment, reducing the risk of failures and optimizing maintenance efforts. These strategies contribute to safer operations, regulatory compliance, and cost savings. Companies that adopt comprehensive asset integrity strategies may be relatively rare, as not all organizations prioritize proactive maintenance practices or invest in advanced inspection and maintenance methodologies. Implementing asset integrity strategies requires expertise in RBI, RCM, and continuous improvement. Competitors may struggle to replicate these strategies without similar knowledge, experience, and organizational commitment. The company's adoption of standardized AIMS programs across its operating units demonstrates organizational commitment to maintaining asset integrity and ensuring safe and reliable operations.

3) Streamlining Inventory Control Through Centralized Stock Management

Streamlining inventory control through centralized stock management optimizes inventory processes by preventing redundant purchases, reducing costs, and ensuring efficient procurement and allocation of materials. This approach enhances operational efficiency and reduces the risk of stockouts or overstocking. While centralized inventory management systems are not uncommon, implementing centralized stock management at the SHU Company level, especially across multiple business units or subsidiaries, is relatively rare. Competitors may find it challenging to replicate this centralized system without similar organizational structures and capabilities. Implementing centralized stock management requires coordination among business units, standardization of processes, and investment in technology infrastructure. The company's adoption of centralized material management at the SHU Company level demonstrates organizational capabilities in optimizing inventory control and leveraging economies of scale.

4) Optimizing Maintenance Operations with Strategic Contract-Based Management

Optimizing maintenance operations with strategic contract-based management enables the efficient procurement of repair services, leading to cost savings, improved service quality, and streamlined processes. This approach enhances operational effectiveness and ensures the timely completion of maintenance activities. Companies that employ strategic contract-based management for maintenance operations may be relatively rare, as not all organizations collaborate effectively across subsidiaries or operating units to procure repair services jointly. Implementing strategic contract-based management requires collaboration, negotiation skills, and the ability to align service needs across different business units. Competitors may struggle to replicate this collaborative approach without similar organizational structures and capabilities. The company's adoption of collaborative procurement of repair services across subsidiaries or operating units demonstrates organizational capabilities in optimizing maintenance operations and achieving cost efficiencies through joint procurement efforts.

5) Fostering Growth in an Integrated Learning Organization

Fostering growth in an integrated learning organization promotes continuous learning and adaptability, driving ongoing improvement and innovation in maintenance management. This approach encourages knowledge sharing, embraces change, and aligns learning initiatives with organizational goals, enhancing the company's ability to adapt to new challenges and opportunities. An integrated learning organization culture is relatively rare, as it requires a deep commitment to continuous learning and adaptability across all levels of the organization. Many companies may not prioritize or effectively implement such a culture, making it a distinctive and valuable trait. Developing an integrated learning organization culture is difficult to imitate because it involves ingrained practices, values, and behaviors that are cultivated over time. Competitors may struggle to replicate the same level of commitment and organizational alignment necessary to achieve similar results. The company has successfully embedded a culture of continuous learning and adaptability into its operations, demonstrating strong organizational capabilities in fostering growth through integrated learning. This commitment supports sustained innovation and improvement in maintenance management, ensuring the company remains competitive and resilient in a dynamic industry.

By analyzing the core competencies related to the questions in the VRIO framework, the company's competitive advantages are obtained with respect to maintenance management as shown in Table 2.1. In this table, each core competency is assessed based on its value, rarity, imitability, and the organization's capability to exploit it. The analysis indicates that all core competencies provide high value to the company, are moderately rare, and have high barriers to imitation. Additionally, the organization demonstrates strong capabilities in utilizing these competencies. Therefore, these competencies contribute to the company's sustainable competitive advantage in maintenance management.

Table 2.1. VRIO analysis of Core Competence

No	Identified Core Competences	Value	Rarity	Inimitability	Organization	Competitive Advantages
1	Optimizing Maintenance Management with Integrated CMMS and ERP Solutions	Yes	Yes	Yes	Yes	Sustainable Competitive Advantage
2	Enhancing Maintenance Management Through Asset Integrity Strategies	Yes	Yes	Yes	Yes	Sustainable Competitive Advantage
3	Streamlining Inventory Control Through Centralized Stock Management	Yes	Yes	Yes	Yes	Sustainable Competitive Advantage
4	Optimizing Maintenance Operations with Strategic Contract-Based Management	Yes	Yes	Yes	Yes	Sustainable Competitive Advantage
5	Fostering Growth in an Integrated Learning Organization	Yes	Yes	Yes	Yes	Sustainable Competitive Advantage

2.6. SWOT Analysis

SWOT analysis is an analysis of the company's strengths and weaknesses obtained from internal analysis and opportunities and threats faced by the company analyzed from its external conditions.

2.6.1. Strength

The company's strengths in maintenance management are identified as the company's core competencies in the maintenance value chain that meet the criteria of valuable, rare, imperfectly imitable and organized (VRIO) that make these competencies become competitive advantages. Evaluation of core competencies through VRIO framework of strengths owned by companies in the maintenance value chain as follows:

1) Optimizing Maintenance Management with Integrated CMMS and ERP Solutions

   The integration of CMMS with ERP enhances data management and decision-making in maintenance. Not all companies in the industry may have successfully integrated CMMS with ERP, making it a rare capability. The complexity of such integration makes it challenging for competitors to replicate easily. The systematic integration showcases the organization's structured approach to maintenance management.
2) Enhancing Maintenance Management Through Asset Integrity Strategies

   Managing maintenance based on asset integrity improves reliability and ensures compliance. Not all companies may adopt a comprehensive asset integrity approach. While others can adopt the approach, replicating the holistic implementation is challenging. The structured asset integrity approach demonstrates organizational sophistication.
3) Streamlining Inventory Control Through Centralized Stock Management

   Centralized management streamlines procurement, reducing redundancy and optimizing costs. Centralized stock material management is not universally implemented. While possible, replicating a centralized system requires significant organizational restructuring. Centralization reflects a strategic and organized approach to material management.
4) Optimizing Maintenance Operations with Strategic Contract-Based Management

   Strategic contract-based maintenance allows for efficient resource allocation and cost control. Many organizations still rely on traditional maintenance approaches. While others can adopt contract-based models, replicating the strategic aspect may be complex. This approach demonstrates an organized and forward-thinking maintenance strategy.
5) Fostering Growth in an Integrated Learning Organization

   Being a learning organization fosters continuous improvement and adaptability. Not all organizations have successfully embedded a learning culture. Replicating a learning organization requires a comprehensive cultural shift. The emphasis on learning underscores the organization's commitment to improvement.

2.6.2. Weakness

The weakness in managing company maintenance is the company's internal conditions that can hamper the company's maintenance management value chain. These conditions are seen from the analysis of resources and capabilities as follows:

1) Incomplete Toolset for Independent Inspection

   Despite the availability of various maintenance tools, there is a notable lack of specialized equipment crucial for risk-based maintenance inspections. Risk-based maintenance relies heavily on accurate inspections to predict and prevent equipment failures. Specialized tools, such as advanced ultrasonic testing devices, infrared thermography cameras, and laser alignment systems, are essential for detecting early signs of wear, corrosion, and misalignment that standard tools might miss.

   The absence of these specialized inspection tools compromises the ability to conduct thorough and precise evaluations. As a result, maintenance teams may struggle to identify potential issues before they escalate into major problems, leading to unplanned downtime and increased repair costs. Additionally, the dependency on less accurate tools can result in false positives or missed detections, further undermining the reliability of the maintenance process.

   This deficiency also affects the independence of inspections. Without the right equipment, teams may need to rely on external experts or service providers, which can introduce delays and additional costs. Moreover, the lack of autonomy in inspections can lead to inconsistencies in maintenance planning, as external parties may have different standards or approaches.

2) Workforce-Related Challenges

   There are several significant workforce-related challenges affecting the core maintenance team. Firstly, vacant positions within the team remain unfilled, creating gaps in the workforce that can lead to increased workloads and stress for current employees. Additionally, job descriptions and workload analyses for supporting workers are inadequately documented. This lack of clarity in roles and responsibilities can result in inefficiencies and an unclear organizational structure, further complicating the maintenance process.

The organization has not systematically evaluated the need for supporting workers, leading to the absence of a structured replacement program for retiring employees. Without a clear understanding of future staffing needs, the organization risks facing workforce shortages, which can disrupt maintenance operations and impact overall productivity.

Furthermore, the lack of a strategic approach to human resource management exacerbates these issues. Without a comprehensive plan to address workforce gaps, manage retirements, and ensure the clear delineation of roles, the organization is vulnerable to ongoing inefficiencies and operational challenges.

3) Skills Development Gaps

There are notable skills development gaps within the maintenance team that need to be addressed to enhance overall effectiveness. Planning capabilities, in particular, require significant improvement. Key areas needing development include skills in Failure Mode and Effects Analysis (FMEA), Root Cause Analysis (RCA), equipment criticality analysis, and a consistent understanding of SAP Plant Maintenance (SAP-PM). The lack of proficiency in these areas can hinder effective maintenance planning and decision-making, leading to suboptimal maintenance strategies and increased risk of equipment failure.

Additionally, there is a pressing need to bolster capabilities in PM and PdM within the maintenance execution division. Enhancing skills in these areas is crucial for optimizing maintenance processes and reducing reliance on reactive maintenance. Proficiency in PM ensures regular and systematic upkeep of equipment, which can prevent unexpected failures. Similarly, advanced skills in PdM, which involves using data and analytics to predict equipment failures, can lead to more informed and proactive maintenance decisions.

Without improvements in these critical skills, the maintenance team may struggle with inefficient planning and execution, resulting in higher operational costs and increased downtime. Investing in comprehensive training programs and continuous professional development can help bridge these gaps, leading to more effective maintenance practices and improved overall reliability of the equipment.

2.6.3. Opportunities

The company has identified several opportunities through external analysis that can be leveraged to enhance its operations and competitive edge:

1) Highly Educated Local Workforce

   The company benefits from operating in an environment where the level of public education is relatively high, granting access to a pool of qualified local workers. This advantage allows the company to recruit skilled and knowledgeable employees who can contribute to improved operational outcomes. A highly educated workforce enhances the quality and reliability of operations, leading to increased efficiency, better problem-solving capabilities, and a greater capacity for innovation. By leveraging this local talent, the company can strengthen its workforce, reduce training costs, and boost overall productivity.

2) Improvement of Industry 4.0 Technologies

   The application of advanced industrial technologies can significantly boost the company's accuracy and efficiency. The implementation of the Industrial Internet of Things (IIoT) for real-time monitoring and inspection allows for continuous oversight of equipment health, leading to timely maintenance interventions and reduced downtime. Machine learning can be leveraged for PdM, analyzing vast amounts of data to identify patterns and predict equipment failures before they occur, thus enhancing reliability and reducing maintenance costs. Additionally, augmented reality can be utilized for remote maintenance, enabling technicians to perform repairs and inspections from a distance with the aid of detailed visual guides and real-time support. These technologies have the potential to revolutionize maintenance activities, making them more efficient and cost-effective, and positioning the company at the forefront of technological innovation in the industry.

3) Favorable Industry Dynamics

   Industry analysis reveals a favorable landscape characterized by low competition levels, high barriers to entry for new players, and low bargaining power of consumers. This advantageous environment enables the company to operate at maximum capacity in producing oil and gas without concerns about market absorption issues. With stable demand for its products assured, the company can focus on optimizing production processes, enhancing efficiency, and maintaining consistent output levels. Moreover, the low competition and high barriers to entry provide the company with a strategic advantage, allowing it to secure a strong market position and potentially command higher prices for its products. Overall, these favorable industry dynamics position the company for sustained growth and profitability in the market.

4) Competitive Supplier Environment

   The company benefits from a procurement process that involves a tender system, fostering high competition among suppliers. This competitive dynamic diminishes the bargaining power of suppliers, empowering the company to secure goods and services meeting desired specifications at lower prices. By leveraging this competitive supplier environment, the company can effectively manage procurement costs and optimize resource allocation. Furthermore, collaborative strategies among business units or subsidiaries can amplify the company's bargaining power by scaling up procurement activities. This strategic collaboration not only enhances cost-saving opportunities but also promotes synergies across the organization, driving operational efficiency and enhancing overall competitiveness in the market.

5) Synergy with affiliated companies

   The company benefits from a strategic relationship with a sister company, which serves as its main consumer. This symbiotic arrangement ensures guaranteed distribution channels through a synergy strategy initiated by the holding company. By leveraging this internal collaboration, the company enhances reliability and stability in distribution, bolstering continuous and efficient operations. The close alignment between the company and its sister entity facilitates seamless coordination in meeting consumer demand, optimizing supply chain efficiency, and minimizing distribution-related risks. Moreover, this synergy enables the company to capitalize on shared resources, expertise, and market insights, fostering a competitive edge and driving sustained growth within the broader organizational ecosystem. Overall, this strategic partnership with sister companies enhances the company's market positioning, operational resilience, and ability to deliver value to stakeholders.

2.6.4. Threat

The following are external threats faced by the company:

1) High Level of Oil and Gas Business Risk

   The high level of risk inherent in the oil and gas industry poses a significant threat to the company's operations and reputation. Improper maintenance practices can lead to equipment failures, potentially resulting in uncontrolled releases of petroleum and gas products into the environment. This not only poses immediate environmental hazards but also poses significant health risks to individuals, particularly due to the presence of high levels of H2S in the raw gas produced.

The release of H2S gas into the atmosphere can have severe health consequences, including respiratory issues and even fatalities if individuals are exposed to certain concentrations. Beyond the immediate health and environmental risks, such incidents can also lead to regulatory violations, attracting scrutiny from regulatory authorities and potentially resulting in fines and penalties for the company. Additionally, these incidents can tarnish the company's reputation, eroding trust among stakeholders and damaging its brand image.

To mitigate this threat, the company must prioritize comprehensive maintenance practices that adhere to strict safety standards and regulations. This includes regular inspections, PM measures, and robust safety protocols to minimize the risk of equipment failures and gas releases. Investing in advanced monitoring technologies and employee training programs can further enhance safety and mitigate risks associated with H2S exposure. By prioritizing safety and environmental stewardship, the company can mitigate regulatory, reputational, and financial risks while safeguarding public health and the environment.

2) Change in Contract Scheme

The transition from the PSC with cost recovery to the PSC with gross split scheme introduces a significant financial threat to the company. Unlike the previous arrangement where operational costs could be recovered, under the new scheme, all operational expenses are solely the responsibility of the company. This shift in contractual terms exposes the company to heightened financial risks, as inefficient management of operations could lead to reduced revenue or even financial losses. To mitigate these risks, the company must undertake a strategic reassessment of its operational efficiency and cost management practices. This includes optimizing operational efficiency across all facets of its operations, such as production, maintenance, and resource allocation. Streamlining processes, implementing best practices, and leveraging technology can help minimize costs and maximize output. Additionally, implementing rigorous cost management strategies, such as identifying cost-saving opportunities, negotiating favorable contracts with suppliers, and eliminating unnecessary expenses, is crucial. The company should also conduct thorough risk assessments to identify potential financial risks and develop strategies to mitigate them, while continuously monitoring its financial performance and market dynamics to identify emerging challenges and opportunities. Engaging with stakeholders, including government agencies, industry partners, and investors, is essential to ensure alignment with regulatory requirements and market expectations. By proactively reassessing its operational strategies and staying agile in response to changing contractual terms, the company can mitigate financial risks and position itself for long-term success under the new contractual framework.

3) Regulatory Compliance Requirements

   As an oil and gas company operating in Indonesia, the company is subject to stringent regulatory requirements, including compliance with Minister of EMR No. 5 of 2015. Identified gaps in the qualifications of maintenance function workers, particularly regarding the certification requirements outlined in the regulation, pose significant regulatory compliance risks. Failure to meet these regulatory standards not only exposes the company to potential penalties and legal liabilities but also undermines operational integrity and reliability. Ensuring compliance with these regulations is crucial to maintaining the company's legal standing and operational effectiveness. Addressing these gaps requires a focused effort on certifying maintenance workers in accordance with regulatory standards, thereby safeguarding the company against regulatory breaches and reinforcing its commitment to high operational standards.

Addressing these external threats requires proactive measures to enhance operational safety, efficiency, and regulatory compliance. Implementing robust maintenance protocols, investing in workforce training and certification programs, and closely monitoring changes in regulatory frameworks are essential steps to mitigate these risks and safeguard the company's long-term viability and sustainability.

The summary of internal strengths and weaknesses and external opportunities and threats can be seen in the SWOT matrix as shown in Table 2.2.

Table 2.2. The SWOT Matrix

[redacted]	[redacted]
[redacted]	[redacted]

BUSINESS SOLUTION

The competition environment between companies in an industry has led to a race to create core competencies as a source of competitive advantages. The process of searching for competitive advantages is not only focused on the value chain in the core business, but also targets the value chain of support business processes spread across several functions in the organization. This search is also included in the system maintenance process. The main role of maintenance management in an industry is to ensure the reliability and availability of equipment to support the continuity and quality of the production process. Various strategies have been established to achieve maintenance excellence. Franklin (2008) very well explains how maintenance excellence can provide benefits for companies; such as reducing production unit costs, reducing maintenance costs, increasing process stability, extending equipment life, reducing spare part inventory costs, reducing overtime costs, improving workforce morale, increasing safety and avoiding environmental impacts.

In this chapter, we will discuss the formulation of strategies that companies can use to achieve excellent maintenance. Alternative strategies are formulated from the SWOT analysis which was discussed in Chapter 2. Porters' generic strategies act as a basis for formulating action plans.

3.1. Business Solution Alternatives

3.1.1. Generic Strategies

The analysis of generic strategies serves as a foundational framework for formulating alternative strategies and subsequent action plans. A competitive strategy is essentially a proactive or defensive measure undertaken to secure a competitive advantage within an industry, as viewed through the lens of Porter's Five Forces (Porter, 1985). The essence of winning in this context involves achieving profitability with a rate of return surpassing the industry average, even under unfavorable industry conditions (Porter, 1980).

Regarding competitive advantage, two fundamental strategies emerge as potential profit sources: achieving lower costs and establishing differentiation. The amalgamation of these advantages with a defined target market results in three primary generic strategies for companies seeking superior industry performance: cost leadership, differentiation, and focus. Within the focus strategy, two distinctive variants exist—cost focus and differentiation focus. This strategic spectrum is visually represented in Figure 3.1.

