

Optimization O&M Cost of Coal Handling Port Facility from 30 – 48 MTPA

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ABSTRACT

The challenge of O&M cost efficiency in the midst of increasing global demand for coal, which requires optimal cost management without reducing operational performance. The objective of this study is to determine the optimal O&M cost by analyzing key cost components such as fuel, heavy equipment, spare parts, labor, and infrastructure investment, and their impact on production achievement. The research used a case study approach with a combination of quantitative and qualitative analysis. Primary data was obtained through interviews and direct observation, while secondary data was analyzed using the Activity-Based Costing (ABC) method, simulation modeling, and regression to evaluate the impact of cost variations on production achievement. The results show that the optimal O&M cost for a production capacity of 30-48 MTPA is in the range of 10,568-11,970 IDR/ton, which is still lower than the market price. This optimization was achieved by mapping key cost components, including fuel, crusher and conveyor system maintenance, and labor. The application of the ABC method enabled the identification of areas of efficiency, resulting in more cost-effective operations without compromising facility performance. The implications of this research include improved operational efficiency, coal industry competitiveness, as well as the sustainability of port operations. The findings provide a strategic foundation for more effective cost management, especially in the face of demand fluctuations and operational challenges due to external conditions.

Keywords: Coal Port Facility, Operational Cost Optimization, Activity-Based Costing, Production Capacity.

INTRODUCTION

Optimization of operation and maintenance (O&M) costs at coal handling port facilities is an important issue in improving operational efficiency in the coal industry, especially at ports with a production capacity of 30-48 MTPA. As global coal demand increases, coal handling ports are expected to manage larger cargo volumes without significantly increasing costs (Botín & Vergara, 2015). Therefore, efficient management of O&M activities at port facilities is crucial to reduce cost wastage, optimize resource usage, and ensure smooth ongoing operations. This is challenging, given the complexity of operational activities involving various cost components, such as fuel, equipment maintenance, and labor (Al Zaabi et al., 2023).

This condition encourages the need to implement O&M cost optimization strategies that can increase productivity without compromising service quality and work safety. At coal handling ports, O&M cost components include heavy equipment maintenance, fuel for machinery and supporting equipment, as well as labor and infrastructure costs (Samaranayake et al., 2024). With a larger production capacity, managing these costs must be done carefully in order to maintain cost efficiency, especially amid fluctuations in fuel and equipment prices (Ari et al., 2022). Optimization of O&M costs will not only affect the reduction of operational expenditure but also the improvement of port performance and competitiveness, thus becoming an important factor in maintaining sustainability and competitiveness in the global market (Sullivan et al., 2010).

PT. XYZ Operated with Managing Contract Scheme, included but not limited to the O&M works for Coal Handling Port Facilities, will growth until 48 MTPA. Production growth has achieved gradually as planned, from 9 – 30 MTPA at 2017 – 2022, 30 – 42 MTPA at 2023 – 2024 and need to be optimized become 30 – 48 MTPA for 2025 – 2028. The optimal Operating and Maintenance Costs of Coal Handling Port Facilities from 30 – 48 MTPA are determined by evaluating and analyzing the existing O&M cost components and examining their impact on production achievement from 30 MTPA to 48 MTPA (Seifullina et al., 2018).

Another concern, the annual production is the sum of the monthly production achievement that vary, mostly due to weather condition at PT. XYZ Area, rainy season will make monthly production low, under the average production target and the deviation must be add to the target at hot season. As shown on the table production achievement below, PT. XYZ must optimize the resources, i.e., Heavy Equipment, Man Power, etc. to achieve production target with cost effective manner (Ramires & Sampaio, 2022).

Based on above condition, based on the milestone from 9 – 30 MTPA in 2017 – 2022, 30 – 42 MTPA in 2023 – 2024, PT. XYZ must optimize the O&M Cost of Coal Handling Port Facilities, how the cost can accommodate the production range capacity 30 – 48 MTPA for 2025 - 2028 and still optimum in both low monthly production season and high monthly production season.

With Managing Contract Scheme and Expansion Production Plan, PT. XYZ must optimize the O&M Cost of Coal Handling Port Facilities, how the cost can accommodate the production range from 30 – 48 MTPA for next 2025 – 2028 and still optimum in both low and high production achievement. The O&M Cost covering all major activity at Coal Handling Port Facilities, consist but not limited to:

- a. Fuel consumed, for both Heavy Equipment support and Diesel Generator to generate the electricity.
- b. Heavy equipment support required, i.e. Wheel Loader, Dozer, Excavator, etc.
- c. All spare part required (consumable, operational and routable spares) for fix plant equipment, heavy equipment and diesel generator.
- d. Labor cost to perform Operation and Maintenance activities.
- e. Investment cost to build Crushing Plant, Warehouse, etc.

All O&M cost as mentioned above, to be set become variable cost, lump sum price IDR/Ton.

