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Analysis for Selecting the Operation and Maintenance (O&M) Scheme to Improve Pltmg Performance: A Case Study of PT PLN (Persero)

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ABSTRACT

Gas engine power plants (Pembangkit Listrik Tenaga Mesin Gas / PLTMG) play a critical role in maintaining electricity supply in Indonesia's small and isolated power systems. However, several units continue to experience low availability and significant operational losses under different operation and maintenance (O&M) arrangements. This study aimed to identify the main causes of PLTMG O&M performance gaps, determine appropriate evaluation criteria, and select the most suitable O&M scheme to improve performance. A mixed-method case study was conducted using operational data from 18 PLTMG units during 2025–June 2026, supported by interviews, focus group discussions, and expert assessments. The analysis integrated Overall Equipment Effectiveness (OEE), Pareto analysis, Current Reality Tree, Value-Focused Thinking, and the Analytic Hierarchy Process (AHP). The results showed that aggregate availability reached 89.67% for Mandiri O&M, 93.15% for Mandiri O&M with Long-Term Service Agreement (LTSA), and 96.84% for Sharing O&M. Maintenance Outage contributed 61.65% of total equivalent loss hours, primarily due to limited technical support, spare-parts readiness, knowledge transfer constraints, and incompatibility between operational needs and the selected O&M model. The AHP results ranked Sharing O&M as the highest-priority scheme with a weight of 69.56%, followed by LTSA at 23.59% and Mandiri O&M at 6.81%. Therefore, Sharing O&M was recommended for a controlled pilot implementation at PLTMG Bima and Langgur before broader adoption. The pilot implementation should be monitored using reliability, cost-efficiency, and organizational capability indicators.

INTRODUCTION

PT PLN (Persero) is the state-owned enterprise responsible for providing electricity throughout Indonesia, ranging from large interconnected systems to small isolated systems in remote areas. PLN manages 935 power systems with a national peak load of approximately 48 GW in 2025, of which around 90% is supplied by 24 major systems, while the remaining capacity serves smaller and isolated systems. In small grids and isolated systems, electricity supply often depends on one or only a few priority generating units without interconnection support. Therefore, PLN relies on gas engine power plants (Pembangkit Listrik Tenaga Mesin Gas / PLTMG) as priority generators because they can be developed rapidly, provide operational flexibility, offer relatively high efficiency with lower emissions, and support variable operating patterns. Due to their critical role, any PLTMG outage or derating event can directly affect local electricity supply reliability and increase the risk of supply disruptions or blackouts (Haqqi et al., 2026; Machfudiyanto et al., 2023; Pramono et al., 2024; Silitonga et al., n.d.; Umardi et al., 2026; Wijaya & Indianto, n.d.).

Following PLN's Holding–Subholding transformation, two generation subholdings, PLN Indonesia Power and PLN Nusantara Power, were established to strengthen business specialization and improve operational capabilities. Several PLTMG assets serving small and isolated systems remain managed under PLN Holding and are operated through O&M Service Contracts under three main schemes: Mandiri O&M, Mandiri O&M with a Long-Term Service Agreement (LTSA), and Sharing O&M. One of the key indicators used to evaluate power-plant reliability is the Equivalent Availability Factor (EAF), which represents the proportion of an operating period during which a generating unit remains available without forced outages or equipment-related derating (Rahman et al., 2023). A higher EAF reflects better operational readiness and reliability performance (Firstantara et al., 2025).

PLTMG performance assessments in 2025 indicated that several plants did not achieve the EAF targets established in their Service Level Agreements (SLAs), particularly PLTMG Bima and PLTMG Langgur. Low EAF performance creates significant business implications for PLN, including potential losses from reduced electricity generation and revenue, increased risk of insufficient generation capacity requiring temporary rental power solutions, and inefficiencies arising from a mismatch between O&M costs and plant performance. Based on an assumed average electricity selling price of Rp1,467 per kWh, the estimated lost generation and potential revenue exposure across the 18 observed PLTMG units reached Rp1,045.04 billion, with PLTMG Bima and PLTMG Langgur contributing the largest proportions (Table 1).