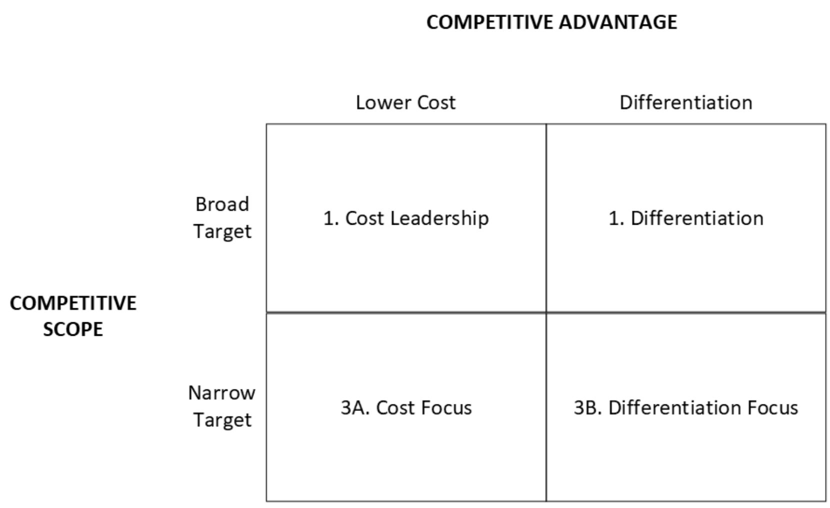


Figure 3.1. Porter's Generic Strategies
(Source: Porter (1985))

In the upstream sector of the oil and gas industry, products like crude oil and natural gas lack significant differentiation. Crude oil or condensate products, in particular, do not exhibit product variation, and any potential differentiation occurs downstream in the midstream sector, a realm not directly ventured into by the company's core business but managed by sister companies. Natural gas products, although offering some differentiation possibilities (e.g., LNG, CNG), face challenges due to distribution constraints. The differentiation process for natural gas products often involves additional business processes that can escalate product prices, potentially discouraging consumers who would need to invest in additional equipment and facilities for product utilization.

Consumer analysis reveals that crude oil or condensate products primarily cater to refinery companies, coincidentally aligned with sister companies. On the other hand, natural gas products serve consumers connected to the gas distribution network, generally comprising entities with higher product absorption capabilities. The existing consumer base exhibits significant absorption potential, with indications of growth, while oil and gas field production tends to decline. This dynamic suggests a less pressing need to seek new consumers or target those with lower absorption capabilities.

Considering the evaluation of competitive advantage, particularly emphasizing low cost and a narrow market focus, it becomes evident that the most suitable generic strategy for the company is a cost focus strategy. This strategy aligns with the company's positioning, emphasizing efficiency and cost-effectiveness in a market characterized by a limited consumer base and the challenges associated with product differentiation.

3.1.2. Alternative Strategies

The exploration of alternative strategies is facilitated by the TOWS matrix, a tool that combines external opportunities and threats with internal strengths and weaknesses to formulate strategic options (Weelen & Hunger, 2012). This matrix generates four sets of strategic alternatives by integrating internal and external factors, as illustrated in Table 3.1. S-O Strategies leverage internal strengths to capitalize on external opportunities. W-O Strategies involve addressing internal weaknesses to exploit external opportunities. S-T Strategies utilize internal strengths to mitigate or counteract external threats. W-T Strategies aim to address internal weaknesses and guard against external threats.

Table 3.1. TOWS Matrix Analysis

Internal Factors / External Factors	**Strengths (S):**	**Weaknesses (W):**
	S-1. Optimizing Maintenance Management with Integrated CMMS and ERP Solutions S-2. Enhancing Maintenance Management Through Asset Integrity Strategies S-3. Streamlining Inventory Control Through Centralized Stock Management S-4. Optimizing Maintenance Operations with Strategic Contract-Based Management S-5. Fostering Growth in an Integrated Learning Organization	W-1. Incomplete Toolset for Independent Inspection W-2. Workforce-Related Challenges W-3. Skills Development Gaps
Opportunities (O): O-1. Highly Educated Local Workforce O-2. Improvement of Industry 4.0 Technologies O-3. Favorable Industry Dynamics O-4. Competitive Supplier Environment O-5. Synergy with affiliated companies	**S-O Strategies:** SO-1. Implementing industrial technology 4.0 in maintenance (S1, S2, O2) SO-2. Managing maintenance management based on risk-based efficiently and effectively using CMMS (S1, S2, O3) SO-3. Maintenance execution by strategic contract with third parties (S4, O4)	**W-O Strategies:** WO-1. Assessment of the organization and manpower requirements for maintenance excellence (W2, W3, O1)
Threats (T): T-1. High Level of Oil and Gas Business Risk T-2. Change in Contract Scheme T-3. Regulatory Compliance Requirements	**S-T Strategies:** ST-1. Managing maintenance management based on asset integrity approach (S1, T1, T2) ST-2. Improving labor qualifications (S5, T3)	**W-T Strategies:** WT-1. Upgrade skill on maintenance labor to fulfill minimum requirement as regulation (W3, T1, T3)

The TOWS matrix analysis has yielded seven alternative strategies. However, due to similarities among these alternatives, an integration process has resulted in the formulation of four proposed strategies, as outlined in Table 3.2. This synthesis aims to consolidate and refine the strategic options, providing a clearer and more focused set of recommendations based on the initial TOWS matrix findings.

Table 3.2. Integrating alternative strategies

Alternative strategies		Proposed Strategies
SO-1.	Implementing industrial technology 4.0 in maintenance	Managing maintenance management based on risk analysis using CMMS.
SO-2.	Managing maintenance management based on risk-based efficiently and effectively using CMMS	
ST-1.	Managing maintenance management based on asset integrity approach	
WO-1.	Assessment of the organization and manpower requirements for maintenance excellence	Excellent Maintenance Organization
WT-1.	Upgrade skill on maintenance labor to fulfill minimum requirement as regulation	Improving workforce's skill
ST-2.	Improving labor qualifications efficiently	
SO-3.	Maintenance execution by strategic contract with third parties	Strategic partnership (with supplier and service provider)

3.2. Analysis of Alternatives

3.2.1. Managing Maintenance Management Based on Risk Analysis Using CMMS

The maintenance management process involves the effective utilization of both internal and external resources to achieve specific objectives related to asset reliability, availability, maintainability, and safety. These objectives play a critical role in ensuring continuous production, maintaining product quality, and ultimately contributing to the company's profitability. To optimize the maintenance system, it is essential to manage various inputs, including labor, materials, spares, tools, information, and financial resources. Additionally, external factors such as services and regulatory requirements must be considered to enhance the overall effectiveness of the maintenance process.

The dynamic interaction between these inputs and outputs is depicted in Figure 3.2, highlighting the interconnected nature of maintenance management. This illustration underscores the importance of a well-coordinated and integrated approach to maintenance in achieving the overarching goals of the organization.

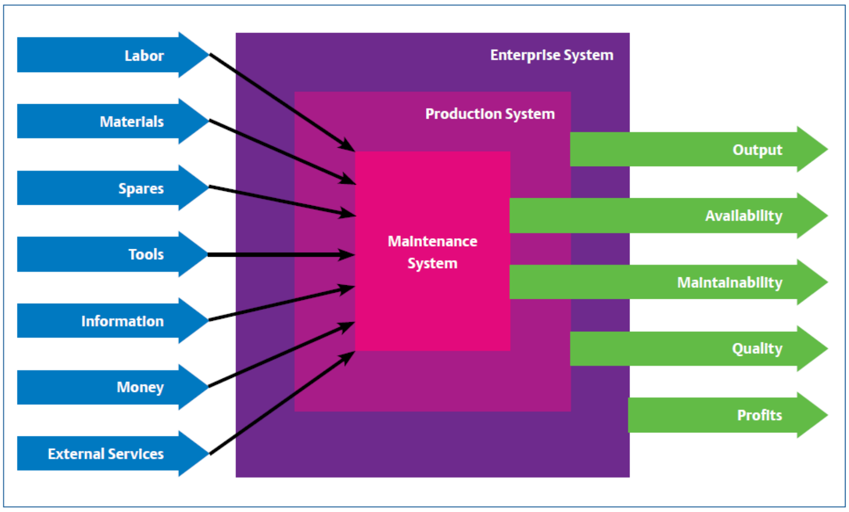


Figure 3.2. Maitenance system as input and output
(Source: Zafar (2018))

When it comes to managing equipment reliability, the Company employs two distinct yet interconnected business processes. The first process centers around maintenance management, utilizing a CMMS. This system is specifically designed to concentrate on the planning, scheduling, and execution of maintenance activities. Concurrently, the AIMS program is dedicated to upholding the integrity, reliability, and compliance of assets throughout their life cycle.

Despite their divergent focuses, the integration of CMMS and AIMS is crucial for enhancing overall asset management efficiency. This integration serves as a conduit for seamless data exchange and coordination between maintenance activities and broader asset integrity objectives. The result is a cohesive and synergistic approach to comprehensive asset management, where the alignment of these two processes facilitates a more streamlined and effective strategy.

In the development of a maintenance strategy following the AIMS framework, the Company utilizes the Plan-Do-Check-Action (PDCA) cycle framework, as depicted in Figure 3.3. The PDCA cycle approach in maintenance management facilitates continuous improvement within maintenance management itself. Through iterative cycles, organizations systematically plan, implement, evaluate, and refine their maintenance processes. At the planning stage, maintenance objectives and strategies are determined. During implementation, maintenance activities are performed, providing real-time asset performance data. In the inspection phase, results are monitored against predefined metrics, highlighting areas for improvement. Finally, in the action phase, corrective actions and process improvements are implemented based on the evaluation findings. This iterative approach fosters a culture of continuous improvement, allowing organizations to adapt, learn, and optimize maintenance practices over time.

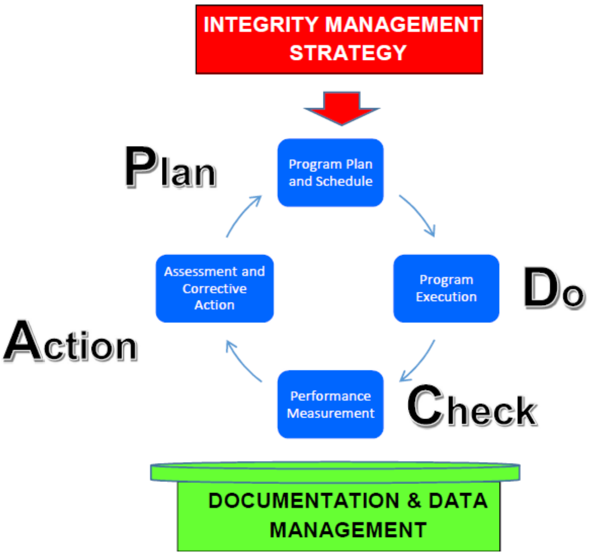


Figure 3.3. Overview of the Integrity Management Program

1) Maintenance Planning

Maintenance planning is a crucial phase aimed at developing work programs, schedules, budgets, labor allocations, equipment provisioning, spare parts management, and detailed work procedures. These components collectively ensure the efficient execution of maintenance activities in line with predetermined objectives, thereby enhancing the operational efficiency of the Company's production activities. The stages of maintenance planning include incorporating the asset list into the CMMS database, determining tailored maintenance methods for distinct equipment types, establishing priorities based on equipment criticality levels, formulating maintenance packages according to equipment risk assessments, and meticulously preparing maintenance schedules. Executing these stages systematically helps in establishing a well-organized and effective maintenance strategy, ensuring the Company's production operations run smoothly and achieve their goals.

a) Asset Register

The implementation of computerized maintenance management starts with updating the asset register within the CMMS database, facilitated through SAP-MDM in the Company's ERP system. Key elements of this update include the maintenance work center, functional location, equipment master records, bill of materials (BoM), measuring points, maintenance task list, maintenance plan & items, classification/characteristics, damage catalog/failure code, and document management system (DMS). These components collectively form a well-organized foundation for computerized maintenance management within the Company's operational framework.

1. Maintenance Work Center

   The work center is a collective unit of technicians responsible for executing maintenance activities within the organization. This component enables strategic planning and task assignment to technicians based on their competencies and availability. It facilitates task scheduling, schedule determination, and cost capacity computation. Each functional location and equipment is associated with a default work center, streamlining work center assignments during maintenance order creation.

   Key aspects of information within the work center include scheduling, capacity planning, and cost centers. Scheduling involves entering operation time and formulas into the work center to calculate operation durations, ensuring precision in planning and execution. Capacity planning incorporates capacity-related information and formulas to calculate the required capacity, optimizing resource utilization within the work center. Cost centers integrate formulas to compute operation costs and link cost centers to work centers, enabling comprehensive tracking of costs related to various operations. By leveraging these elements within the work center, the organization can enhance its maintenance efficiency, optimize resource allocation, and accurately calculate costs associated with maintenance operations.

2. Functional Location

   Functional location in SAP serves as crucial master data that delineates specific areas or locations where maintenance activities are conducted, and where equipment can be subsequently installed. This functionality encompasses several key aspects. First, it provides a comprehensive description of the operational systems or structures within the company, delineating them based on their functions. Second, it facilitates the tracking of maintenance activity costs on a per-location basis, aiding in the meticulous management of financial aspects related to maintenance. Third, functional location acts as a repository for collecting technical data pertinent to each location, supporting comprehensive evaluation processes. Fourth, it allows for the tracing of equipment installation locations, providing a systematic overview of where each piece of equipment is placed or installed. Lastly, functional location enables the analysis of how location conditions may impact damage to installed equipment, offering insights for strategic decision-making.

Functional Location Category

The functional location category serves as an indicator differentiating functional locations based on their intended purpose and is instrumental in establishing default parameters during the creation of functional locations in SAP. Pertinent parameters include the change document, which controls all changes to functional location fields and meticulously documents each alteration in master data through a change document history. The object info key identifies object information key parameters, displaying technical object data in a specialized information window, with PHE adopting the 'PM' key information object as per SAP Standard. The Status Profile regulates user status, with PHE opting to use the system status from SAP Standard without the need for user status at the functional location. The view profile manages the display of screens during transactions related to functional location master data.

Structure Indicator Functional Location

Functional location requires a defined structure indicator, determining its hierarchical level in the structure. The hierarchical structure used by the Company refers to the ISO 14224 standards, as shown in Figure 3.4, providing a visual representation of asset hierarchy based on the specified document. This structured hierarchy enhances the organization's ability to depict and manage its assets effectively.

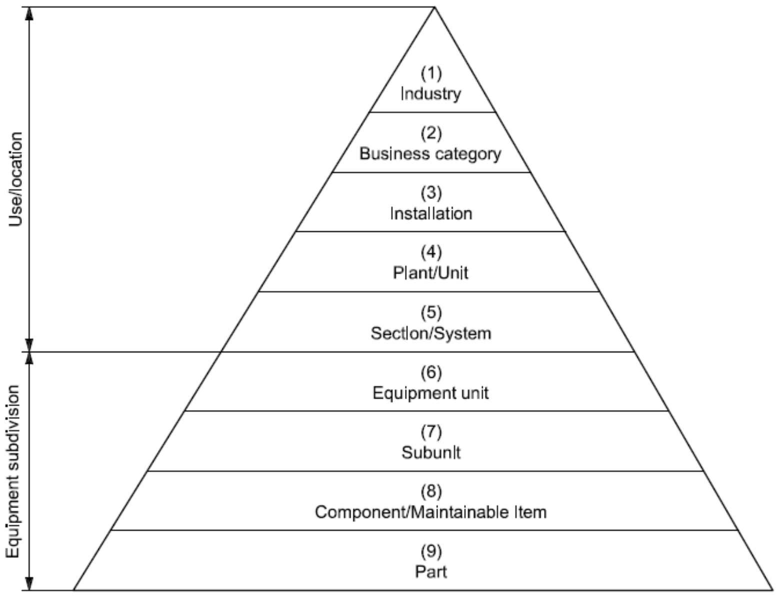


Figure 3.4. Taxonomy of asset register
(Source: ISO 14224)

Therefore, considering the structure of the diagram above, the following indicator structure is used as a reference for creating functional locations which can be seen in Table 3.3.

Table 3.3. Structure Indicator Functional Location

Structure Indicator	Description	Coding Mask & Level
PHE01	PHE PM Structure Indicator	XX – XXXX – XX – XXXX – XXX – XX – XXXXXXX 1 – 2 – 3 – 4 – 5 – 6 – 7

Where:

- Level 1 : Entity - Corporate Level PHE
- Level 2 : Entity - Subsidiary Level
- Level 3 : Plant
- Level 4 : Platform/ Area/ Fields/ District
- Level 5 : Sub-area/System/ Section
- Level 6 : Classification/ Unit
- Level 7 : Sub-unit

3. Equiment Master Record

Equipment refers to individual objects subjected to a physical maintenance process, each capable of being installed at a specific functional location. Managed and processed within the SAP system, each piece of equipment serves various functions. These include managing data on an individual maintenance basis, creating and displaying records of all maintenance activities, storing historical data for each piece of equipment, collecting and evaluating data over a defined period, monitoring maintenance costs associated with each piece of equipment, and recording installation times and durations at specific functional locations. The equipment master data encompasses details of equipment slated for individual maintenance, ensuring a comprehensive maintenance history. Concurrently, part materials are organized into a BoM, a concept further elaborated in the subsequent section on the Bill of Materials (BoM).

Each piece of equipment is assigned a unique number, differentiating it from others, and can be configured with either an internally generated SAP number or an externally defined manual number, based on specific needs or agreements regarding master equipment numbering. PHE opts for internal numbering, with the TAG code stored in a designated field within the equipment master data. In the creation of equipment master data, several parameters necessitate configuration in SAP, including equipment category and number range, equipment criticality, and equipment user status. The subsequent section provides an elucidation of these parameters.

Equipment Category

The equipment category serves as a classification system grouping equipment types according to their distinctive characteristics, facilitating streamlined reporting. The equipment categorization aligns with the specifications outlined in ISO 14224: 2006 as outlined in Table 3.4.