Previous research conducted by (Tian et al., 2024) stated that the proposed method was able to reduce the average waiting time of ships at the terminal by 15.8% and save total scheduling and maintenance costs by 10.3%. By optimally utilizing historical data of equipment breakdowns and integrating the maintenance scheme into the scheduling problem of the ship loading operation system, the method effectively reduces the impact of equipment breakdowns on ship loading operations while providing decision support for coal export terminal management.

In contrast to previous studies, the novelty of this research lies in its approach to optimizing operation and maintenance (O&M) costs at coal handling port facilities with a capacity of 30-48 MTPA by mapping the main O&M activities that significantly impact costs. This focus addresses the increasing demand for cost efficiency in the midst of expanding port capacity while ensuring reliable operational performance. Such optimization is crucial for sustaining port operations, supporting the competitiveness of the coal industry, and providing strategic solutions for more efficient export terminal management. The study aims to determine the optimal O&M costs by identifying and analyzing the impact of each major cost component on production variance, offering a deeper understanding of the factors driving costs and strategies to enhance operational efficiency.

The benefits of this research extend to reducing cost wastage, improving resource utilization, and ensuring smooth and effective operations at coal handling ports. By delivering actionable insights, the findings not only contribute to enhancing port performance and competitiveness but also ensure sustainability in the global coal industry. The comprehensive analysis of cost components and their impacts provides valuable support for decision-making processes, enabling the achievement of production targets in a cost-effective manner, even under fluctuating operational conditions. This study, therefore, plays a strategic role in promoting efficient, resilient, and sustainable port management practices.

RESEARCH METHOD

This research uses a case study approach at PT XYZ to optimize the operation and maintenance (O&M) costs of coal handling port facilities with a production capacity of 30-48 MTPA over the period 2025-2028. The research subjects include the main O&M activities that affect costs, such as diesel generator fuel, heavy equipment maintenance, crusher and conveyor systems, and labor. The object of the study is the port facility of PT XYZ, with the main focus on cost efficiency to support the larger production capacity target. The research criteria include cost efficiency within the capacity range and the impact of each cost component on achieving production variance.

Data collection methods involved primary and secondary data. Primary data was obtained through in-depth interviews with O&M management and direct observation in the field, while

secondary data included analysis of historical O&M cost reports, production data, and equipment breakdown data. The collected data were analyzed using the Activity Based Costing (ABC) approach to map the main cost components, followed by statistical analysis to measure the correlation between cost components and production achievement. Optimization modeling was applied to determine efficient O&M costs based on various production capacity scenarios. The conceptual framework in this study is as follows.

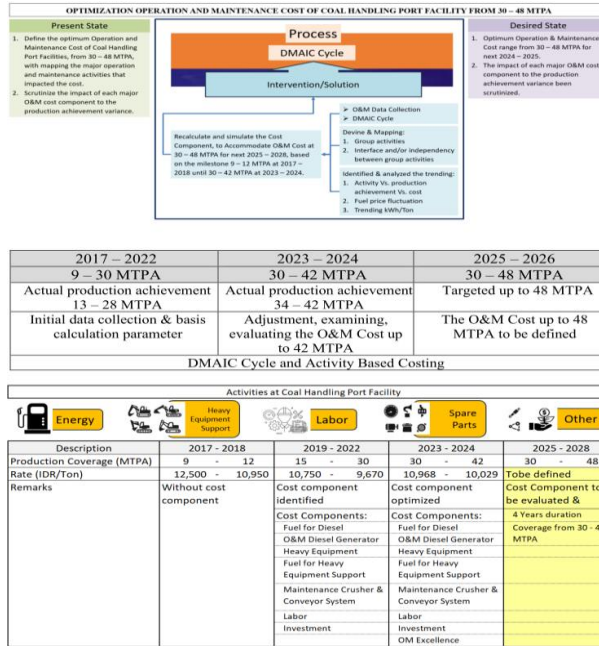


Figure 1. Conceptual Frameworks

From the conceptual frameworks above, research process to optimize the O&M Cost of Coal Handling Port Facilities at 30 – 48 MTPA as mentioned below:

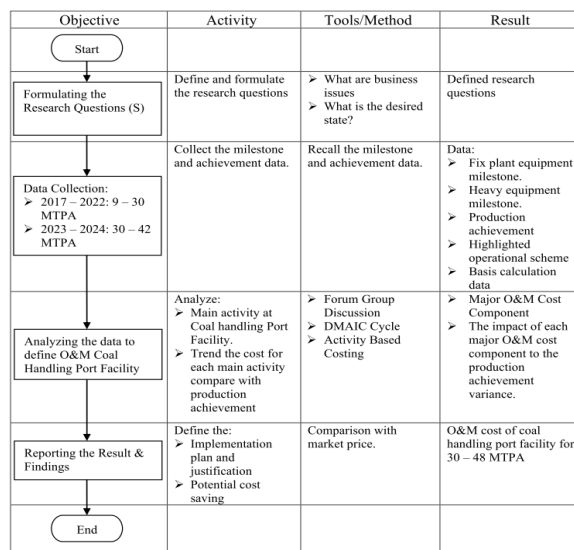


Figure 2. Research Process

RESULT AND DISCUSSION

Result

With DMAIC cycle, the analysis to measure the optimum O&M Cost of Coal Handling Port Facilities at 30 – 48 MTPA and other research question and objective are based on data collection, value stream mapping and activity-based costing.