Table 1. Estimated Lost Generation and Potential Revenue at Risk by PLTMG in 2025

No	Power Plant	Capacity (MW)	Potential Avail. (MWh)	Net Avail. (MWh)	Lost Gen. (MWh)	Revenue at Risk (Rp billion)
1	PLTMG Bima	50	695,429	490,759	204,670	300.25
2	PLTMG Langgur	20	292,795	181,927	110,868	162.64
3	PLTMGU Lombok Peaker	150	1,797,857	1,745,147	52,710	77.33
4	PLTMG Maumere	20	585,830	537,360	48,470	71.11
5	PLTMG Jayapura	30	761,645	722,014	39,631	58.14
6	PLTMG Jayapura Peaker	50	634,704	599,212	35,492	52.07
7	PLTMG Ambon Peaker	30	481,993	449,420	32,573	47.78

No	Power Plant	Capacity (MW)	Potential Avail. (MWh)	Net Avail. (MWh)	Lost Gen. (MWh)	Revenue at Risk (Rp billion)
8	PLTMG Sumbawa	50	695,429	664,951	30,478	44.71
9	PLTMG Kendari	50	767,362	739,448	27,913	40.95
10	PLTMG Kupang Peaker	40	597,642	574,903	22,739	33.36
11	PLTMG Tanjung Selor	15	229,986	208,365	21,621	31.72
12	PLTMG Flores	30	307,263	287,557	19,705	28.91
13	PLTMG Ternate	30	495,571	476,270	19,301	28.32
14	PLTMG Nabire	30	289,224	274,222	15,002	22.01
15	PLTMG Merauke	20	324,349	313,181	11,169	16.38
16	PLTMG Biak	15	233,461	223,949	9,513	13.96
17	PLTMG Bau-Bau	30	496,095	488,851	7,244	10.63
18	PLTMG Seram Peaker	20	309,098	305,835	3,263	4.79
TOTAL			**9,995,734**	**9,283,370**	**712,363**	**1,045.04**

Source: Author, processed from the 2025 PLTMG operational dataset.

A related issue concerns the alignment between O&M expenditure and plant performance. Actual cost data reveal inconsistencies between operation and maintenance spending and the performance achieved by the plants (Table 2). Lower actual expenditure without corresponding improvements in performance may indicate deferred scheduled maintenance, incomplete preventive maintenance activities, or delays in spare-parts procurement. However, these potential causes require further verification through systematic root-cause analysis (Fluitman et al., 2016; Pietsch et al., 2024; Soldani & Brogi, 2022; Van Galen et al., 2016; Yunusa-Kaltungo et al., 2017).

Table 2. Planned and Actual O&M Costs and Cost Accuracy by PLTMG in 2025

No	Power Plant	Capacity (MW)	Planned ABOP 2025 (Rp)	Actual ABOP 2025 (Rp)	Cost Accuracy (%)
1	PLTMG Maumere	20	58,994,689,112	37,797,826,310	64.1%
2	PLTMG Merauke	20	42,357,152,261	34,229,263,213	80.8%
3	PLTMG Biak	15	28,751,485,297	23,366,025,697	81.3%
4	PLTMG Kendari	50	70,717,104,649	60,767,528,776	85.9%
5	PLTMG Seram Peaker	20	27,618,824,101	23,330,165,816	84.5%
6	PLTMG Jayapura	30	40,358,437,765	33,725,678,229	83.6%
7	PLTMG Flores	30	39,152,670,636	32,784,588,303	83.7%
8	PLTMG Ternate	30	48,588,022,723	32,552,117,544	67.0%
9	PLTMG Nabire	30	40,649,536,707	31,851,832,795	78.4%
10	PLTMG Jayapura Peaker	50	56,504,608,390	50,627,255,499	89.6%
11	PLTMG Langgur	20	32,197,909,747	19,261,778,788	59.8%
12	PLTMG Bau-Bau	30	27,286,643,058	26,766,072,713	98.1%
13	PLTMG Ambon Peaker	30	25,363,880,060	25,201,944,953	99.4%
14	PLTMG Tanjung Selor	15	25,677,175,943	11,387,683,066	44.3%
15	PLTMG Bima	50	34,986,893,216	36,681,957,654	104.8%
16	PLTMG Sumbawa	50	34,469,023,427	32,268,087,714	93.6%