Table 3.4. Equipment Category

Equipment Category	Description	Change Document	Usage History	Object Info	Install at Functional Location
B	Marine	Yes	Yes	PM	Yes
C	Civil & Structure	Yes	Yes	PM	Yes
E	Electrical	Yes	Yes	PM	Yes
F	Hsse	Yes	Yes	PM	Yes
I	Instrument, Control & Custody	Yes	Yes	PM	Yes
K	Communication	Yes	Yes	PM	Yes
L	Pipeline	Yes	Yes	PM	Yes
M	Mechanical	Yes	Yes	PM	Yes
G	General Supporting	Yes	Yes	PM	Yes

Equipment Category	Description	Change Document	Usage History	Object Info	Install at Functional Location
S	Subsea Production	Yes	Yes	PM	Yes
T	Rotating	Yes	Yes	PM	Yes
U	Utilities	Yes	Yes	PM	Yes
W	Well Completion (Downhole)	Yes	Yes	PM	Yes

Equipment Number Range

The assignment of an equipment number range can be done either internally or externally for each equipment category, and it's possible for multiple equipment categories to share the same number range. At PHE, the decision has been made to utilize an internal number range for all equipment categories. In this configuration, the system will autonomously allocate a number based on the predetermined range. While the TAG number remains relevant, it can be incorporated by entering it into either the Technical Identification Number (TechIdentNo.) field or the Sort field within each equipment master. The designated number ranges for each category are as despiced in Table 3.5.

Table 3.5. Equipment Number Range

Equipment Category	Description	Number Range
B	Marine	21000000-21999999
C	Civil & Structure	22000000-22999999
E	Electrical	23000000-23999999
F	Hsse	24000000-24999999
I	Instrument, Control & Custody	25000000-25999999
K	Communication	26000000-26999999
L	Pipeline	27000000-27999999
M	Mechanical	28000000-28999999
G	General Supporting	29000000-29999999
S	Subsea Production	41000000-41999999
T	Rotating	42000000-42999999
U	Utilities	43000000-43999999
W	Well Completion (Downhole)	44000000-45999999

Equipment Criticallity

The Criticality Indicator functions as a crucial assessment tool for maintenance objects, signifying their respective levels of importance in the context of specific activities. This classification facilitates prompt response in case of malfunctions, aligning with the perceived significance of each object. At PHE, the Criticality Indicator is denoted by the categories Safety Critical Equipment (SCE), Production Critical Equipment (PCE), Safety Non-Critical Equipment (SNCE), PNCE (Production Non-Critical Equipment), and OTHERS. Each designation plays a key role in guiding the prioritization of maintenance actions based on the criticality level attributed to individual equipment types.

User Status

In addition to the system status, which provides a general overview of equipment status (such as installed, available, or in the warehouse), user status serves as an additional tool to convey detailed equipment status tailored to user-specific requirements.

In the Company, equipment user status consists of 5 types as shown in Table 3.6.

Table 3.6. Equipment User Status

Status Code	Description
01	In Operation
02	Stand-By
03	Stored in Warehouse
04	Inactive/ Mothballed
05	Demolished/ Decommisioned

4. Bill of Material (BoM)

The SAP-PM module encompasses the essential functionality of the BoM, serving the purpose of linking spare parts lists to technical objects, such as functional locations or equipment. This BoM functionality is further categorized into three types: functional location BoM, equipment BoM, and BoM material.

Functional location BoM involves a direct linkage of the material list to the functional location. It essentially serves as a spare parts list tailored for the functional location, ensuring that all necessary materials for maintenance are readily accessible and organized according to the specific location's requirements.

Equipment BoM involves linking the material list directly to the equipment, essentially constituting a spare parts list designed for that specific equipment. For example, a spare part list can be created for a pump, treating the pump as an individual equipment entity. This allows for precise management and allocation of spare parts required for the maintenance and operation of that particular piece of equipment.

BoM material involves connecting the material list to the primary material assembly, acting as a spare parts list for materials. The assembly material is then linked to multiple similar equipment instances. For instance, a PM assembly type material can be created for a pump, followed by the development of a spare parts list for the pump assembly. This pump assembly material is subsequently interconnected with various pump equipment instances, allowing for efficient management of spare parts across multiple pieces of similar equipment.

This comprehensive categorization within the BoM functionality ensures a versatile and tailored approach to managing spare parts and materials associated with Functional Locations, Equipment, and general material assemblies in the SAP-PM module. This structured method enhances the efficiency and effectiveness of maintenance activities, ensuring that all necessary materials are systematically organized and easily accessible.

5. Measuring Points

Measuring points within the SAP-PM module serve as essential master data, capturing the condition of a technical object, be it a functional location or equipment, through various parameters such as temperature, pressure, operating time, distance traveled, and more. The recorded values from these measuring points, which can either increase or decrease, are documented in the SAP system as measurement documents.

There are two primary types of measuring points, counter measuring point and non-counter measuring point. Counter measuring points exhibit results that consistently either increase (forward counter) or decrease (backward counter) over time. Examples include measurements like running hours, odometer readings, and KWH meters. These measurements provide a cumulative record of usage or distance traveled. On the other hand, non-counter measuring points capture values that can fluctuate over time. This category includes parameters such as temperature, pressure, water discharge, and other variables that may vary without a cumulative trend.

6. Maintenance Task Lists

The maintenance task list serves as a comprehensive guide detailing the step-by-step procedures for individual activities aimed at maintaining technical objects, particularly in the context of PM. This structured list not only outlines the sequence of operations but also finds utility in corrective maintenance order activities, streamlining the planning process by integrating task list master data. This integration eliminates the need for maintenance planner groups to manually transcribe work sequences into each maintenance order.

Beyond the sequencing of operations, the maintenance task list is a master data repository that accommodates components (materials) required for each operation or maintenance activity. Additionally, it can store maintenance package data aligned with predefined maintenance strategies.

Key elements within a maintenance task list include:

- Operation: Detailed operations or work activities required for maintenance.
- Sub-operation: Further breakdown or detailed steps within an operation.
- Components: Materials or spare parts necessary for completing each operation.
- Maintenance Packages: Aggregated sets of operations and components aligned with specific maintenance strategies.

Maintenance task lists are categorized into three types: functional location task list, equipment task list, and general maintenance task list. The functional location task list delineates the sequence of operations specific to the maintenance of a particular functional location. Similarly, the equipment task list outlines operations tailored for the maintenance of specific equipment. Both types are inherently tied to one technical object code (functional location/equipment) from their inception, ensuring that the sequence of operations is specific to a singular technical object.

In contrast, the general maintenance task list is a versatile sequence of operations designed for maintaining technical objects. Created to be applicable to equipment or similar functional locations, it provides flexibility by not being bound to a specific technical object from the outset. This characteristic enables its use across various equipment or functional locations, enhancing its adaptability and usability.

7. Maintenance Plan & Item

   A maintenance plan serves as crucial master data encompassing a comprehensive list of maintenance tasks slated for technical objects, such as functional locations or equipment. Within the framework of maintenance plans, cycles and items play pivotal roles. Maintenance plans are categorized into different types:

   i. Single Cycle Plan (Time-based or Performance-based)

      A maintenance plan characterized by a single cycle that can be determined based on either the elapsed time or the performance of the equipment.

   ii. Strategy Plan (Time-based or Performance-based)

      Maintenance plans featuring multiple cycles, selected through options in the maintenance package list defined within the maintenance strategy. A maintenance task list is a requisite for this type of maintenance plan.

   iii. Multiple Counters (Cycle Set)

      A maintenance plan designed to specify several cycles with distinct units of measurement. For instance, this could involve tasks like changing engine oil every 5000 km and/or every 4 months.

   Maintenance Items are components of a maintenance plan, outlining PM activities scheduled regularly for a specific technical object. Each maintenance item is associated with one technical object, which can be a functional location or equipment.

   In the context of strategy plans, a maintenance strategy is pivotal. It serves as a structured list of periods incorporated into the task list. This maintenance strategy can be time-based, including intervals like weekly, monthly, or yearly, and may also encompass performance-based parameters such as running hours or cycles.

   In essence, the interplay between maintenance plans, maintenance items, and maintenance strategy establishes a robust framework for systematically organizing and executing PM activities for diverse technical objects.

8. Classification / Characteristic

   Classification in SAP plays a crucial role in grouping equipment based on its function or type, facilitating efficient object retrieval through the use of characteristics as search criteria. This process ensures swift identification of objects with identical or matching characteristics. The naming conventions for classes involve the use of alphanumeric characters, with a maximum limit of 18 characters.

Characteristics, integral to the classification system, serve as a medium for storing detailed information, equipment specifications, and act as master data for measuring points. The naming convention for characteristics employs alphanumeric characters, with a maximum limit of 30 characters. These characteristics are created and subsequently assigned to the relevant classification, enhancing the depth and precision of equipment-related information within the SAP system.

9. Failure Catalog/Code

A Catalog is a compilation of historical data regarding an object's parts, types of damage, causes, and solutions for problem-solving. This information is recorded in the system or reported to the responsible maintenance planner after technicians perform maintenance work. The catalog is an integral part of the notification document and contributes to the maintenance history. Standardization of catalog data is crucial to facilitate its utilization in the evaluation process.

The catalog system is cross-application, meaning it can be employed across various modules, and it is specifically utilized to complement notification documents. This system operates on a hierarchical structure, with the first level being the catalog type. Each catalog type corresponds to a specific group and can be further subdivided using a code group. This code group contains codes that correspond to different series of findings.

Catalog Types:

i. Catalog Type A : Activities
ii. Catalog Type B : Object Parts
iii. Catalog Type C : Damage
iv. Catalog Type 5 : Cause of Damage

This structured catalog system ensures a systematic and organized approach to recording and utilizing historical data. It provides a framework for standardized documentation of activities, object parts, damage, and causes of damage, streamlining the maintenance processes and enhancing the efficiency of evaluation and analysis.

10. Document Management System (DMS)

The Document Management System (DMS) in SAP serves as a vital link between master data (functional location, equipment, material) or transactional data (notification, maintenance order, purchase requisition, purchase order, etc.) and external documents or files. This system enables the attachment of various types of files, such as technical drawings, manuals, or inspection results, to SAP objects, ensuring that all relevant information is accessible through the SAP platform.

Two types of DMS are utilized in SAP:

i. SAP DMS with Data Carrier

This type employs SAP DMS standards using data carriers as links to the original file locations. The data carrier contains a file path, usually a shared folder configured in the SAP system. Users create a document by attaching the file to the data carrier, and a document number is then assigned to the corresponding SAP object (equipment, notification, maintenance order, etc.).

ii. SAP Object Services

SAP Object Services is a standard functionality within SAP Office designed for data management purposes. It encompasses features such as sending emails to fellow SAP User IDs and creating attachment lists.

For attachments using SAP Object Services, two methods are available:

- Content Repository with Content Server:

  This method involves using a content repository with a content server to store and manage documents.

- Share URL Code:

  This method utilizes a shared URL code to link to external documents, providing a convenient way to access files associated with SAP objects.

Both methods under SAP Object Services contribute to the seamless integration of external documents with SAP data, enhancing the accessibility and management of information within the SAP ecosystem.

b) *Maintenance Method*

Effectively managing the maintenance of production equipment and facilities, particularly with limited resources, demands meticulous planning and scheduling. Although organizing maintenance for a small number of equipment is relatively straightforward, the complexity escalates as the quantity of equipment grows. The use of maintenance management software becomes essential in this scenario, especially when dealing with an expanding array of assets.

A CMMS refers to a comprehensive collection of computer programs and data files strategically developed to offer users a cost-effective solution for efficiently handling extensive volumes of maintenance, inventory control, and purchasing data (Cato & Mobley, 2001). It serves as a centralized platform that integrates various functionalities to facilitate efficient planning, tracking, and management of maintenance activities related to equipment, assets, and facilities.

As explained in Chapter 2, the Company has utilized SAP as an ERP application. This application is equipped with a SAP-PM module which can function as a CMMS software. The SAP-PM module is designed to integrate seamlessly with other modules, giving companies the flexibility to leverage SAP's extensive capabilities to manage various aspects of their operations, with a particular focus on meeting asset maintenance needs. This module in SAP acts as a comprehensive tool, facilitating the planning, execution and monitoring of maintenance activities, thereby encouraging a cohesive and integrated approach to managing specific maintenance functions across the enterprise.

Selecting an appropriate maintenance strategy holds significant importance for ensuring the long-term sustainability of a company. This choice directly influences the reliability, availability, and performance of assets and equipment. Moreover, the financial health of the company can be adversely affected by improper maintenance management. In Kym Fraser research (2014), he identified a comprehensive list of 37 maintenance types, methods, models, or philosophies applicable across diverse industries. Despite this variety, the overarching maintenance strategy typically relies on four fundamental methods: breakdown maintenance, preventive maintenance, predictive maintenance, and proactive maintenance.

1. Breakdown maintenance (BdM), also known as reactive maintenance, is a strategy employed to address unexpected equipment failures, faults, or malfunctions. In this approach, maintenance activities are initiated in response to a breakdown situation, aiming to restore the equipment to operational status.
2. Preventive maintenance (PM), also referred to as time-based maintenance, is a systematic approach that involves scheduled and repetitive tasks to ensure the ongoing reliability and availability of equipment. Unlike BdM, PM is proactively performed at regular intervals to avoid potential failures.
3. Predictive maintenance (PdM) is a corrective maintenance (CM) strategy that relies on the continuous monitoring of actual mechanical conditions, operating efficiency, and various indicators related to equipment and process systems. This data-driven approach aims to predict potential failures, allowing for timely interventions to ensure extended intervals between repairs and minimize the impact of unscheduled shutdowns.
4. Proactive maintenance, also known as prescriptive maintenance (RxM), represents a sophisticated evolution of PdM. This advanced strategy leverages real-time monitoring, incorporating cloud computing and artificial intelligence. RxM goes beyond predicting failures; it actively prescribes maintenance actions based on dynamic, continuously updated assessments.

The implications of different maintenance methods can be analyzed through various factors such as technical requirements and cost considerations. In a comparison by Kučera & Kopčanová (2020), the four types of maintenance—reactive, preventive, predictive, and proactive—are evaluated based on aspects like special knowledge, special equipment, implementation costs, repair needs, and downtime. The findings, as depicted in Table 3.7, suggest that reactive maintenance may appear simpler to implement when considering the need for special knowledge, special equipment, and implementation costs. However, when assessing costs related to repairs or losses resulting from downtime, proactive maintenance emerges as the most effective method compared to reactive maintenance. This underlines the trade-offs and considerations involved in choosing an appropriate maintenance strategy based on different organizational needs and priorities.

Table 3.7. Comparison of maintenance strategies
(Source: Kučera & Kopčanová (2020))

Maintenance Approach	Applicability	Technical Requirement		Cost Requirements		
		Specialized knowledge	Specialized equipment	Cost to Implement	Repair after failure	Downtime and extended damages
Reactive	low impact of failure	Low	Low	Low	Highest	Highest
Preventive	increased impact of failure	High	Average	Average	Average	Average
Predictive	simple prediction of failure	High	High	High	Low	Low
Proactive	multiple prediction of failure	Highest	Highest	Highest	Lowest	Lowest

Choosing the right maintenance method is crucial for a company's success, as it can either serve as a source of profit or result in additional costs. Patil et al. (2022) present various methods for selecting the type of maintenance, including Analytical Network Process (ANP), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), Measuring Attractiveness by a Categorical-based Evaluation Technique (MECBETH), VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR), Complex Proportional Assessment (COPRAS), and Fuzzy Axiomatic Design (FAD). Each method requires specific criteria tailored to the company's goals.

The determination of these criteria can vary among companies, depending on individual needs. For instance, Patil et al. (2022) outline six criteria: economic, technical, safety, environmental, feasibility, and social. In contrast, Fouladgar et al. (2012) propose four criteria: cost, accessibility, risk, and added value.

Similarly, PHE-NSO, in line with industry practices, has established risk-based equipment integrity management guidelines to guide the selection of maintenance methods. According to these guidelines, the default maintenance methods are RBI or RCM, with the choice between them contingent on the specific equipment category. The company has meticulously categorized equipment into nine distinct categories, and the prescribed maintenance methods for each category are detailed in Table 3.8. This systematic and structured approach ensures the formulation of a customized and effective equipment maintenance strategy aligned with the principles of risk-based management.

Table 3.8. Maintenance methodology by equipment group

No	Integrity Program	Metodology
1	Surface Facilities (Pressure Vessel & Piping) Integrity	RBI
2	Rotating Equipment Integrity (Reliability dan Availability)	RCM
3	Pipeline Integrity	RBI
4	Structure Integrity	RBI
5	Lifting Integrity	RBI
6	Electrical & Instrumentation Integrity (Reliability dan Availability)	RCM
7	Well Integrity	RBI
8	Floating Integrity	RBI
9	Corrosion Management System	RBI

Despite the identification of maintenance methodologies for each piece of equipment, full implementation of RCM and RBI may result in increased resource requirements, including both labor and costs. The comprehensive nature of this methodology, while effective in improving equipment reliability and minimizing risk, often requires the commitment of additional resources to effectively execute the specified maintenance strategy.

Companies need to carefully weigh these resource considerations against the anticipated benefits in terms of increased asset reliability, reduced downtime, and improved safety and compliance. Effective planning, resource allocation, and ongoing evaluation are critical elements in ensuring the successful implementation of RCM and RBI. For this reason, an assessment of criteria is needed to determine maintenance packages for each approach.

c) *Equipment Criticality Ranking*

The Company utilizes two types of criteria in determining priorities and maintenance packages: Equipment Criticality Ranking (ECR) and Risk Value. These criteria play a crucial role in guiding the allocation of resources and ensuring that maintenance efforts are aligned with the overall objectives of enhancing asset integrity and managing operational risks.

The Equipment Criticality Ranking (ECR) assessment is designed to establish maintenance priorities for equipment. While the success of implementing a maintenance, program is ideally measured by the number of successfully executed maintenance plans, the reality may involve instances of maintenance backlogs. In such cases, prioritization serves as a strategic approach to determine which types of equipment should take precedence over others. This prioritization ensures that resources are allocated efficiently, addressing critical equipment needs first and minimizing the impact of potential failures on operations. It enhances the overall effectiveness of the maintenance program and contributes to the long-term reliability and integrity of the assets.