Fuel for Diesel Generator

Cost for Diesel Generator’s fuel to generate the electric power, as power source for Fix Plant Equipment and Infrastructure at Coal Handling Port Facility, can be calculated:

Table 1. Fuel for Diesel Generator

Description	Value	
Fuel Price	8,217	IDR/Liter
Fuel Consumption	0.280	Liter/kWh
Energy Consumption Rate	0.708	kWh/Ton
Fuel Consumption per Ton [0.708 (kWh/Ton) * 0.280 (Liter/kWh)]	0.198	Liter/Ton
Diesel Fuel Price per Ton [0.198 Liter/Ton * 8,217 Rupiah/Liter]	1,629.90	IDR/Ton

Based on the available data and calculations, it can be concluded that the energy consumption rate for each cargo handling volume is relatively constant, which is 0.708 kWh/Ton. In addition, the fuel cost for the diesel generator used to generate electricity remains constant, which is 1,629.90 IDR/Ton according to the initial calculation, but after negotiations between PT XYZ and the O&M Contractor, the fuel cost was agreed to be 1,600 IDR/Ton.

Maintenance for Diesel Generator

Maintenance cost for Diesel Generator to generate the electric power, as power source for Fix Plant Equipment and Infrastructure at Coal Handling Port Facility, can be calculated:

Table 2. Maintenance for Diesel Generator

Description	Value	
Maintenance cost per hour, up to TOH (12,000 Hours) Refer to Appendix 3	78,747	IDR/Hour
Generator Set Load (80%)	640	kWh
Energy Consumption Rate	0.708	kWh/Ton
Coal Transfer Rate [640 (kWh) / 0.708 (kWh/Ton)]	903.90	Ton/Hour
Maintenance Diesel Price per Ton [78,747 (IDR/Hour) * 903.90 (Ton/Hour)]	87.12	IDR/Ton

Based on the data and calculations above, it can be concluded that the energy consumption rate remains relatively constant at 0.708 kWh/Ton for any volume of cargo handling. The cost of maintaining the diesel generator to produce the necessary electric power is also constant at 87.12 IDR/Ton. However, after negotiations between PT. XYZ and the O&M Contractor, it was

agreed that the cost of diesel fuel for the generator, which is used to generate electricity, will be fixed at 65 IDR/Ton for any volume of cargo handling.

Heavy Equipment Support

Based on calculations and negotiations between PT XYZ and the O&M Contractor, the cost for Heavy Equipment Support at the Coal Handling Port Facility experienced an increasing trend in the 2017-2022 period along with the achievement of production, which was influenced by the operational mode that mostly used rehandling and heavy equipment working hours allocated 120% of the Crushing Plant simulation working hours. Meanwhile, in the period 2025-2028, costs will tend to decrease along with the use of Dump Hopper in almost all Crushing Plants, except CP2, as well as the need for more limited heavy equipment for stockpile management and load rate optimization through Draw Down Hopper. Cost increases between 2023-2024 and 2025-2026 and 2027-2028 include inflationary factors.

Fuel for Heavy Equipment Support

Based on Calculation, refer to Appendix 4, Detail Heavy Equipment Cost Calculation, and to be followed with negotiation between PT. XYZ and O&M Contractor, it is agreed the rates (IDR/Ton) of Fuel for Heavy Equipment with basis fuel price at 8.217 Rupiah/Liter and to be adjusted, raise and fall, with actual monthly average fuel price. The cost fuel for heavy equipment support for 2025 – 2026 and 2027 – 2028 are the same value.

Maintenance Crusher & Conveyor System

Based on record lifetime of critical and/or major component and spending for maintenance crusher and conveyor system on the previous years. Negotiation between PT. XYZ and O&M Contractor been conducted and it is agreed the rates (IDR/Ton) of Maintenance Crusher & Conveyor System with crusher and conveyor system maintenance costs in the 2025-2028 period are higher than those in the 2023-2024 period due to several factors, namely: a) the number of crushers and conveyor systems that must be maintained will be higher; and b) an increase in the price of spare parts influenced by inflation and an increase in the exchange rate of IDR against USD. In addition, the maintenance cost trend in the 2025-2028 period will also increase as production exceeds 44 MTPA, due to: a) crusher and conveyor systems operating at maximum capacity, which reduces the material life of worn parts and consumable components; and b) all drive systems (motors & gearboxes) operating on average above 95%, which also shortens their lifespan.