The Company employs a five-tier classification system for equipment criticality ranking (ECR), outlined in Table 3.9. Safety critical equipment (SCE) is specifically designated for equipment with the most substantial impact on personnel safety, environmental protection, and overall installation integrity. Equipment significantly influencing plant production is assigned a heightened criticality level within the production critical equipment (PCE) category. Categories deemed non-significant to safety, such as Safety non-critical equipment (SNCE), and those non-significant to production fall into the production non-critical equipment (PNCE) category. Any remaining categories are collectively grouped to the OTHER category.

Table 3.9. Equipment categories based on criticality level

Rank	Criticality
1	SCE (Safety Critical Equipment)
2	PCE (Production Critical Equipment)
3	SNCE (Safety Non-Critical Equipment)
4	PNCE (Production Non-Critical Equipment)
5	OTHERS (None Safety & Production Equipment

The process of determining the criticality level of equipment involves a decision tree, illustrated in Figure 3.5. This decision-making framework provides a systematic approach to evaluate various factors and classify equipment into different criticality levels based on their significance to safety, production, or other considerations. It serves as a guide for the Company to make informed decisions regarding the prioritization of maintenance and inspection activities according to the criticality levels assigned to different equipment categories.

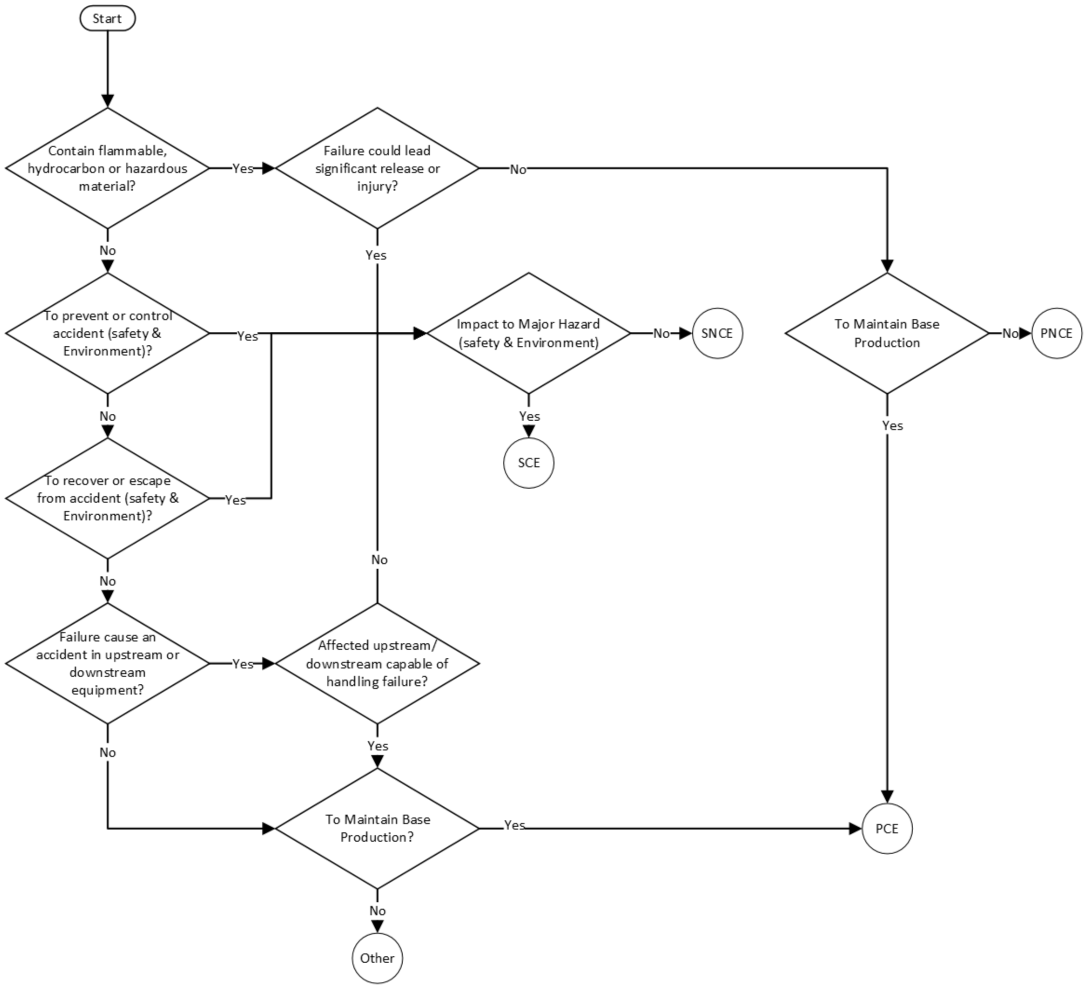


Figure 3.5. Flowchart for determining criticality ranking

d) *Equipment Risk Analysis*

The equipment risk assessment, serving as the foundation for selecting the appropriate maintenance method, is elucidated through the AIMS business process. In this context, the company employs a comprehensive risk-based approach to evaluate equipment and determine the most suitable maintenance methodologies. The AIMS process integrates risk assessments, asset integrity evaluations, and compliance considerations to inform decisions on maintenance strategies, ensuring a holistic and effective approach to managing equipment integrity throughout its lifecycle.

The AIMS adheres to company standards, employing risk-based examination methodologies as a foundational determinant for standardization. While emphasizing risk-based approaches, there exists flexibility to incorporate alternative methodologies, notably RCM for specific equipment categories like rotating, electrical, and instrumentation equipment. This approach ensures adherence to integrity management principles while allowing adaptability based on equipment characteristics.

RBI, a key facet of integrity management, grounds its processes in risk management and assessment principles. This systematic approach involves determining the probability of failure (PoF) and consequences of failure (CoF) for a specific asset or group of assets. The goal is to derive optimally prioritized inspection techniques and schedules for future inspections.

In the oil and gas industry, there is a discernible shift from traditional time-based inspection planning to the application of RBI methodology. RBI introduces efficiency by reducing the frequency and interval of inspections, concentrating efforts on locations identified as having the highest risk. This focused approach aims to reduce risks to As Low as Reasonably Practicable (ALARP).

Previously, it was explained that equipment integrity management is categorized into nine management systems. The elucidation for each management system is detailed as follows:

1. Surface Facilities (Static & Piping) Integrity

   Surface Facilities Integrity Management System (SFIMS) is a critical aspect of equipment integrity, primarily for the oil, natural gas, and petrochemical industries. The focus is on maintaining both static structures and piping systems, with significant annual expenditures involved. SFIMS ensures the availability, usability, and fitness for purpose of surface facilities throughout their lifespan. The structured implementation of SFIMS, guided by standards like API 580, 581, and 571, relies on RBI methodologies. Various equipment under SFIMS, including vessels, tanks, heaters, and piping circuits, undergoes thorough risk analysis at the component level. The PoF and CoF are critical parameters in this process, contributing to a robust SFIMS that ensures sustained integrity and reliability.

2. Rotating Equipment Integrity

   Operational reliability of rotating equipment is paramount, necessitating a maintenance approach that minimizes failures and optimizes repair times. RCM serves as a methodology for formulating comprehensive maintenance strategies.

Standards such as SAE JA 1011, 1012, and EN/IEC 60812 guide the framework for Rotating Integrity Management System (RIMS), covering compressors, turbines, motors, and gearboxes. Key parameters including availability, reliability, and maintainability collectively contribute to a robust RIMS, enhancing overall performance and lifespan.

3. Pipeline Integrity

   The Pipeline Integrity Management System (PIMS) is a methodical approach to proactively address threats to pipeline integrity. Activities involve integrity assessment, inspections, maintenance, and repair operations. Recognized standards such as API 1160, ASME B31.8S, and DNV-RP-F116 guide risk assessment and management. Accurate and detailed information about pipelines is crucial for effective risk-based management. Time-dependent and time-independent PoF parameters, coupled with CoF, form the basis for a robust PIMS, ensuring smooth operations and minimizing damage.

4. Structure Integrity

   A Structural Integrity Management System (SIMS) is essential for both offshore platforms and onshore structures, ensuring availability and functional use throughout their service life. SIMS involves planning inspections, maintenance, and repairs, with standards like API RP 2SIM, ISO 13819, and DNVGL RP-C210 guiding the process. Offshore structures benefit from SIMS by maintaining integrity, correcting degradation, prioritizing activities, and optimizing resource utilization. The assessment considers platform characteristics, actual condition, platform load, and CoF, encompassing safety, assets, environmental impact, and reputation.

5. Lifting Equipment Integrity

   Lifting equipment integrity is crucial for safety and effectiveness in lifting operations. The Lifting Integrity Management System (LIMS) is vital for planning and executing lifting operations without compromising safety. Standards like IMCA LR 006, DNV no.2.22, and ASME B30 series guide practices for Lifting Integrity. The equipment includes portable, fixed, and mobile lifting equipment, accessories, and offshore containers. LIMS covers personnel elements, process elements, and elements of lifting equipment, ensuring safe and efficient lifting operations across various work areas.

6. Electrical and Instrumentation Integrity

   In a production environment, the reliability and availability of electrical equipment and instrumentation are critical. Risk assessment methods following IEEE STD 493 and IEEE STD 43 standards guide the evaluation of generators, transformers, switchgear, motors, and other equipment. Parameters such as Reliability, Availability, and Maintainability contribute to a comprehensive Electrical and Instrumentation Integrity Management System. The system aims to maximize safety, efficiency, and cost-effectiveness in operational activities.

7. Floating Integrity

   Floating System Integrity Management (FIMS) is crucial for assessing offshore platforms or floating systems. FIMS aims to ensure continuous suitability for use, minimize the risk of failure, identify critical elements, and optimize inspection processes. International standards such as API RP 2 F-SIMS, ISO-19902, ISO-19904, and ISO 19901-7 serve as references for FIMS. The structured approach involves assessing hull integrity, mooring integrity, and the integrity of floating and subsea components, enhancing the overall reliability and safety of floating systems.

8. Well Integrity

   Well Integrity, following the NORSOK Standard D-010, is a strategic application of technical, operational, and structured solutions to mitigate the risk of uncontrolled release of formation fluids throughout the well life cycle. Well Barriers play a crucial role in preventing unintended fluid flow, with primary objectives including preventing hydrocarbon leaks and ensuring immediate well shutdown during emergencies. Critical parameters for assessing Well Barrier capability include functional, availability, resilience, and integrity monitoring. The potential routes for hydrocarbon leaks are identified, covering equipment such as blowout preventers, wellheads, tubing, and subsurface safety valves.

9. Corrosion Management System

   The Corrosion Management System (CMS) serves as a comprehensive framework to manage corrosion risks and damage mechanisms. Utilizing international standards and references like API RP 970, NACE SP 21430-2019, and the Energy Institute's guidance, CMS encompasses policy and strategy, organization, corrosion risk assessment and planning, implementation and analysis, KPI and system performance review, and auditing. The system is designed for comprehensive application in the field, ensuring the safe and reliable operation of both existing and newly installed assets.

Effective management processes are pivotal for enhancing design and operational integrity. The implementation of RBI has demonstrated potential significant cost reductions by optimizing inspection activities and improving the reliability of operational assets.

Regardless of the specific RBI guidance and methodology employed, a fundamental requirement is the assessment of the PoF and the CoF for individual assets or groups. This risk assessment is crucial for making informed decisions regarding inspection priorities, resource allocation, and risk mitigation strategies within the organization.

Risk analysis involves identifying and assessing factors with potential negative impacts in the future. The company utilizes a qualitative approach, combining the PoF or likelihood and the CoF or severity. PoF quantification follows specific criteria, while CoF involves evaluating impacts on people, environment, assets (costs), and reputation, each assessed with specific quantification.

The PoF and CoF values are translated into a risk matrix to ascertain the risk level. In the case of CoF, if the risk is evident in more than one criterion, the highest value is employed. The risk matrix and corresponding risk levels are detailed in Appendix 2. According to the risk table, equipment failure risks can be categorized into five levels: very high, high, medium, low, and very low, where each level representing varying degrees of risk based on PoF and CoF values.

e) *Inspection, Testing and Preventive Maintenance (ITPM) Plan*

Overseeing maintenance through a corrective maintenance strategy may seem simpler compared to a PM or PdM approach. This method eliminates the need for intricate maintenance schedules; instead, the equipment is operated until it malfunctions, and subsequent repairs are conducted. However, this simplicity can result in escalated costs attributed to equipment failures, including factors such as production loss and increased repair expenditures. Conversely, an excessive reliance on PM and PdM can amplify expenses associated with executing these measures.

The relationship between planned maintenance and unplanned maintence, as well as their impact on total maintenance costs, is illustrated in Figure 3.6. To address these challenges and strike a balance between efficiency and costs, the implementation of RCM and RBI becomes crucial. These methodologies aim to achieve optimal maintenance costs by judiciously integrating various available maintenance approaches aligned with the specific risks associated with the equipment.

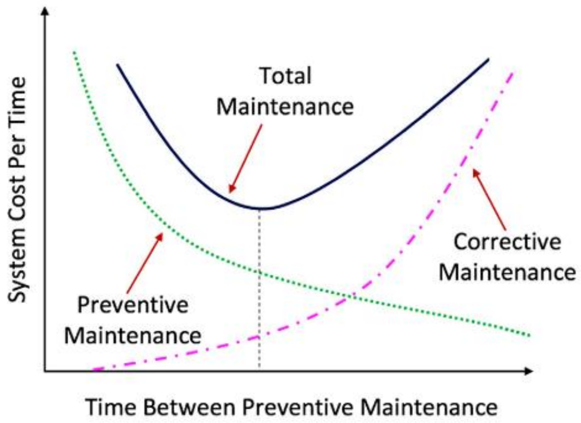


Figure 3.6. The correlation between maintenance expenses and costs.

The pivotal element in attaining optimal maintenance costs revolves around the method of determining ITPM packages, along with their corresponding intervals. The company has offered guidance to aid decision-making in establishing the ITPM packages for each maintenance method based on RCM and RBI. This approach ensures a strategic and informed framework for managing equipment maintenance, tailored to the specific requirements and risks associated with each asset.

The determination of ITPM packages and intervals for each RCM and RBI approach is outlined as follows:

1. RBI maintenance method approach
    i. High and Medium-High Risk Categories

       Time intervals for inspections are established based on the Inspection Plan, referring to API 580/API 581 standards.

ii. Medium and Low-Medium Risk Categories

Time intervals for inspections are determined based on Time-Based Conditions, referencing the in-service inspection code (API 510 for Vessels, API 570 for Piping, API 653 for Tanks, etc).

iii. Low Risk Category

Time intervals for inspections are determined based on Monitoring-Based Conditions.

2. RCM maintenance method approach

i. High and Medium-High Risk Categories

Time intervals for ITPMs are determined based on the inspection plan, involving monitoring, measuring, and sampling the results of RCM implementation.

ii. Medium and Low-Medium Risk Categories

Time intervals for ITPMs are determined based on scheduled maintenance, referring to the manual book for each equipment.

iii. Low Risk Category

Time intervals for inspections are determined based on Monitoring-Based Conditions.

This structured approach ensures that the inspection and maintenance intervals are tailored to the specific risk levels of each equipment category. The utilization of industry standards and codes, such as API 580/API 581 and in-service inspection codes, provides a solid foundation for establishing effective maintenance schedules. Additionally, the incorporation of RCM principles, including monitoring and scheduled maintenance, further enhances the precision and efficiency of the maintenance strategy.

Following the determination of ITPM packages, another critical aspect of maintenance planning involves defining the strategy for executing the maintenance. This encompasses mapping out the manpower, tools, equipment, and associated costs, ensuring that necessary resources are strategically allocated for efficient and cost-effective maintenance task execution.

1. Manpower Allocation

   In determining workforce allocation, it is imperative to identify qualifications and the required number of personnel essential for completing the ITPM task list. Skill upgradation and training initiatives target identified skill gaps within the existing workforce. Tailored programs, including workshops and seminars, facilitate obtaining necessary certifications and qualifications. Internal skill development, supported by continuous learning opportunities, fosters a culture of improvement. Alternatively, staff augmentation and contracting external parties offer flexibility for specialized tasks, allowing organizations to tap into external proficiency without permanent additions.

   A balanced and strategic approach combines internal skill development with external support, ensuring a skilled, flexible, and efficient workforce capable of meeting maintenance demands.

2. Tools and Equipment

   In the strategic planning of maintenance activities, a systematic approach to tools and equipment is essential. Identifying special tools, ensuring availability, and maintaining their condition are paramount. Considering any special tools or technology required for specific tasks enables effective planning. Decisions regarding investment or outsourcing for tools and equipment are made based on factors such as maintenance frequency, scale, budget, and external expertise.

   A comprehensive approach involves meticulous planning, proactive maintenance, and strategic decision-making, ensuring the maintenance team is well-equipped.

3. Sparepart and consumable material management strategy

   An effective spare parts management strategy minimizes downtime and efficiently addresses equipment failures. This strategy involves optimizing inventory, utilizing PdM techniques, and cultivating relationships with reliable suppliers. Centralized cataloging, criticality assessments, and lifecycle management enhance equipment reliability. Training programs for proper spare parts handling and storage ensure personnel competence, and a commitment to continuous improvement adapts to evolving needs.

4. Budgetary

   In the budgetary aspect, a thorough estimation of costs related to manpower, tools, equipment, and logistics is conducted. This includes direct expenses associated with labor, tools, and equipment procurement, as well as consideration of indirect costs like downtime and potential production losses. Developing a comprehensive budget for the entire maintenance execution phase serves as a financial roadmap, ensuring preparedness and effective resource utilization.

2) Maintenance Execution

In the SAP system, maintenance strategies are broadly categorized into two main groups: scheduled maintenance and unscheduled maintenance. Scheduled maintenance involves planned activities executed at routine intervals. This category includes PM, conducted to prevent potential issues, and scheduled PdM, which involves planned activities based on predictive analysis. Unscheduled maintenance encompasses activities that do not adhere to a routine schedule and are triggered by unexpected events. This category includes emergency maintenance for immediate repairs to address urgent issues, unscheduled PdM initiated based on unforeseen predictive analysis, corrective maintenance to rectify identified damage during routine inspections, and modification/fabric/project orders for tasks related to equipment modification, fabrication, new installations, or specific projects. Additionally, operation/prod/general orders cover work not directly associated with maintenance, following processes generally similar to corrective maintenance. This dual classification ensures a comprehensive approach to managing various maintenance needs within the SAP framework.

a) Maintenance Notification

In the maintenance management system, synchronization of all maintenance activities is achieved through a structured maintenance order mechanism. Unscheduled maintenance activities are manually inputted, while maintenance orders for scheduled activities are automatically generated by the system when the maintenance due date is reached. Requests for unscheduled maintenance are initiated by creating notifications in the SAP system. The seamless transition from a maintenance notification to a maintenance order is visually illustrated in Figure 3.7, outlining the systematic flow of the process.

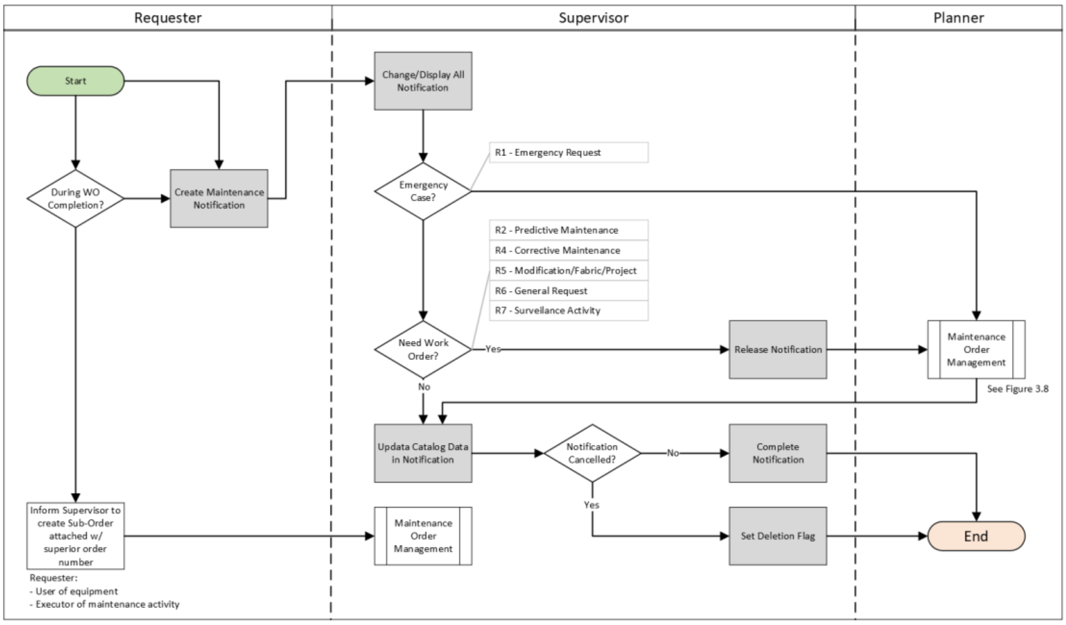


Figure 3.7. Maintenance Notification Flow Process

The unscheduled maintenance order initiates when the requester creates a notification in SAP, serving as a request for repairs, maintenance, or a proposal to create a maintenance order for specific activities like modifications, new installations, or project-related tasks. Supervisors and planners regularly inspect the notification list, either through routine checks or prompted by email notifications. The supervisor meticulously reviews the notification list, and if a notification is deemed valid and necessitates further action, the supervisor initiates the release process before the planner can convert the notification into a maintenance order. Notably, emergency request notifications bypass the validation of the release process, proceeding directly to the creation of a maintenance order by the planner. The planner generates maintenance orders based on the compiled notification list.

In cases where the existing notification reveals no need for activities incurring costs (materials and/or services), the supervisor promptly populates catalog data in the notification. For notifications not requiring a maintenance order, the supervisor conducts the closing process, automatically updating the notification status to "Notification Completed". Invalid notifications prompt the supervisor to set the canceled status by activating the deletion flag. Consequently, the notification status is updated to "Deletion Flag" and "Notification Completed."

b) Maintenance Order

A maintenance order serves as a work directive issued by the maintenance planner group to the maintenance executor for the purpose of carrying out various maintenance activities, including repairs, inspections, reconditioning, and more. The comprehensive process of creating a maintenance order for a maintenance activity, from the initial request to the final closure of the order, is visually outlined in Figure 3.8.

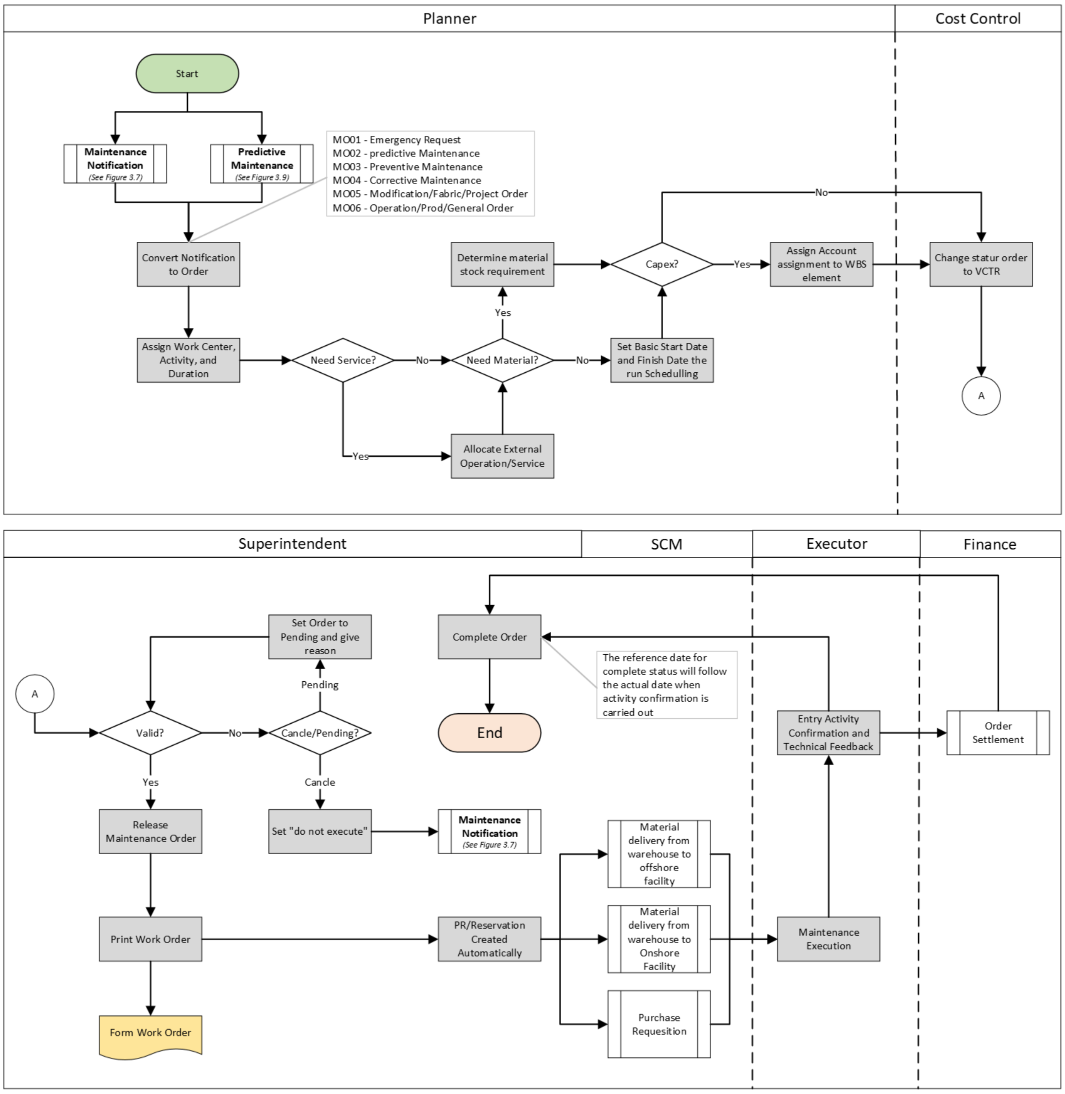


Figure 3.8. Maintenance Order Management

The process of creating maintenance orders manually initiates with the generation of notifications for both unscheduled maintenance and unscheduled PdM. Upon the decision of supervisors to proceed with the notifications, planners take charge of creating maintenance orders in SAP based on the provided notification details.

The planning phase involves determining the sequence of work or activities required for maintenance or repairs. Each activity is assigned a Work Center code responsible for execution, followed by planning the duration of the work and the necessary workforce. In cases where external labor (third-party services) is essential, the planner outlines the required service activities along with estimated costs. This necessity triggers the automatic generation of service Purchase Requisition (PR) documents, subsequently handled by the Procurement Department.

Utilizing stock materials in maintenance orders involves selecting them directly from the material list with specified quantities. This stock material planning leads to the automatic generation of Reservation documents for stock materials or Purchase Requisitions for non-stock materials, managed by the Warehouse Department.

For orders linked to project activities requiring capitalization, the planner must modify the related account assignment order from a cost center to Work Breakdown Structure (WBS). Before the order is released, the Cost Controller scrutinizes the account assignment made by the planner, mitigating charging errors associated with maintenance activities.

Validated maintenance orders are reviewed and approved to ensure meticulous planning of work, materials, and costs. If an order is deemed invalid or unnecessary, it can be closed by setting 'do not execute,' updating the status to "Closed" and "Not completed."

In situations requiring maintenance delays, the order status can be set to "Pending." For external activities or services, an automatic creation of service PR takes place, subsequently converted into a Purchase Order (PO) through the Supply Chain Management (SCM) function.

Once all criteria are met, the planner prints the Work Order, submitting it to the maintenance work center or assigned technicians for execution or supervision (in the case of external parties). The Maintenance Work Center, under the supervision of the Work Center Head, carries out the maintenance or repair process based on the provided work orders.

Upon completion of the work, technicians document the actual duration, details of repaired parts, the cause of damage, activities performed, and additional information. This information is then submitted to the supervisor. For each completed maintenance order, closure is achieved by setting the order status to "Technically complete." This meticulous process ensures thorough planning, execution, and documentation of maintenance activities.

c) *Preventive Maintenance*

PM is a systematically planned maintenance activity triggered at specified intervals, which can be time-based (weekly, monthly, yearly, etc.) or performance-based (running hours, cycles, etc.). In cases where PM issues maintenance orders automatically, the requirement for resources (internal labor, external labor, spare parts) can be pre-planned in a Maintenance Task List assigned to the Maintenance Item/Plan. The entire process of PM planning, beginning from the creation of maintenance items to execution, is visually presented in the flow diagram detailed in Figure 3.9.

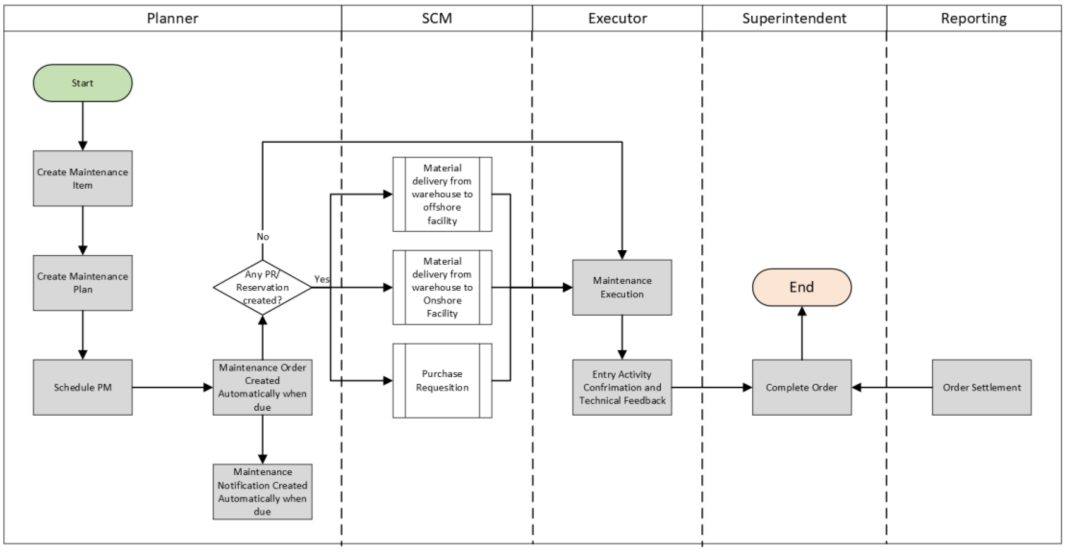


Figure 3.9. Preventive Mainteance

PM activities are initiated by the imperative to conduct routine upkeep on equipment, necessitating the establishment of a meticulous maintenance strategy defining the type of maintenance and the corresponding maintenance package. The responsibility of formulating Maintenance Plans/Items and maintenance task lists for each equipment lies with the Maintenance Planner, who ensures their accurate integration into the SAP system. Following this, the SAP system undergoes a comprehensive scheduling process for all created maintenance plans/items.

Upon reaching the designated timeframe, the system autonomously generates a Maintenance Order, concurrently initiating the creation of a notification with NOPR ORAS status (Notification on process, Order assigned). In instances where materials or spare parts are associated with the order, the system seamlessly generates a reservation for stock materials, routed to the warehouse function. For non-stock materials, a Purchase Requisition (PR) is generated, subsequently handled by the Supply Chain Management (SCM) function. In the presence of external activities or services, the system automatically creates service PRs.

The ensuing step involves the execution of the maintenance/repair process by the Maintenance Work Center or technicians, operating under the supervision of the Work Center Head, relying on the work orders specified in the maintenance order. Upon completion of the work, technicians meticulously document the actual duration, details of the repaired parts, the cause of damage, activities performed, and additional information.

Successfully executed work orders are then officially closed, with the order status transitioning to "Technically complete." This systematic workflow guarantees the efficient planning, execution, and documentation of PM activities, fostering a proactive and structured approach to equipment maintenance within the organization.

d) *Predictive Maintenance*

PdM represents a proactive approach to equipment upkeep, leveraging devices and data analysis to identify anomalies and potential defects. The primary objective is to predict and address issues before they escalate into significant damage. This method involves scheduled detection integrated into the maintenance task list within the PM program. Alternatively, on-the-spot detection can occur through notifications triggered by abnormal symptoms in operating parameters. The process flow for these two PdM approaches is visually represented in Figure 3.10.

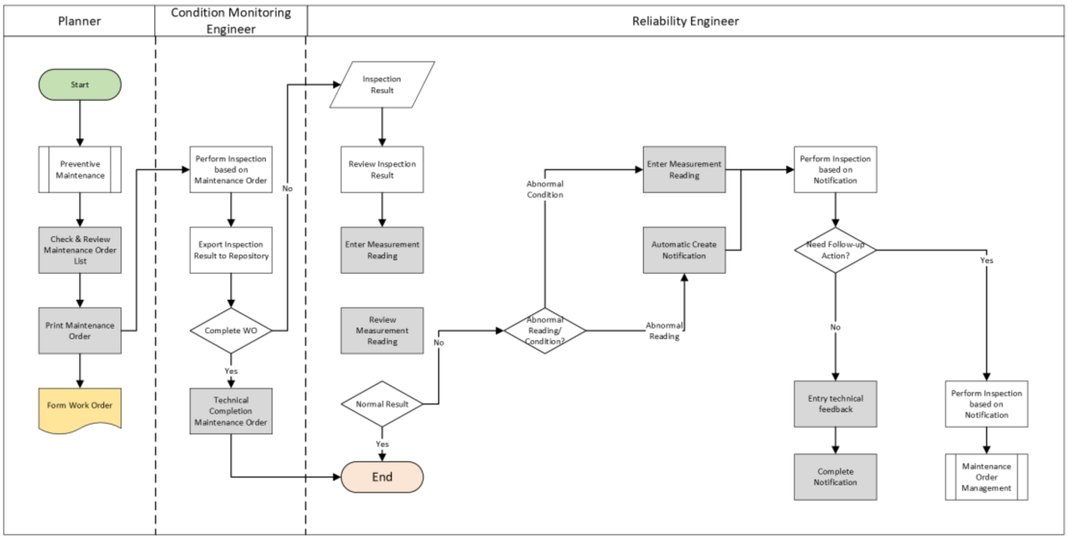


Figure 3.10.Predictive Maintenance

Scheduled or routine PdM is seamlessly integrated into PM procedures, utilizing the PM activity type "PdM" to specifically denote the maintenance schedule tailored for predictive activities. The automated generation of the order with the status "Release" initiates the process, followed by the printing and subsequent delivery of the order to the engineer responsible for field execution. The condition monitoring engineer takes charge of the execution process, generating predictive data in the form of measurement results, which is then subjected to thorough analysis by the reliability engineer.

Upon analysis, if the results indicate normal conditions, signifying the absence of a need for follow-up maintenance, the maintenance order completion process can be efficiently set to "Technical Complete." However, in the event of abnormal measurement readings, the system triggers automatic notification creation. Moreover, if an abnormal condition is identified, the subsequent maintenance follow-up involves the creation of a Surveillance Activity notification, serving as a formal request for an additional inspection.

In cases where inspection results recommend repairs, the engineer communicates the findings to the planner, facilitating the seamless continuation and conversion of the notification into an unscheduled maintenance order.

3) Controlling and Monitoring

Controlling and monitoring maintenance activities is vital for ensuring the reliability, availability, efficiency, and safety of equipment and facilities. This comprehensive process involves systematically supervising and managing maintenance tasks to meet operational requirements and maintain optimal asset performance. Key components include efficient work order management, where the creation, prioritization, assignment, and tracking of work orders facilitate organized and timely completion of maintenance tasks. Asset management is crucial, involving comprehensive recording of all assets, their criticality levels, maintenance histories, and current conditions, to prioritize tasks based on asset importance. Proactive implementation of PM and PdM strategies helps address issues before equipment failures occur. Effective resource planning, including managing manpower, materials, and equipment, optimizes staffing levels and ensures the availability of required spare parts. Monitoring KPIs, such as equipment uptime and overall equipment effectiveness, provides insights into maintenance efficiency. Leveraging condition monitoring technology enables real-time equipment assessment, allowing for early detection of abnormalities. Routine data analysis and reporting help identify trends and inform decisions for continuous improvement. Ensuring compliance with regulations and safety standards is paramount to prevent accidents and maintain a safe work environment. Fostering a culture of continuous improvement involves conducting process reviews, learning from past experiences, and incorporating feedback to enhance overall efficiency. Managing maintenance costs through budget control and expenditure analysis contributes to cost-saving practices. Through these systematic steps, organizations can enhance asset reliability, minimize downtime, and optimize operational performance.