Labor

Compared to the 2023–2024 period, labor costs in 2025–2028 will be higher at 30–39 MTPA and lower at 40–49 MTPA due to several factors: a) organizational changes, including but not limited to: the addition of equipment to be operated and maintained at the Coal Handling Port Facility, the addition of a Mid Management Team to act as thinkers, and the addition of specialist control system personnel; and b) an increase in labor salaries in line with the regional minimum wage (UMK) standards. These factors will cause fixed labor costs to be spread across varying

production levels, resulting in higher labor costs per ton at 30–39 MTPA and lower at 40–49 MTPA in the 2025–2028 period compared to 2023–2024.

Investment

The investment cost will decrease along with the production achievement, as the fixed investment value is divided by the production volume. In the 2025-2026 period, investment costs are higher than in 2023-2024 due to the addition of an investment item (CP9). Meanwhile, in the 2027-2028 period, investment costs will be lower than in 2023-2026, as all investment items have been completed except CP9.

Improve

By agreement, both PT. XYZ and O&M Contractor acknowledge their commitment to the principle of continuous improvement to achieve the highest possible standards in all aspects of this Work. Continuous improvement involves the integration of various factors, such as advanced technologies, new methods, and organizational changes, that significantly impact work processes, unit prices, and operational costs. This approach is further supported by advanced technologies, including robotics, augmented reality, and machine learning (ML), which enhance efficiency, precision, and productivity. The discipline at the intersection of ML and process improvement focuses on leveraging data-driven insights to optimize operations, automate repetitive tasks, and improve decision-making. By continuously advancing technological capabilities and refining work methods, organizations can achieve significant improvements in cost-effectiveness, quality, and overall performance, driving long-term sustainability and competitiveness (Rai et al., 2021). The Parties will in good faith discuss the advantages made that it is the intention of the Parties to share the benefits or costs of any such changes.

1. Improvement at Power Sources

To optimize fuel and maintenance costs for the Diesel Generator, PT. XYZ began shifting its power sources from Diesel Generator to PLN starting in mid-July 2019. PLN became the primary source of power, with the Diesel Generator serving as a backup. The fuel and maintenance costs for the Diesel Generator under the O&M contract are now allocated proportionally based on the energy consumption by PLN compared to the Diesel Generator. On December 1, 2023, PLN implemented a new policy, replacing the Premium Platinum scheme with the Prioritas scheme. This change will affect the subscription schemes from the previous Premium Platinum, Premium Silver, and Regular schemes, to the new Regular and Prioritas schemes. After evaluating the new subscription options, PT. XYZ decided to adopt the Regular scheme for the 2025–2028 period to support production levels of 30–48 MTPA. Actual cost savings from PLN utilization are illustrated in the figure below, with the blue bar showing the savings under the Premium Platinum scheme, and the red bar representing the simulated savings under the Prioritas scheme. These savings are calculated based on the agreed fuel and maintenance costs of 1,600 IDR/Ton for Diesel Generator fuel and 65 IDR/Ton for maintenance. As shown in Table 4.1.4, total energy consumption in July 2022 was 1,804,613

kWh, with 99.63% sourced from PLN and 0.37% from Diesel Generator. The cargo handled that month was 2,606,096 tons, yielding an energy consumption ratio of 0.692 kWh/Ton. Based on the proportional energy consumption, the total cost savings amounted to 8.09 IDR-Bio. The contract scheme for energy conversion from Diesel Generator to PLN has been validated, as demonstrated by the sensitivity to fuel prices—such as in May 2020 when the fuel price reached 4,255 IDR/Liter, resulting in savings of 150 million IDR.

2. Optimize Port Coal Handling Facility Utilization.

PT. XYZ has a demographic opportunity in its area, as there are three other Coal Handling Port Facilities owned by different companies, which are close to and have the same capabilities as PT. XYZ's Coal Handling Port Facility (coal crushing and coal conveyance to barges), as shown in the figure below. PT. XYZ has an agreement with the owners of these other facilities to use them as a backup in achieving production targets, at a cost of 40,000 - 50,000 IDR/Ton. Given this situation, the utilization of PT. XYZ's own Coal Handling Port Facility must be optimized because:

- a) The total cost of major O&M activities, as analyzed above, is no more than 12,000 IDR/Ton.
- b) The cost of utilizing other Coal Handling Port Facilities is significantly higher, adding an additional 28 IDR-Bio for every 1 million tons handled by other facilities.

3. O&M Excellence

With a high production target of 30-48 MTPA, operations and maintenance activities must be carried out with a high level of excellence. PT XYZ and the O&M Contractor have agreed to introduce an O&M Excellence fee to ensure stable operation and maintenance at the Coal Handling Port Facility, with the following conditions and justifications: a) The O&M Excellence fee will cover several things, including: increased customer productivity along with increased production, such as the provision of key spare parts, fabrication work, increased safe stock for critical parts, and improved belt conditions; maintenance and fuel costs for support vehicles, maintenance trucks, mobile cranes, crane trucks, pontoons, offices, and workshops; and backup teams if needed. b) The O&M Excellence score was determined based on expert judgment from PT XYZ's Technical Director and Commercial Team, considering: the high costs of using other Coal Handling Port facilities, as well as trends for 2025-2028 that differ from 2023-2024 to accommodate the higher risks associated with achieving greater production.