4) Maintenance Evaluation

In maintenance management, the evaluation phase serves as an important stage to drive continuous improvement. This phase involves careful assessment of maintenance activities against predetermined metrics and goals. Organizations closely monitor a variety of performance indicators, including equipment uptime, reliability, maintenance costs, and safety incidents, to measure the effectiveness of their maintenance efforts. By comparing actual results to established benchmarks and KPIs, they can spot any deviations or areas that require attention. Through this process, they identify opportunities for improvement and areas where maintenance processes can be optimized or improved. The findings from this evaluation are documented systematically, providing a basis for decision-making and serving as a reference for future assessment and improvement. Additionally, soliciting feedback from maintenance personnel, stakeholders, and end users will enrich the evaluation process, offering valuable insight into the effectiveness of maintenance activities and areas ripe for improvement. By conducting thorough evaluations and leveraging the insights gained, organizations can continually refine their maintenance strategies, improve performance, and foster a culture of continuous improvement in maintenance management.

The Company uses a framework as in Figure 3.11 to conduct periodic reviews of the AIMS program for continuous improvement. The diagram illustrates a comprehensive maintenance management evaluation system within an AIMS framework. The AIMS program performance is the primary objective, targeting the prevention of catastrophic events, reduction of near-misses, compliance with regulations, and cost-effectiveness. To support these goals, root cause failure analysis is employed, focusing on the mechanical integrity of equipment and human performance. These analyses delve into the fundamental causes of failures, ensuring both the physical robustness of equipment and the efficiency of human operations.

The foundation of this system is the AIMS Program, encompassing an extensive equipment list, an ITPM program, quality assurance, continuous training for personnel, identification and rectification of equipment deficiencies, and standardized maintenance procedures. These components generate leading indicators, which are proactive measures designed to predict and prevent potential failures.

To foster continual enhancement, the system integrates a continuous improvement program (CIP). This program formulates recommendations and corrective actions based on direct performance measures and regular program audits. The feedback loop ensures that both mechanical integrity and human performance are consistently monitored and improved. This structured approach promotes ongoing improvement and adaptation, ensuring the reliability, safety, and efficiency of both equipment and maintenance operations within the organization.

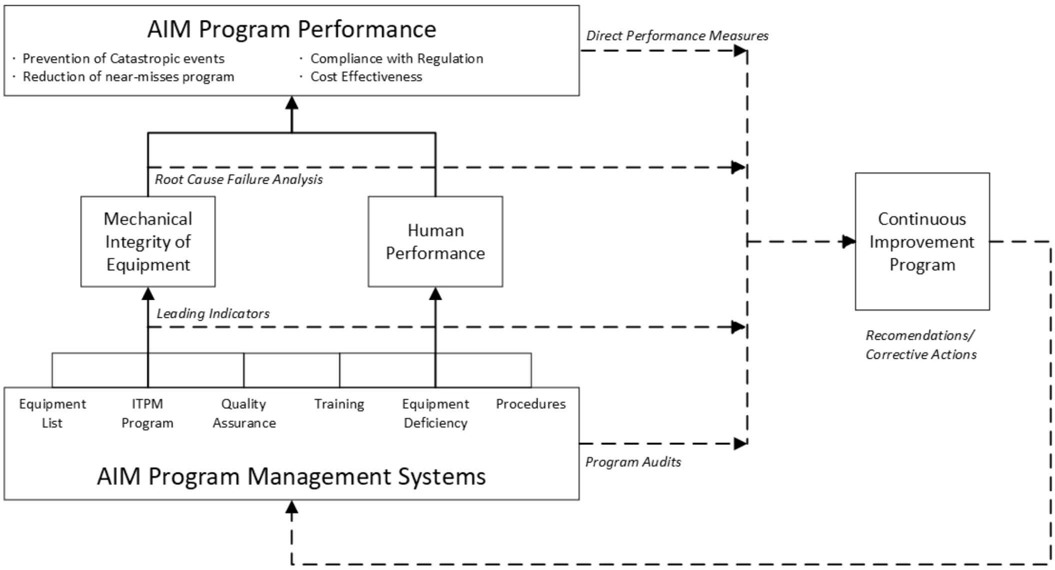


Figure 3.11. Continuous Improvement Model in Integrity Management

In essence, the evaluation phase within the AIM framework is instrumental in driving continuous improvement by systematically assessing performance, identifying areas for enhancement, and implementing targeted actions based on comprehensive analysis and feedback. This ensures that maintenance strategies remain effective and aligned with the overarching goals of operational excellence and safety.

3.2.2. Excellent Maintenance Organization

Maintenance organization refers to the structured entity responsible for overseeing and managing all aspects of maintenance activities within a company or facility. This organization typically includes personnel, processes, and resources dedicated to ensuring the maintenance, reliability, and efficiency of equipment, infrastructure, and assets. A maintenance organization's responsibilities may include planning and scheduling maintenance tasks, allocating resources, performing inspections and repairs, implementing preventative maintenance programs, and optimizing maintenance processes to support overall business goals. By managing maintenance activities effectively, maintenance organizations play a critical role in maximizing asset performance, minimizing downtime and ensuring operational continuity.

The dynamic nature of the oil and gas industry requires companies to be agile and adaptive in facing increasingly complex business challenges. This has also been experienced by the Company. To become a larger, more agile, and stronger SOE in the energy sector, and to enhance efficiency and effectiveness, the Government of the Republic of Indonesia, through the Ministry of SOEs, established an Oil and Gas Holding Company in 2020, appointing PT. Pertamina (Persero) as the Holding Company.

The formation of the Holding Companies was followed by the appointment of Sub-Holding Companies in 2021, leading to a massive restructuring of the company's organizational structure, including at the operational unit level. The placement of personnel within this new organizational structure is centrally managed by the Sub-Holding Companies.

Because the formation of this organization was carried out top-down by the Sub-Holding Companies without considering the specific needs of each operating unit, it is necessary to review and evaluate the suitability of the organization in relation to the operational needs of each unit. This is particularly important for the maintenance function, as its effectiveness and efficiency are crucial for overall performance. The results of this evaluation can then be used as a basis for proposing changes or adjustments to the organizational structure.

Positions in this newly restructured organization are designated exclusively for employees directly hired by the Company, while outsourced workers are not included in this restructuring. To enhance the efficiency of work coordination with outsourced personnel, it is necessary to extend the organizational structure to include the smallest maintenance teams, incorporating outsourced workers into this structure.

Haroun & Duffuaa (2009) identified three essential elements in designing a maintenance organization: maintenance capacity, the balance between centralization and decentralization, and the decision of whether to handle maintenance in-house or outsource it. Various criteria can guide the design process, including delineating clear roles and responsibilities, establishing an appropriate span of control, enabling effective supervision and reporting mechanisms, and minimizing costs. Adhering to these criteria helps create an efficient maintenance organization that effectively supports the overall maintenance management function.

1) Maintenance Capacity Planning

Maintenance capacity planning is a critical process aimed at identifying the resources necessary for efficient maintenance operations, encompassing equipment, administration, tools, and space needed to fulfill maintenance department objectives. Central to this endeavor is the assessment of the workforce's number and skill sets required to manage the maintenance workload effectively. Al-Fares & Duffuaa (2009) outline three fundamental steps in this planning process. Firstly, there's the estimation or forecasting of the total maintenance capacity needed for each designated time period, accounting for varying workloads. Secondly, it involves determining the available maintenance capacity of each resource, such as employees, contract workers, regular time, and overtime, for the same time periods. Finally, the process entails allocating the appropriate level of each maintenance resource to fulfill the maintenance workload requirements for each period effectively. By following these steps, organizations can strategically align their resources with maintenance demands, ensuring smooth operations and the achievement of departmental objectives.

a) *Maintenance Load Forecasting*

Maintenance load forecasting is a crucial element of maintenance planning, involving the anticipation of both the volume and nature of maintenance activities within a specified timeframe. Accurate estimation of maintenance loads enables organizations to efficiently allocate resources, plan schedules, and optimize maintenance operations. Various methods, including historical data analysis, predictive modeling, and expert judgment, can be employed to estimate maintenance burdens, considering factors such as equipment usage patterns, past maintenance records, environmental conditions, and production schedules. The overarching objective is to proactively address maintenance needs, minimize unplanned downtime, and ensure the smooth operation of equipment and facilities. Regular review and refinement of forecasting techniques are essential to adapt to evolving operational conditions and optimize maintenance strategies over time.

Forecasting methods are typically classified into two primary types: qualitative and quantitative. Qualitative approaches, also referred to as subjective techniques, are utilized in the absence of historical data, such as for new machines or products, relying on personal expertise or expert judgment. In contrast, quantitative methods, or objective techniques, utilize existing numerical data, leveraging mathematical and statistical methodologies, particularly for established machines and products. In this research, maintenance load forecasting is carried out using quantitative methods.

Maintenance activities are further delineated based on implementation time into planned maintenance and unplanned maintenance. Section 3.2.1. outlines the steps for preparing planned maintenance planning. The total number of ITPM task lists serves as the maintenance load data for planned maintenance activities.

Concurrently, the maintenance load for unplanned maintenance is estimated, drawing upon historical data from previous years, supplemented by personal expertise or expert judgment as needed. The amalgamation of maintenance loads for planned and unplanned maintenance forms the basis for forecasting maintenance load.

b) *Capacity Planning*

In capacity planning, determining the skills and number of workers needed to complete an ITPM task list is essential for ensuring the successful execution of maintenance activities. The process begins by evaluating the specific tasks outlined in the ITPM task list and identifying the skills and expertise required to perform them effectively. This may include technical competencies related to equipment operation, maintenance procedures, troubleshooting, and safety protocols.

Once the skill requirements are established, the next step is to determine the appropriate workforce size. This involves considering factors such as the complexity and duration of each task, the frequency of inspections or maintenance activities, and any potential constraints such as regulatory compliance or budgetary limitations.

By multiplying the skill requirements by the number of ITPM task lists scheduled within a designated time period, organizations can estimate the total workforce needed to complete the maintenance program. This calculation helps in ensuring that adequate resources are allocated to meet the maintenance workload and achieve organizational objectives efficiently.

Furthermore, capacity planning also involves considering factors such as workforce availability, scheduling constraints, and the potential for overlapping tasks or multitasking to optimize resource utilization. Regular review and adjustment of workforce allocation based on evolving maintenance needs and operational priorities are essential for effective capacity planning and maintenance management.

2) Balancing Centralization and Decentralization

Organizations can be categorized based on their authorization hierarchy into three main types: centralized, decentralized, or hybrid. In a centralized maintenance organization, all maintenance activities are managed and coordinated from a central location or department. This centralized structure allows for standardization of processes, centralized resource allocation, and better control over maintenance operations across multiple locations or facilities. Centralization often leads to economies of scale, improved coordination, and consistency in maintenance practices. However, it may also result in slower decision-making and reduced flexibility in responding to local needs or specific maintenance requirements at different sites.

Decentralized maintenance organization involves distributing maintenance responsibilities across various departments or locations within the organization. Each department or site may have its own maintenance team or resources, providing autonomy and flexibility in managing maintenance activities. Decentralization allows for faster decision-making, better alignment with local needs, and more tailored maintenance approaches based on site-specific requirements. However, it may lead to duplication of efforts, inconsistent maintenance practices, and challenges in coordinating maintenance activities across different locations.

A hybrid maintenance organization combines elements of both centralized and decentralized structures to leverage the benefits of each approach. In a hybrid model, certain maintenance functions or activities may be centralized for standardization and efficiency, while others are decentralized to ensure responsiveness to local needs and optimize resource allocation. For example, strategic planning and resource allocation may be centralized, while execution and implementation of maintenance activities are decentralized to individual departments or facilities. A hybrid approach allows organizations to balance the advantages of centralization and decentralization, adapting to varying needs and circumstances across different parts of the organization.

In Chapter 1, it was elaborated that the Company's operational area encompasses both offshore and onshore facilities. Given the considerable geographical distance between these two types of facilities, rapid deployment of workers for maintenance activities is impractical. Therefore, a hybrid organizational approach is deemed suitable.

Within a hybrid maintenance organization, there exists a blend of centralized and distributed elements. Certain maintenance activities necessitating standardization or the utilization of global resources are centrally managed. For instance, long-term maintenance planning or inventory management of spare parts are coordinated centrally.

Conversely, owing to the operational characteristics, particularly in offshore locations, rapid responsiveness to address issues is crucial. Consequently, the establishment of dedicated teams becomes imperative.

3) **In-house and/or Outsourcing Maintenance**

The decision to pursue in-house or outsourcing maintenance services is pivotal for companies, each avenue presenting distinct advantages and considerations. Opting for in-house maintenance offers the advantage of direct control over the entire maintenance process, from scheduling to execution, fostering a sense of ownership and accountability. Additionally, in-house teams can cultivate specialized expertise tailored to the company's unique equipment and operational demands, ensuring optimized performance and efficiency. Furthermore, the inherent flexibility of in-house teams allows for swift adaptation to evolving priorities and unforeseen maintenance exigencies. Conversely, outsourcing maintenance can yield significant cost savings by obviating the need for dedicated staff, training, and equipment investments. Moreover, outsourcing provides access to a breadth of specialized skills and expertise that may not be readily available in-house, enhancing the overall quality and effectiveness of maintenance operations. By outsourcing non-core activities such as maintenance, companies can reallocate resources and attention to their core competencies and strategic imperatives. Moreover, outsourcing may mitigate liability concerns, as the responsibility for compliance, safety, and regulatory adherence often lies with the outsourcing partner. Ultimately, the choice between in-house and outsourcing maintenance hinges on factors such as budget considerations, the complexity of maintenance needs, the availability of skilled labor, and the overarching strategic objectives of the organization. Many companies adopt a hybrid approach, leveraging both in-house and outsourcing solutions to capitalize on the respective strengths of each approach while mitigating potential drawbacks.

A thorough evaluation of company resources is key in determining an effective maintenance strategy. By understanding in detail, the availability of personnel, infrastructure, equipment, and financial allocations, companies can make informed decisions regarding which maintenance activities will be handled internally and which will be outsourced.

Evaluation of personnel is a crucial step in this process. An assessment of personnel capacity to handle the amount of maintenance load that has been forecasted will provide an idea of whether there is a shortage or surplus of workforce currently available. Apart from that, this evaluation will also identify whether the personnel's skills are capable of completing maintenance tasks. The results of this evaluation will be the basis for companies to make decisions regarding adding or reducing the number of workers, upgrading worker qualifications, or determining which jobs will be outsourced.

Likewise, with the evaluation of existing infrastructure and equipment, the output of this evaluation can provide an idea for the company. It can determine whether it is more efficient to invest in new infrastructure and equipment compared to the rental option, or full outsourced maintenance work.

4) Proposed Organization of Maintenance Functions

The authority or approval for changes to the Company's organizational structure, including the organization of the maintenance team at NSO, rests with the SHU Company. However, NSO Field can play a role as a proposer in proposing changes or reviewing the organizational structure, which can be done at most once a year. Each proposal process should include a comprehensive business overview, outlining the strategic intent behind the proposed change and detailing the anticipated impact on activities within the proposer's function. These requirements ensure that proposed modifications are assessed thoroughly and aligned with the organization's broader strategic objectives. Additionally, the inclusion of a business overview helps evaluate the potential implications of proposed changes to the overall operations and effectiveness of the maintenance function, thereby encouraging decision making and accountability.

Based on the analysis of the existing maintenance organization, the following can be used as a basis for proposing changes to the maintenance function organization:

a) As previously explained, the geographical location of the work areas of onshore facilities and offshore facilities are far apart, as well as the limited capacity of people on board (POB) in offshore facilities which does not allow the placement of large numbers of personnel according to the type of expertise available, then the type The organization that is suitable for use is the hybrid type. This type of organizational approach allows for a balance between centralized control and decentralized decision making. In this model, certain functions or processes that require centralized standardization, coordination, and oversight, such as planning, policy, and resource allocation, can be managed centrally. However, given the unique operational requirements and constraints that offshore facilities have, certain decision-making authority and operational autonomy may be delegated to decentralized units or teams located on site. These decentralized units are empowered to make day-to-day operational decisions, address urgent issues, and adapt quickly to local conditions, thereby increasing responsiveness and agility in offshore operations.

b) The company's maintenance team is organized into several divisions based on discipline groups, including mechanics (rotating and static), electrical, and instrumentation. However, currently there is no specific subdivision in the maintenance team structure for civil and structural disciplines. Considering that the equipment being managed is old and requires special maintenance attention, there is an urgent need to establish a division specifically tasked with maintaining buildings and structures. This addition will increase responsibility and accountability for infrastructure-related maintenance activities, ensuring comprehensive care and maintenance of company facilities.

c) Establishing a dedicated division dedicated to equipment integrity management is critical to consistently and effectively navigating the complexities and demands of this critical process. The division will focus on developing a comprehensive strategy to ensure equipment integrity and reliability across the organization. Additionally, having a dedicated division allows for focused attention on equipment integrity, ensuring that it gets the necessary priority amidst other operational demands. This focus allows the division to establish standard protocols, guidelines and best practices for consistent implementation of equipment integrity management processes across the organization. Additionally, the division plays a critical role in managing risks associated with equipment failure by leading risk assessment efforts, developing mitigation strategies, and ensuring compliance with regulatory requirements. Additionally, the division fosters a culture of continuous improvement by conducting regular audits, performance reviews and learning exercises to identify areas for improvement and drive continuous improvement in equipment integrity management practices.

In summary, the proposed organizational structure mentioned above can be seen in Figure 3.12.