Control

By agreement, both PT. XYZ and O&M Contractor has committed to control the works, to optimize the O&M Cost, consist but not limited to:

1. To control the cost for Fuel & Maintenance Diesel Generator, both PT. XYZ and O&M Contractor continue monitoring:
 - a) Actual portion of kWh from both Diesel Generator and PLN.
 - b) Actual power usage compares to cargo handling (kWh/Ton).
 - c) Actual cost saving due to PLN utilization.

2. To control the cost for Heavy Equipment Support, both PT. XYZ and O&M Contractor continue monitoring the KPI for Heavy Equipment support that stated on the Contract, to be evaluated in weekly meeting to ensure the performance and utilization to achieve Production targeted.
3. To control the cost for Maintenance Crusher & Conveyor System, both PT. XYZ and O&M Contractor continue monitoring, consist but not limited to the:
 - a) PA, MA, UA and EU.
 - b) Lifetime of Critical Parts.
 - c) Actual TPH output.
4. To control the cost for labor, both PT. XYZ and O&M Contractor continue monitoring, consist but not limited to the:
 - a) Man Power Quantity and Quality.
 - b) Man Power Training and Competencies.
5. Both PT. XYZ and O&M Contractor to control the investment cost. Criticality at project phase, build the Crushing Plant, to meet the project scope, cost, schedule and quality.

Solution and Proposed Implementation Plan

Based on analysis above, the solution and proposed implementation plan are as mentioned below:

1. The O&M activities that impacted to the cost as mentioned below:
 - a. Fuel for Diesel Generator.
 - b. Maintenance for Diesel Generator.
 - c. Heavy Equipment Support.
 - d. Fuel for Heavy Equipment Support.
 - e. Maintenance Crusher & Conveyor System.
 - f. Labor.
 - g. Investment.
 - h. OM Excellence
2. Matrix of O&M Cost of coal handling port facility from 18 – 42 MTPA at 2021 – 2024 and 30 – 48 MTPA that to be implemented at 2025 – 2028 are shown on the table 4.2.1, Matrix of O&M Cost of Coal Handling Port Facility below.

Description	Before		After	
	XYZ-10-0001 AMD II	XYZ-10-0001 AMD III	XYZ-10-0001 AMD IV	
	2021 - 2022	2023 2024	2025 - 2026	2027 - 2028
Production Coverage and Capacity (MTPA)	18 - 30	30 - 42	30 - 48	30 - 48
Total O&M Cost (IDR/Ton)	10,248 - 9,670	10,968 - 10,029	11,970 - 10,801	11,528 - 10,568
Cost Components:				
Fuel for Diesel Generator	1,600 - 1,600	1,600 - 1,600	1,600 - 1,600	1,600 - 1,600
O&M Diesel Generator	65 - 65	65 - 65	65 - 65	65 - 65
Heavy Equipment Support	1,197 - 1,922	1,217 - 1,008	1,278 - 969	1,304 - 988
Fuel for Heavy Equipment Support	628 - 1,023	591 - 494	591 - 462	591 - 462
Maintenance Crusher & Conveyor System	3,173 - 2,581	3,366 - 3,294	3,843 - 4,604	3,898 - 4,673
Labor	2,796 - 2,005	2,718 - 2,552	3,053 - 2,083	3,143 - 2,145
Investment	789 - 474	1,263 - 902	1,392 - 870	779 - 487
OM Excellence		148 - 114	148 - 148	148 - 148
Number of Main Heavy Equipment Support				
Wheel Loader	7 Unit	2 Unit	2 Unit	2 Unit
Excavator	3 Unit	3 Unit	3 Unit	3 Unit
Dump Truck	9 Unit	4 Unit	4 Unit	4 Unit
Dozer	1 Unit	2 Unit	2 Unit	2 Unit
Number of Crusher to be Operated & Maintained	7 Crusher	10 crusher	11 Crusher	11 Crusher
Initial investment cost (IDR-Bio)		42 106	130	68

Figure 3. Comparison Table of Operating Costs and Production Capacity at PT XYZ Port Handling Facility (2021-2028)

3. Detail O&M Cost of Coal Handling Port facility from 30 – 48 MTPA for 2025 – 2026 and 2027 – 2028 as per table and figure below:

	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
2025-2026] AMD IV XYZ-10	11,970	11,857	11,730	11,680	11,604	11,530	11,423	11,319	11,247	11,178	11,117	11,062	11,012	10,967	10,926	10,890	10,857	10,827	10,801
1 Fuel for Diesel Generator	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
2 O&M Diesel Generator	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
3 Heavy Equipment Support	1,278	1,266	1,255	1,244	1,234	1,225	1,216	1,208	1,200	1,192	1,162	1,134	1,107	1,081	1,057	1,033	1,011	989	969
4 Fuel for Heavy Equipment Support	591	588	585	582	580	577	575	573	571	569	555	541	528	516	504	493	482	472	462
5 Maintenance Crusher & Conveyor System	3,843	3,858	3,851	3,915	3,945	3,971	3,960	3,945	3,958	3,969	4,043	4,116	4,189	4,260	4,330	4,401	4,469	4,537	4,604
6 Labor	3,053	2,985	2,921	2,860	2,803	2,751	2,699	2,651	2,606	2,564	2,500	2,439	2,380	2,326	2,273	2,222	2,174	2,127	2,083
7 Investment	1,392	1,347	1,305	1,266	1,229	1,193	1,160	1,129	1,099	1,071	1,044	1,019	995	971	949	928	908	889	870
8 OM Excellence	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148
2027-2028] AMD IV XYZ-10	11,528	11,395	11,297	11,258	11,202	11,120	11,041	10,965	10,905	10,862	10,784	10,753	10,716	10,685	10,659	10,631	10,607	10,586	10,568
1 Fuel for Diesel Generator	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
2 O&M Diesel Generator	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
3 Heavy Equipment Support	1,304	1,291	1,280	1,269	1,259	1,249	1,240	1,232	1,224	1,216	1,186	1,157	1,129	1,103	1,078	1,054	1,031	1,009	988
4 Fuel for Heavy Equipment Support	591	588	585	582	580	577	575	573	571	569	555	541	528	516	504	493	482	472	462
5 Maintenance Crusher & Conveyor System	3,898	3,875	3,881	3,940	3,976	3,980	3,983	3,985	3,998	4,025	4,072	4,161	4,237	4,315	4,393	4,464	4,534	4,604	4,673
6 Labor	3,143	3,075	3,008	2,946	2,887	2,834	2,781	2,731	2,684	2,640	2,574	2,511	2,453	2,395	2,340	2,288	2,239	2,191	2,145
7 Investment	779	753	730	708	687	667	649	631	615	599	584	570	556	543	531	519	508	497	487
8 OM Excellence	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148	148

Figure 4. PT XYZ Port Handling Facility Operation and Maintenance (O&M) Cost Details per Month (2025-2028)

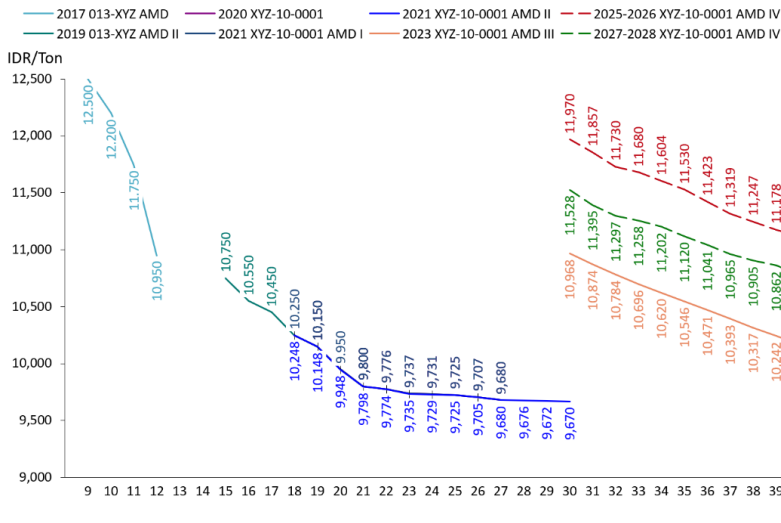


Figure 5. Trend Chart of Operating Cost per Ton against Production Capacity (MTPA) of PT XYZ (2017-2028)

Justification Of Implementation Plan

The O&M Cost of Coal Handling Port facility that will be applied at 2025 – 2026 and 2027 – 2028 is increase compare with 2023 – 2024 with justification as mentioned below:

1. Rate is adjusted from 10.968 IDR/Ton to 11.970 IDR/Ton for 30 MTPA by 1 January 2025, due to:
 - a. Additional 1 crusher (CP9) from 10 to 11 and also additional work load and volume, Man Power & equipment support, etc.
 - b. In line with PT. XYZ’s high Production, requirement of service of excellences for steady state Operation and Maintenance that requires additional special tools, double fast-moving stock and more competent personnel to execute Schedule & Un-schedule Maintenance faster.
 - c. Inflation rate affect in increasing of some components such as Spare Part.
 - d. Market price of Labor and Spare Part.
2. The adjustment rate is still reasonable and comes with more benefit, considering:
 - a. O&M Contractor adds investment for 1 Crusher, total become 7 Crushers (CP2, CP2A, CP2B, CP4, CP5, CP8 and CP9) owned by O&M Contractors while 4 Crushers (CP1, CP3, CP6 & CP7) owned by PT. XYZ.
 - b. The rates are still significantly below other Port’s Rate (40.000 IDR/Ton – 50.000 IDR/Ton), that potentially saving 28 IDR-Bio for each 1 Mio-Ton absorbed by Coal Handling Port facility (compared via other Port).
3. The optimum O&M Cost of Coal Handling Port Facilities, from 30 – 48 MTPA, that to be implemented to the next 2025 – 2026 and 2027 – 2028 is as mentioned below:
 - a. 2025 – 2026:

Table 3. Optimum O&M Cost Table for 30-48 MTPA Production Capacity (2025-2028)

MTPA	30	31	32	33	34	35	36	37	38	39
IDR/Ton	11,970	11,857	11,730	11,680	11,604	11,530	11,423	11,319	11,247	11,178
MTPA	40	41	42	43	44	45	46	47	48	
IDR/Ton	11,117	11,062	11,012	10,967	10,926	10,890	10,857	10,827	10,801	

- b. 2025 – 2026:

Table 4. Optimum O&M Cost Table for 30-48 MTPA Production Capacity (2025-2028)

MTPA	30	31	32	33	34	35	36	37	38	39
IDR/Ton	11,528	11,395	11,297	11,258	11,202	11,120	11,041	10,965	10,905	10,862
MTPA	40	41	42	43	44	45	46	47	48	
IDR/Ton	10,784	10,753	10,716	10,685	10,659	10,631	10,607	10,586	10,568	

4. The impact of each major O&M cost component to the production achievement variance is as table & figure below:

Table 5. Effect of O&M Cost Components on Variance in Production Achievement

No.	O&M Cost Component	Trend to the Production Achievement
1.	Fuel for Diesel Generator	Constant
2.	Maintenance for Diesel Generator	Constant
3.	Heavy Equipment Support	Increase in line with higher production
4.	Fuel for Heavy Equipment Support	Increase in line with higher production
5.	Maintenance Crusher & Conveyor System	Increase in line with higher production
6.	Labor	Decrease in line with higher production
7.	Investment	Decrease in line with higher production
8.	OM Excellence	Constant

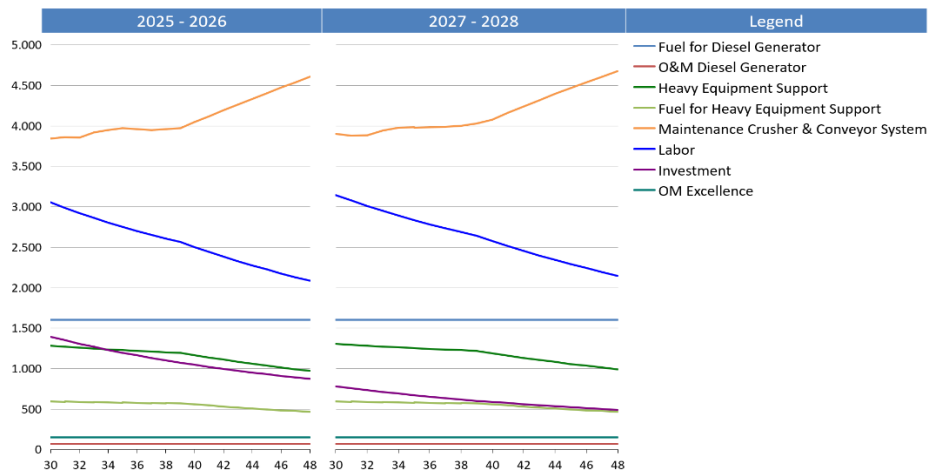


Figure 6. Trend Chart of O&M Cost Component against Production Capacity (2025-2028)

Discussion

Optimization of O&M (Operation and Maintenance) costs at the Coal Handling Port Facility from 30–48 MTPA aims to keep operating costs lower than market prices, with a cost range of IDR/Ton between 10,568 to 11,970. Although there is an increase in costs compared to the previous period, this increase is necessary to support higher production capacity and ensure more stable operations. Optimizing O&M costs for this larger production capacity requires a balance between cost efficiency and the need to maintain high operational performance, so that production targets and cost containment can be achieved effectively.

Research by (Seifullina et al., 2018) shows that O&M costs can be controlled by utilizing Activity-Based Costing (ABC) analysis, which allows companies to allocate costs more accurately according to the activities that occur, thereby minimizing waste. Another study by (Ramires & Sampaio, 2022) also emphasizes the importance of optimizing the use of resources, such as heavy equipment and labor, in the face of production fluctuations due to external factors, such as weather conditions. They show that by integrating technology and good planning, companies can mitigate the negative impacts of the rainy season or extreme weather conditions, which often cause monthly production declines. This approach is in line with the findings presented by (Ma et al., 2020) which stated that implementing a proactive and data-driven maintenance

management system can improve operational performance, reduce maintenance costs, and increase efficiency across facilities. The combination of these studies provides a strong foundation for a more targeted and data-driven O&M cost optimization strategy, which focuses not only on reducing immediate costs, but also on increasing long-term operational efficiency and effectiveness.