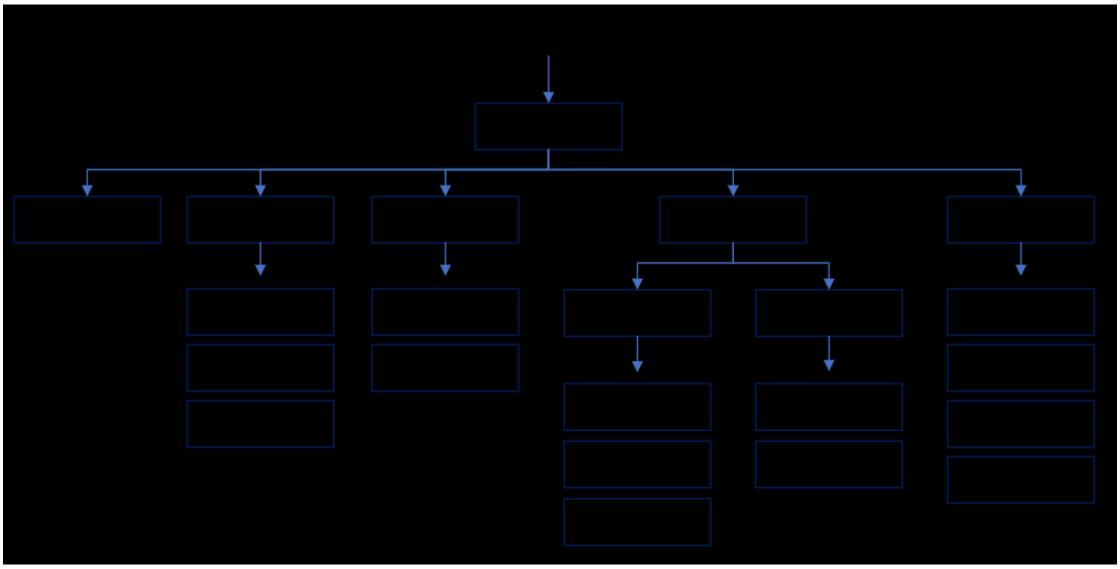


Figure 3.12. Proposed maintenance organization

3.2.3. Improving Workforces Skill

Improving workforce skills is a critical endeavor for organizations aiming to stay competitive and adaptable in today's dynamic business landscape. Employing a multifaceted approach, companies can enhance employee capabilities through various means. This includes implementing regular training and development programs tailored to upgrade technical proficiencies, soft skills, and industry-specific knowledge. Cross-training initiatives further bolster versatility among staff, fostering collaboration and teamwork. Supporting employees in obtaining relevant certifications or licenses adds formal recognition to their expertise, boosting confidence and credibility. Mentorship and coaching programs facilitate knowledge transfer and skill refinement, pairing experienced personnel with newer members to provide personalized guidance and career advancement opportunities. Investment in online learning platforms empowers self-directed learning, enabling access to a vast array of courses and resources at employees' convenience. On-the-job training, coupled with constructive feedback and performance reviews, allows for hands-on skill application and targeted development plans. Cultivating a culture of continuous learning encourages professional growth, with recognition and rewards for proactive skill enhancement. Additionally, fostering team collaboration and knowledge sharing ensures the dissemination of best practices and up-to-date industry insights. By staying abreast of industry trends and promoting ongoing skill enhancement initiatives, organizations can cultivate a workforce equipped with the diverse skill set necessary for sustained success.

Companies today face the ongoing challenge of developing the knowledge and skills of their workforce to remain competitive and innovative. This challenge is addressed through various methods, each with distinct advantages and limitations. Face-to-face learning includes in-house training tailored to the company's needs and organized by the HR Service function. It offers a controlled environment where training aligns closely with the company's strategic goals. Internal trainers familiar with the company's culture and processes often facilitate these sessions, though external experts can be brought in to provide specialized knowledge and fresh perspectives. The primary advantage of in-house training is its customization and relevance to specific company challenges. Public training, on the other hand, involves enrolling employees in courses organized by third parties. These sessions cover general content relevant to specific industries or scientific disciplines and can be conducted both domestically and internationally. The benefit of public training lies in its exposure to diverse practices and new insights that can be brought back to the company, though its general nature may limit its immediate applicability.

Digital learning, or e-learning, has become increasingly popular due to its flexibility and accessibility. Companies deploy Learning Management Systems (LMS) that host various learning modules, accessible anytime and anywhere, allowing employees to learn at their own pace and according to their schedules. E-learning is particularly effective for dispersed workforces, enabling consistent training delivery across different locations. The asynchronous nature of e-learning also supports continuous learning and skill development, as employees can revisit materials as needed. Companies also manage and leverage their internal knowledge assets, including employees' abilities, skills, and experiences. Effective knowledge management ensures that valuable insights and expertise are systematically captured and disseminated throughout the organization, building a robust organizational memory that facilitates problem-solving, innovation, and strategic decision-making.

To enhance knowledge sharing and collaboration, companies often establish Communities of Practice (CoPs), which bring together practitioners and experts with common interests in specific topics or areas of critical knowledge. These communities provide a platform for members to exchange ideas, discuss challenges, and develop best practices, fostering a culture of continuous learning and collective intelligence that drives improvements and innovation across the organization. To reach all employees, especially those spread across multiple locations, companies facilitate online knowledge-sharing sessions using various digital tools and platforms, such as webinars, video conferences, and collaborative software.

Online knowledge sharing ensures that all employees have equal access to critical information and can contribute to discussions regardless of their geographical location, promoting inclusivity and ensuring that the entire workforce benefits from shared knowledge and experiences.

For maximum effectiveness, companies need to integrate their learning and knowledge management initiatives. By aligning training programs with knowledge management strategies, companies can ensure that newly acquired skills and insights are systematically captured and shared, creating a learning organization where continuous improvement and innovation are embedded in the company's culture. To gauge the effectiveness of these initiatives, companies should implement robust metrics and evaluation frameworks, identifying areas of improvement and ensuring alignment with strategic objectives. Feedback loops and continuous improvement mechanisms are essential for refining these programs and maximizing their impact. In conclusion, the dynamic nature of modern industries necessitates a comprehensive approach to workforce development. By leveraging a combination of face-to-face learning, e-learning, and knowledge management, companies can build a skilled and knowledgeable workforce capable of navigating complex business challenges. The integration of these approaches, supported by effective evaluation and continuous improvement, ensures that companies remain agile, innovative, and competitive in the global marketplace.

Mapping and planning learning needs for the maintenance function is a comprehensive and strategic process aimed at ensuring that maintenance personnel are equipped with the necessary skills, knowledge, and competencies to effectively maintain equipment and infrastructure. This process begins with the alignment of organizational goals, where the strategic objectives and KPIs of the organization are clearly understood, particularly those related to maintenance, such as minimizing downtime, enhancing equipment reliability, reducing maintenance costs, and ensuring safety compliance. Once these goals are identified, specific maintenance objectives are defined to support these broader aims, focusing on targets such as mean time between failures (MTBF), mean time to repair (MTTR), and overall equipment effectiveness (OEE).

Next, a thorough skills gap analysis is conducted. This involves a detailed job analysis to document the roles and responsibilities of each maintenance position, followed by competency mapping to identify the technical and soft skills required for each role. The current skill levels of the maintenance team are then assessed through performance reviews, skill assessments, and feedback from supervisors. This step helps in identifying the gaps between the existing competencies and those required to meet the maintenance objectives.

Data collection and analysis play a crucial role in this process. Employee surveys are conducted to gather input from maintenance personnel about their training needs and areas where they feel less confident. Interviews with maintenance managers and supervisors provide additional insights into the team's strengths, weaknesses, and training requirements. Data from the Learning Management System (LMS) is also analyzed to identify patterns in training completion rates, performance on assessments, and areas where additional training is needed.

Prioritizing learning needs involves identifying the most critical skills that have the highest impact on performance and determining the availability of resources such as budget, time, and trainers. Once priorities are set, a detailed learning and development plan is created. This plan includes defining clear, measurable objectives for each training program, selecting appropriate training methods (such as in-house training, public training, e-learning, or on-the-job training), and developing comprehensive training curricula, materials, and assessment tools.

Implementation involves effective communication of the training plan to all stakeholders, ensuring that maintenance personnel understand the objectives, schedule, and expectations. Training sessions are strategically scheduled to minimize disruption to maintenance operations, and necessary resources, including training facilities and materials, are allocated. The effectiveness of training programs is then evaluated through feedback, assessments, and performance metrics, with continuous improvement efforts ensuring that training remains relevant and effective.

Finally, staying informed about industry trends, technological advancements, and best practices in maintenance ensures that training programs are current and effective. Regular reviews of the entire training and development strategy help ensure alignment with changing organizational goals and maintenance challenges, thereby continuously enhancing the skills and competencies of the maintenance workforce.

3.2.4. Strategic Partnership

Strategic partnerships in maintenance strategy involve collaborating with external entities to enhance operational efficiency, reduce costs, and improve service delivery. By forging alliances with maintenance service providers or specialized companies, organizations gain access to a broader range of expertise, experience, and innovative solutions. These partnerships often lead to cost savings through economies of scale, shared resources, and streamlined processes. Moreover, they offer flexibility and scalability, allowing organizations to adjust their maintenance operations according to fluctuating demand or evolving business needs. Collaborating with reliable partners also helps mitigate risks associated with maintenance operations, with service level agreements ensuring accountability and risk-sharing. Furthermore, strategic partnerships foster innovation and technology adoption, enabling organizations to stay at the forefront of industry trends. By focusing on core competencies and outsourcing non-core activities, companies can optimize resource allocation and free up internal teams for strategic initiatives. Enhanced collaboration and knowledge sharing with external partners drive continuous improvement and mutual benefit, ultimately helping organizations achieve their operational goals more efficiently and competitively.

Strategic partnerships for maintenance functions encompass collaborations in providing materials, goods, spare parts, or services related to maintenance activities. By forming alliances with dependable suppliers or manufacturers, organizations can secure favorable prices, streamline procurement processes, and ensure sufficient inventory levels to support maintenance operations effectively. These partnerships can vary in form based on the organization's needs and objectives. Here are several forms of strategic partnerships that can be implemented in the maintenance function:

1. Partnership with Suppliers or Manufacturers

   Partnerships with suppliers or manufacturers enable companies to secure timely and high-quality supplies of materials, parts, or equipment crucial for maintenance operations. By forging such partnerships, organizations can streamline their supply chains, mitigating the risk of delays or shortages. Moreover, these collaborations can lead to reduced inventory holding costs, as the responsibility for stock management can be transferred from the company's warehouse to that of the supplier or manufacturer. This arrangement not only ensures efficient inventory management but also fosters closer collaboration between the company and its suppliers, facilitating better coordination and communication throughout the supply chain. Overall, partnerships with suppliers or manufacturers contribute to smoother maintenance processes, improved resource utilization, and enhanced operational resilience.

2. Partnership with Service Providers

   Partnering with specialized service providers is a strategic move for organizations looking to enhance their maintenance activities, including equipment repairs, periodic inspections, and PM. These partnerships enable organizations to tap into the expertise and experience of service providers, leveraging their specialized skills and tools to improve maintenance efficiency and effectiveness. By outsourcing these tasks to trusted service providers, organizations can benefit from their in-depth knowledge and resources, ultimately leading to optimized maintenance processes and enhanced equipment reliability. Additionally, partnering with service providers allows organizations to focus their internal resources on core business activities, while still ensuring that maintenance needs are met with high quality and professionalism. Overall, such partnerships contribute to smoother operations, reduced downtime, and increased overall productivity.

3. Partnerships between Divisions or Business Units

   Partnerships between divisions or business units within large or diversified organizations are instrumental in sharing resources, knowledge, and best practices in maintenance. By fostering such partnerships, organizations facilitate better coordination among different parts of the company and promote the optimized use of resources. Collaboration between divisions or business units enables the pooling of expertise, experience, and resources related to maintenance activities. This sharing of knowledge and resources allows for more efficient problem-solving, improved decision-making, and enhanced overall maintenance effectiveness. Additionally, partnerships between divisions or business units create opportunities for standardization of maintenance practices and processes across the organization, leading to greater consistency and reliability in maintenance operations. Overall, these partnerships contribute to a culture of collaboration, continuous improvement, and operational excellence within the organization.

4. Partnership with External Parties

   Partnering with external parties, such as other companies in the same industry or research and development institutions, is a strategic move for organizations looking to enhance their maintenance capabilities. These partnerships open doors to new innovations, facilitate knowledge exchange, and provide access to the latest technology in maintenance. By collaborating with external parties, organizations can leverage their expertise, resources, and networks to drive innovation and improve maintenance practices. These partnerships may involve joint research and development projects, technology transfer agreements, or collaborative initiatives aimed at addressing common challenges or pursuing shared opportunities. Overall, partnering with external parties enhances organizations' ability to stay competitive, adapt to technological advancements, and achieve their strategic objectives in maintenance.

5. Partnership with Contractors or Subcontractors

   Partnering with contractors or subcontractors is a valuable strategy for organizations undertaking complex or large-scale maintenance projects. These partnerships enable organizations to leverage external expertise and capacity to support the implementation of specific tasks. By engaging contractors or subcontractors, organizations can access specialized skills, resources, and knowledge that may not be readily available internally. This collaboration allows for the efficient execution of maintenance activities, particularly in situations where the organization lacks the necessary expertise or manpower to handle certain tasks independently. Additionally, partnering with contractors or subcontractors can help organizations manage project timelines, mitigate risks, and ensure the successful completion of maintenance projects within budget constraints. Overall, these partnerships contribute to the overall effectiveness and efficiency of maintenance operations, enabling organizations to achieve their maintenance objectives more effectively.

Several forms of strategic partnerships that can be applied in the Company both in carrying out maintenance activities and to support maintenance programs.

1. Joint Procurement Between KKKS

   Collaborative procurement among oil and gas contractors (KKKS) operating under the oversight of SKK Migas presents a strategic avenue for optimizing the acquisition of essential goods and services required for maintenance operations. Guided by the Work Guidelines for Procurement of Goods/Services by SKK Migas, this approach encourages multiple KKKS to engage in joint procurement processes, yielding several significant advantages. Firstly, it promotes efficiency and cost reduction by consolidating demand and enabling collective negotiation, thereby securing more favorable terms and competitive prices. This collaborative effort not only lowers overall procurement expenses but also ensures that each participating KKKS receives standardized supplies, fostering compatibility and streamlining maintenance procedures. Moreover, by centralizing procurement through a single provider, relationships with suppliers are strengthened, potentially leading to enhanced service levels and innovative solutions tailored to the collective needs of the KKKS. Additionally, the distribution of risk among participating companies safeguards against supply chain disruptions and price fluctuations, bolstering the resilience of operations. Furthermore, the pooled purchasing power of the KKKS enables them to achieve economies of scale, driving operational efficiencies and cost savings that might be unattainable through individual endeavors. In essence, the joint procurement strategy advocated by SKK Migas not only optimizes cost-effectiveness and operational efficiency but also promotes standardization, strengthens supplier relationships, and mitigates risks, thereby facilitating smoother and more effective maintenance activities across the oil and gas sector.

2. Partnership with SOEs or affiliated companies with SOEs

   Partnering with SOE or affiliated companies is a pivotal strategy to bolster the performance and impact of SOEs towards national development in Indonesia. The Ministry of SOE's Sinergi SOE program aims to harness the potential for collaboration among these entities, encompassing consolidation, alliance, collaboration, and transactional partnerships. Consolidation involves the merger or formation of holding companies to strengthen capital structures and enhance operational efficiency. Alliances enable SOEs to pool resources through joint ventures for specific projects, while collaborations entail contractual cooperation to optimize business activities and expand market reach. Additionally, transactional partnerships facilitate efficient procurement of goods and services necessary for business operations. With a portfolio of 44 companies managed by the Ministry, there exists substantial potential for mutually beneficial collaborations, especially when involving affiliated firms. For instance, in sectors like oil and gas and steel, SOEs can leverage each other's products and services, such as using steel products from PT. Krakatau Steel for infrastructure needs. In addition, special services such as inspections offered by PT. Biro Klasifikasi Indonesia can increase the Company's operational efficiency in carrying out PdM programs. These collaborative efforts underscore SOEs' role as key drivers of sustainable development, fostering economic growth and resilience across various sectors in Indonesia.

3. Partnerships between Subsidiaries or with Affiliated Companies with Holding/Sub Holding Companies

   Partnerships between subsidiaries or affiliated companies within holding or sub-holding structures are pivotal for enhancing operational efficiency, optimizing resource allocation, and ensuring strategic alignment within a corporate conglomerate. These collaborations capitalize on the inherent synergies between different entities, fostering a shared sense of purpose and facilitating the achievement of mutual objectives. Through such partnerships, subsidiaries can leverage each other's strengths and resources, leading to streamlined operations and improved performance across the board. For instance, manufacturing subsidiaries may collaborate with distribution counterparts to streamline supply chain processes and enhance customer service. Additionally, partnerships enable subsidiaries to access specialized resources or expertise that may not be readily available internally, thereby fostering innovation and driving growth opportunities. Strategic alignment is also reinforced through collaborative initiatives, ensuring that all entities work cohesively towards overarching corporate goals. Moreover, partnerships within holding structures facilitate effective risk management by diversifying exposures and sharing liabilities among affiliated entities. This collaborative approach, facilitated by clear governance structures and performance metrics, ultimately drives collective success and creates sustainable value for the entire corporate group and its stakeholders.

[redacted] IMPLEMENTATION PLAN

After formulating alternative strategies, the next step is to develop an implementation plan for the strategy. This implementation plan outlines the specific actions, steps, and initiatives required to effectively implement the chosen strategy. In this plan, the action plan details specific tasks, responsibilities, and timelines for each initiative. Additionally, a timeline is established to provide a clear implementation roadmap, indicating when each action or milestone is expected to be completed. This timeline serves as a guide to ensure that implementation runs according to the established schedule. By formulating a detailed implementation plan, complete with action plans and timelines, organizations can effectively translate strategic objectives into actionable steps and achieve desired results.

4.1. Implementation Plan

1) Managing maintenance management based on risk analysis using CMMS:
   a) Update equipment register in SAP-PM

      Begin by creating comprehensive equipment registers within the CMMS. This involves inputting detailed information about each piece of equipment, including its specifications, maintenance history, and location. Ensure that the equipment registers are regularly updated to reflect any changes or additions to the asset inventory.
   b) Perform equipment criticality ranking

      Prioritize equipment based on criticality to operations. Utilize CMMS functionalities to assign criticality levels to each piece of equipment. Factors to consider may include the equipment's impact on production, safety implications, regulatory requirements, and downtime costs. Criticality rankings help focus maintenance efforts on the most essential assets.
   c) Conduct equipment risk analysis

      Utilize the CMMS to perform risk analysis for each critical piece of equipment. Identify potential failure modes, their consequences, and the likelihood of occurrence. Incorporate historical maintenance data, failure patterns, and industry best practices into the risk analysis process. This step helps identify high-risk assets that require proactive maintenance interventions.

d) Develop ITPM task lists

Based on the criticality ranking and risk analysis results, develop inspection, testing, and PM task lists for each piece of equipment. Leverage the CMMS to create detailed task lists, including frequency, procedures, and required resources. Align maintenance activities with identified risks and criticality levels to prioritize resources effectively.

e) Integrate risk-based maintenance strategies

Implement risk-based maintenance strategies within the CMMS to optimize maintenance scheduling and resource allocation. Utilize condition-based monitoring techniques, PdM algorithms, and RCM principles to enhance asset reliability and performance. Continuously monitor equipment health and adjust maintenance plans based on real-time data and evolving risk profiles.

f) Regular review and optimization

Periodically review and optimize the maintenance management processes based on performance feedback, reliability data, and changes in operational requirements. Use the CMMS to track KPIs, such as mean time between failures (MTBF), mean time to repair (MTTR), and overall equipment effectiveness (OEE). Continuously refine maintenance strategies to minimize risks, maximize asset uptime, and optimize maintenance costs.

2) Improving maintenance excellence organization

a) Conduct maintenance load forecasting

This involves predicting future maintenance requirements based on historical data, current operational conditions, and expected equipment performance. Accurate forecasting helps ensure that maintenance resources are allocated efficiently and downtime is minimized.

b) Analyze capacity planning

This step involves assessing the current capacity of maintenance teams and resources to handle the forecasted load. It includes evaluating the availability of skilled personnel, tools, and equipment to meet the maintenance demands. Proper capacity planning ensures that the organization can handle both routine maintenance and unexpected repairs without overburdening the workforce.

c) Decide on the structure of its maintenance operations—whether to adopt a centralized, decentralized, or hybrid approach.

A hybrid maintenance organization approach is the optimal solution for operational areas divided between offshore and onshore. In this approach, the offshore facilities have basic maintenance teams in place to handle routine tasks, while expert teams or other supporting teams are pooled into onshore teams that can be deployed to offshore facilities as needed to address complex issues. This overcomes the limitation on the number of personnel that can be stationed on offshore platforms and allows for more flexible and efficient resource allocation. Consequently, companies can improve maintenance responsiveness and effectiveness, ensure the availability of the right expertise at the required locations, and optimize operational costs.

d) Identify work carried out in-house or outsourced

By analyzing maintenance load estimates and capacity planning, companies can effectively decide which tasks should be managed internally and which should be outsourced. In-house maintenance includes routine and predictable tasks that can be efficiently handled by the internal team. Conversely, outsourced maintenance covers specialized tasks that demand skills or equipment not readily available within the company, or routine tasks during peak periods when the workload exceeds internal capacities. This approach ensures that resources are optimally allocated, enhancing operational efficiency while maintaining flexibility to address varying maintenance demands.

e) Identify workforce fulfillment

To ensure workforce alignment with the developed ITPM task list, it is crucial to conduct a comprehensive assessment of both quantity and qualifications of the existing workforce. Begin by evaluating the number of personnel available compared to the tasks outlined in the ITPM list, ensuring adequate resources to meet workload demands. Simultaneously, assess the qualifications, skills, and experience of each team member to ensure their suitability for the specified tasks.

Once the capability assessment is complete, develop a strategic plan to address identified gaps. This plan should encompass two primary approaches: outsourced and training. Determine if additional personnel are needed to bolster the workforce or fill specific skill gaps. At the same time, implement targeted training and development programs to enhance the qualifications of existing employees, ensuring they have the necessary skills to effectively carry out the tasks outlined in the ITPM list.

3) Improving Workforces Skill
   a) Develop skill matrix for updated ITPM Tasklist.
      This matrix should map out the required skills and competencies for each maintenance task, with a particular emphasis on fulfilling work safety and regulatory requirements. By clearly defining the skills needed for each task, the organization can identify gaps in the current workforce and target specific areas for improvement.
   b) Submit the training list to functional human resources to ensure compliance.
      This list should include detailed training programs designed to address the identified skill gaps and ensure that all maintenance personnel are equipped with the necessary knowledge and competencies. The training programs should also emphasize safety practices and regulatory compliance to minimize risks and adhere to industry standards. By collaborating with the human resources department, the organization can ensure that the training programs are effectively implemented and that all employees receive the necessary training to perform their tasks safely and efficiently.
   c) Collaborating with the HR function for carrying out effective in-house training or e-learning.
      By working together, the maintenance and HR departments can develop comprehensive training modules tailored to the specific needs of the maintenance workforce. These modules can be uploaded to the Learning Management System (LMS), allowing employees to access training materials conveniently and at their own pace. The LMS can track progress and completion rates, ensuring that all personnel are up-to-date with the required skills and knowledge.
4) Develop Strategic Partnership
   a) Identify contracts that can be jointly procured with other business units in the same Zone or under the same Regional Company or SHU Company.
      This process involves conducting a comprehensive inventory assessment across all business units to identify common goods and services that are regularly procured, such as maintenance services and spare parts. A detailed spend analysis helps pinpoint high-value contracts and categories where joint procurement can yield significant savings. Engaging with procurement managers and key stakeholders from other business units ensures a thorough understanding of procurement needs and constraints, facilitating communication and collaboration. Identifying potential suppliers who can meet the collective needs of multiple business units and reviewing

existing contracts for consolidation opportunities are essential steps. The development of a joint procurement strategy will outline the objectives, benefits, and implementation plan, with clearly defined roles and responsibilities for each business unit involved.

b) Coordinate with PGE and Medco E&P Malaka to examine joint procurement opportunities.

The Company, PGE, and Medco E&P Malaka are all KKKS entities located in close proximity to each other. These three companies share a similar history, having managed termination blocks previously overseen by EMOI. This shared background potentially leads to similarities in processes, technology, and types of equipment owned by each company. Furthermore, these KKKS entities adopt the same procurement guidelines regulated by SKK Migas. As outlined in these guidelines, it is possible to carry out joint procurement between two or more KKKS. By exploring joint procurement opportunities, the companies can leverage their similarities to achieve cost efficiencies, streamline procurement processes, and enhance operational synergy. This collaboration could lead to more competitive pricing, shared expertise, and an overall improvement in procurement practices, benefiting all parties involved. Forming a joint procurement committee with representatives from each company will provide oversight for the entire process, from planning to execution. This committee will conduct market analysis to identify suitable suppliers capable of meeting the combined needs, aiming to negotiate better terms through economies of scale. Collaborative efforts will be made to develop detailed procurement specifications that cater to all three companies, followed by issuing a joint tender to solicit bids from suppliers. The joint procurement committee will evaluate the bids based on cost, quality, and delivery timelines, leading to joint negotiations to finalize favorable contract terms. Once contracts are awarded, the implementation phase will be closely monitored to ensure timely delivery and adherence to terms. Regular feedback from all stakeholders, including procurement teams, end-users, and suppliers, will be collected to refine the strategy and drive continuous improvement. This coordinated approach not only aligns with SKK Migas guidelines but also fosters a strategic partnership among the companies, resulting in cost savings, improved efficiency, and enhanced collaboration for long-term benefits.

c) Identify the capabilities of SOEs and their affiliates for outsourced work

This involves assessing their expertise, resources, and past performance. Engaging with these companies through formal meetings and site visits will help explore potential outsourcing opportunities. Establishing partnerships based on proven capabilities can lead to cost efficiencies, enhanced operational synergy, and improved service quality. Formal agreements should define the scope of work and performance metrics, ensuring accountability and fostering a collaborative environment for long-term benefits.

In summary, the targets of each implementation plan described above can be seen in Table 4.1 below.

Table 4.1. Milestone for implementation plan

No.	Implementation Plan	Milestone
1	**Managing maintenance management based on risk analysis using CMMS**	
1.1	Update equipment register in SAP-PM	Asset register updated
1.2	Perform equipment criticality ranking	ECR updated
1.3	Conduct equipment risk analysis	Equipment risk analysis updated
1.4	Develop ITPM task lists	ITPM tasklist for each
1.5	Integrate risk-based maintenance strategies	WO for PM, PdM, PxM
1.6	Regular review and optimization	Evaluate MTBF, MTTR, OEE
2	**Implementation plan for improving maintenance excellence organization**	
2.1	Conduct maintenance load forecasting	Maintenance load list
2.2	Analyze capacity planning	Workload and team matrix
2.3	Decide on the structure of its maintenance operations—whether to adopt a centralized, decentralized, or hybrid approach	Update Workload and team matrix
2.4	Identify work carried out in-house or outsourced	Update Workload and team matrix
2.5	Identify workforce fulfillment	List outsourced job
3	**Improving Workforces Skill**	
3.1	Develop skill matrix for updated ITPM Tasklist.	Qualitification Matrix
3.2	Submit the training list to functional human resources to ensure compliance.	Training request
3.3	Collaborating with the HR function for carrying out effective in-house training or e-learning.	LMS training modules
4	**Develop Strategic Partnership**	

No.	Implementation Plan	Milestone
4.1	Identify contracts that can be jointly procured with other business units in the same Zone or under the same Regional Company or SHU Company.	Update list of Maintenance Contract Planning
4.2	Coordinate with PGE and Medco E&P Malaka to examine joint procurement opportunities.	Update list of Maintenance Contract Planning
4.3	Identify the capabilities of SOEs and their affiliates for outsourced work	Update list of Maintenance Contract Planning

4.2. Time Schedule

After determining the implementation plan, which includes milestones for each program, it's essential to establish a timeline table for implementation. Table 4.2 illustrates the timeline for various programs, indicating the status of each. Some programs are already underway, while others will commence according to the outlined schedule.

Table 4.2. Proposed time schedule of implementation plan

No.	Implementation Plan	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
1	**Managing maintenance management based on risk analysis using CMMS**												
1.1	Update equipment register in SAP-PM												
1.2	Perform equipment criticality ranking												
1.3	Conduct equipment risk analysis												
1.4	Develop ITPM task lists												
1.5	Integrate risk-based maintenance strategies												
1.6	Regular review and optimization												
2	**Implementation plan for improving maintenance excellence organization**												
2.1	Conduct maintenance load forecasting												
2.2	Analyze capacity planning												
2.3	Decide on the structure of its maintenance operations—whether to adopt a centralized, decentralized, or hybrid approach												
2.4	Identify work carried out in-house or outsourced												
2.5	Identify workforce fulfillment												
3	**Improving Workforces Skill**												
3.1	Develop skill matrix for updated ITPM Tasklist.												
3.2	Submit the training list to functional human resources to ensure compliance.												
3.3	Collaborating with the HR function for carrying out effective in-house training or e-learning.												
4	**Develop Strategic Partnership**												
4.1	Identify contracts that can be jointly procured with other business units in the same Zone or under the same Regional Company or SHU Company.												
4.2	Coordinate with PGE and Medco E&P Malaka to examine joint procurement opportunities.												
4.3	Identify the capabilities of SOEs and their affiliates for outsourced work												

4.3. Conclusion

This research aimed to formulate a functional maintenance strategy to transform maintenance management from merely a cost object into a source of profit. The focus was on optimizing maintenance management to reduce maintenance costs while maintaining the reliability and availability of equipment, thereby reducing lost production opportunities. The solution search process was conducted through a SWOT analysis, which was then transformed into a TOWS matrix. From this analysis, four main solutions were identified.

The first solution involves risk-based maintenance management using a CMMS. This includes compiling an equipment register, ranking equipment criticality, conducting equipment risk analysis, developing ITPM task lists, integrating risk-based maintenance strategies, and performing regular reviews and optimizations. This proactive approach allows the company to continuously identify and manage risks associated with equipment, enabling ongoing adjustments based on data from the CMMS.

The second solution is an implementation plan to enhance maintenance excellence within the organization. This plan encompasses maintenance load forecasting, capacity planning analysis, choosing between centralization, decentralization, or hybrid approaches, identifying work performed in-house or outsourced, and fulfilling workforce requirements. By applying continuous improvement principles, the company can continuously evaluate and adjust this implementation plan to consistently meet dynamic operational needs.

The third solution focuses on improving workforce skills through the development of a skills matrix for the updated ITPM task list, emphasizing safety and regulatory compliance. This includes submitting training lists to human resources to ensure compliance. The training and skill development process should be ongoing, with regular evaluations of training effectiveness and program adjustments based on feedback and changing regulatory or technological requirements.

The fourth solution is developing strategic partnerships. This involves identifying contracts that can be jointly procured with other business units within the same zone, region, or sub-holding, coordinating with PGE as the KKKS to explore joint procurement opportunities, and identifying the capabilities of SOEs and their affiliates for outsourced work. Applying continuous improvement principles through regular reviews of these partnerships ensures they remain beneficial and aligned with the company's strategic objectives.

In summary, this strategy is designed to enhance the efficiency and effectiveness of maintenance management through a structured, risk-oriented approach, thorough planning, workforce skill development, and strategic collaboration. Consequently, the company is expected to transform maintenance management into a sustainable source of profit.

Given the highly dynamic nature of the corporation's industry, the company must adapt its maintenance management strategies. Similarly, the proposed solutions require regular reviews. This approach aligns with an asset integrity management system based on continuous improvement using the principles of plan, do, check, and action. This cycle of continuous improvement ensures that maintenance strategies are always optimal and capable of addressing evolving challenges. Therefore, maintenance management becomes not only a source of profit but also a crucial pillar in the company's operational sustainability.

4.4. Recommendation

This research outlines four strategies, each with a specific action plan, to improve the company's maintenance management. At the time of this report, the implementation of these plans was still ongoing, and the effectiveness of the strategies had not yet been measured. To ensure successful implementation and evaluation, the following recommendations are made:

1. Ensure Complete Implementation: Guarantee that the implementation of the plans is executed fully and reaches the final stage. This involves consistent monitoring, adherence to the proposed action steps, and addressing any obstacles that arise during the process.
2. Evaluate Effectiveness: Conduct thorough evaluations of the effectiveness of each strategy. These measurements can serve as a basis for continuous improvement.

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APPENDIX

Appendix 1. List of Universities in Lhokseumawe City, Prov. Aceh

(Source: Pusdatin Kemendikbudristek (2023))

NPSN	School Name	Address	District	Status
10107570	Darussalam Midwifery Academy	Jalan Iskandar Muda No 24	Blang Mangat District	Private
10107571	National Banking Finance Academy	Jalan Merdeka Timur No 135 A Cunda	Blang Mangat District	Private
10107572	Tanah Rencong Secretarial Management Academy	Jalan Teuku Maharaja No 16 Mon Geudong	Blang Mangat District	Private
10107573	Lhokseumawe State Polytechnic	Jalan Medan-Banda Aceh Km 280 Buketrata-Kota Lhokseumawe	Blang Mangat District	Public
10107574	National School of Administrative Sciences	Jalan Merdeka Barat No 01 Kuta Blang Lhokseumawe	Banda Sakti District	Private
10107575	Lhokseumawe School of Economics	Jalan Merdeka Barat No. I B Kuta Blang Lhokseumawe	Blang Mangat District	Private
10107576	STIE Bumi Persada Lhokseumawe	Jalan Banda Aceh Medan No. 59 Alue Awe Lhokseumawe - Aceh	Muara Dua District	Private
10107577	Darussalam Health Sciences Academy	Jalan Sultan Iskandar Muda No. 24F Lhokseumawe	Blang Mangat District	Private
10107578	Bina Bangsa Information Management Academy	Jalan Merdeka Timur No 92	Blang Mangat District	Private
70016554	Kesdam Iskandar Muda Nursing Academy Lhokseumawe	Jalan Alkalali No.9 Hagu Selatan Lhokseumawe	Blang Mangat District	Private
70018043	Lhokseumawe State Islamic Institute	-	Blang Mangat District	Public
70019776	Darussalam Qur'anic Sciences Academy Lhokseumawe	Jalan Iskandar Muda No. 24 F Kampung Jawa Lama Kota Lhokseumawe	Blang Mangat District	Private
70019939	Al-Banna Law Academy	-	Blang Mangat District	Private
70021160	Malikussaleh State Islamic College	Jalan Medan-Banda Aceh Km. 275 No.1, Buket Rata, Lhokseumawe, Aceh	Blang Mangat District	Public
70021319	Bumi Persada Health Sciences Academy Lhokseumawe	Jalan Banda Aceh-Medan Sp. Jalan Elak Alue Awe Lhokseumawe - Aceh	Muara Dua District	Private
70021374	Muhammadiyah Health Sciences Academy Lhokseumawe	Jalan Darussalam No 47	Blang Mangat District	Private
70021512	Darussalam Islamic Teaching Academy Lhokseumawe	Jalan Sultan Iskandar Muda No. 24 F, Kota Lhokseumawe - Aceh	Blang Mangat District	Private
70021604	Bumi Persada Teacher Training College Lhokseumawe	Jalan Medan Banda Aceh No. 59 Desa Alue Awe Kota Lhokseumawe - Aceh	Muara Dua District	Private

Appendix 2. Equipment Risk Assessment Matrix

Consequence of Failure				Level	Probability of Failure				
					1	**2**	**3**	**4**	**5**
People	**Environtment**	**Assets (cost)**	**Reputation**		**Almost impossible to occur**	**Rarely occurs**	**Could happen**	**Very likely to happen**	**Almost certain to happen**
Fatality	Environmental damage in sensitive areas or oil spills of more than 100 barrels	Big loss (greater than US$ 1,000,000)	National impact	5 Very High					
Permanent Total Disability (PTD) or Lost Time Injury (LTI)	Oil spill reaches a sensitive area or oil spill is more than 15 barrels and less than 100 barrels	Large loss (greater than or equal to US$ 100,000 and less than US$ 1,000,000)	Provincial impact	4 High					
Restricted Work Case (RWC)	Environmental damage occurs in the company area or an oil spill is greater than 10 barrels and less than 15 barrels	Medium loss (greater than US$ 10,000 and less than US$ 100,000)	Local impact (municipality/ district)	3 Medium					
Medical Treatment Case (MTC)	Oil spill occurred in the company area or oil spill was greater than 1 barrel and less than 10 barrels	Small loss (greater than or equal to US$ 1,000 and less than US$ 10,000)	Internal impact	2 Low					
First Aid Case	No environmental damage or oil spill of less than 1 barrel	Very small loss (< US$ 1,000)	No reputation impact	1 Very Low					