To achieve O&M cost optimization, cost components can be analyzed using the Activity-Based Costing (ABC) method, which divides the overall O&M costs into specific categories. ABC allows companies to allocate costs more accurately based on the activities consumed by each unit of product or service (Quesado & Silva, 2021). In the context of a coal handling port facility, these cost components include fuel costs for diesel generators, diesel generator maintenance costs, heavy equipment support, heavy equipment fuel costs, crusher and conveyor system maintenance, labor costs, and investment costs (Martinez-Valencia et al., 2021). Each of these cost categories has a direct impact on overall operating costs, and understanding how each category contributes to total O&M costs allows companies to identify areas where greater efficiency is needed. Research by (Koolmees et al., 2021) also shows that ABC is more effective than traditional cost allocation methods, as it can provide a clearer picture of the true cost drivers, as well as assist decision making in terms of cost control and budget planning.

In addition, research conducted by (Ding et al., 2022) on maintenance management shows that activity-based cost analysis is very important in improving maintenance and operational efficiency, especially in industries that rely on heavy equipment and complex systems. In this study, the application of ABC allows companies to monitor and manage maintenance costs per unit more accurately, as well as identify opportunities to reduce waste and optimize resource use. Similar findings were also found in a study by (Manalu et al., 2024), which stated that the application of cost-based maintenance techniques such as ABC can result in significant savings in maintenance costs, reduce downtime, and extend the operational life of equipment. By applying this approach to O&M cost analysis, PT. XYZ can be more effective in planning and optimizing costs associated with each component of operational costs, while improving the efficiency and performance of port facilities as a whole.

The main challenge in optimizing O&M costs lies in the need to maintain or even improve operational performance while minimizing the impact of increased production volumes. As output increases, fuel consumption for diesel generators and heavy equipment will naturally increase. However, fuel consumption can be optimized through more efficient scheduling, the use of more fuel-efficient equipment, and the application of fuel-saving technologies. This approach is supported by the Total Productive Maintenance (TPM) theory, which emphasizes proactive maintenance to keep equipment optimal so that it can operate more efficiently, reducing fuel consumption and downtime (Halloui et al., 2023). In addition, research by Yan et al., (2021) shows that the use of more efficient equipment in terms of fuel consumption can

significantly reduce operational costs in the coal handling industry, thereby increasing company profitability without sacrificing production capacity.

Similarly, maintenance costs for diesel generators and heavy equipment need to be carefully managed so that increased usage does not cause excessive wear and tear that can increase maintenance costs over time. In this case, the Condition-Based Maintenance (CBM) theory can be applied, where maintenance is carried out based on the actual condition of the equipment, rather than just on a fixed time schedule. CBM allows for more targeted maintenance and reduces costs associated with unnecessary maintenance (Acernese et al., 2021). Research by (Yazdi, 2024) also supports the application of CBM, stating that real-time monitoring of equipment conditions can reduce the occurrence of unexpected breakdowns and increase maintenance cost efficiency. The application of CBM to diesel generators and heavy equipment allows for reduced downtime and repair costs, as well as extending the life of the equipment, which is especially important when production volumes increase significantly.

In addition, the use of data-based technologies, such as energy monitoring systems and fleet management, can help companies optimize fuel usage and manage maintenance costs more efficiently. Research by (Ahmad et al., 2021) shows that the application of intelligent monitoring technology in the logistics and energy industry can improve fuel consumption management and equipment maintenance, thereby reducing operational costs and improving long-term performance. By integrating these strategies, PT. XYZ can manage the challenges of O&M costs in the face of increasing production volumes more effectively, while maintaining high operational performance and reducing resource waste.

Meanwhile, relatively fixed labor costs can be optimized through workforce training, operational process improvements, and adoption of automation where possible. Investments in infrastructure, such as crushing plant expansions or conveyor upgrades, can also be considered as part of the optimization process. The challenge is to ensure that these investments deliver long-term cost savings through increased efficiency, rather than creating additional costs that reduce the benefits. Overall, this study aims to explore all of these factors, analyze how each contributes to O&M costs, and identify opportunities to improve cost efficiency and operational performance in support of greater production capacity at the Coal Handling Port Facility.

CONCLUSION

O&M cost optimization of the Coal Handling Port Facility from 30 - 48 MTPA aims to maintain operating costs lower than market prices, with a cost range of IDR/Ton between 10,568 to 11,970, which is slightly higher than before to accommodate higher production capacity and more stable operations. Based on Activity Based Costing, O&M cost components can be grouped to include fuel for diesel generators, diesel generator maintenance, heavy equipment support, fuel for heavy equipment, crusher and conveyor system maintenance, labor, and investment. The problem formulation in this study focuses on how to achieve effective cost optimization in

supporting greater production capacity, taking into account cost efficiency and improved operational performance of coal port facilities. This study is conducted objectively by analyzing the factors that affect the cost and operational performance of O&M facilities.

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First publication right:

Asian Journal of Engineering, Social and Health (AJESH)

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