No	Power Plant	Capacity (MW)	Planned ABOP 2025 (Rp)	Actual ABOP 2025 (Rp)	Cost Accuracy (%)
17	PLTMG Kupang Peaker	40	17,423,411,876	17,349,846,891	99.6%
18	PLTMGU Lombok Peaker	150	34,414,046,987	42,101,358,932	122.3%
TOTAL/AVG			**685,511,515,955**	**572,051,012,893**	**83.4%**

Source: Author, processed from the 2025 PLTMG operational dataset.

Although PLN has implemented mitigation measures, the root causes of the identified performance gaps have not yet been fully determined. Therefore, this study aimed to provide recommendations for improving PLTMG O&M management. The study was guided by three research questions: (a) what root causes influenced O&M performance at PLTMG units; (b) how could appropriate evaluation criteria be developed to assess and improve O&M performance; and (c) which O&M arrangement provided the most suitable alternative for improving operational performance. In accordance with these research questions, the study aimed to identify the main factors affecting PLTMG O&M performance, evaluate the criteria required for improvement, and assess available O&M alternatives to determine the arrangement most suitable for PLTMG operations. The study was limited to PLTMG units operated by PLN's subholdings under existing O&M Service Contract arrangements and evaluated O&M performance from reliability, operational, and managerial perspectives without examining detailed engineering design aspects or contract renegotiation processes.

METHOD

This research employed a mixed-method case-study design that combined quantitative operational data with qualitative evidence from interviews and focus group discussions (FGDs), followed by quantitative multicriteria analysis. The unit of analysis was the individual PLTMG included in the verified dataset and classified under one of three O&M schemes: Mandiri O&M, Mandiri O&M with LTSA, or Sharing O&M. The operational data covered 18 PLTMG units from January–December 2025 and January–June 2026, with cumulative energy-related indicators used for comparisons among plants and O&M schemes.

The study consisted of three connected phases: Business Issue Assessment, Data and Analysis, and Decision. Primary data were collected through semi-structured interviews, FGDs, and AHP expert questionnaires, while secondary data included O&M and LTSA contracts, company reports, outage and derating records, production data, capacity data, maintenance reports, cost records, and relevant previous studies. Stakeholders were mapped using a power–interest grid by assessing formal decision-making authority and control over O&M resources, as well as responsibility for plant performance and exposure to the consequences of the selected scheme (Ackermann & Eden, 2011).

Historical operational and O&M data were processed using Overall Equipment Effectiveness (OEE) in accordance with PT PLN (Persero) Board of Directors Regulation No.

0779.K/DIR/2013. The OEE calculation consisted of Availability × Performance × Quality, with Quality fixed at 100%. Availability was calculated as the ratio of aggregate Net Availability to aggregate Potential Availability, while Performance was calculated as the ratio of aggregate Net Production to aggregate Net Availability. Operational losses were ranked from the largest to the smallest based on equivalent hours and presented in Pareto diagrams for each O&M scheme. Loss categories contributing to approximately 80% of the total losses were prioritized for further analysis.

The dominant controllable losses identified through Pareto analysis were formulated as undesirable effects in a Current Reality Tree (CRT). The CRT applied cause-and-effect logic using the structure "IF cause, and where necessary an additional cause, THEN effect" to analyze relationships validated through interviews and FGDs, ensuring that loss categories were not classified as root causes without further investigation (Dettmer, 1997). Stakeholder concerns, desired outcomes, and organizational values were subsequently translated into fundamental and means objectives using Value-Focused Thinking (VFT), following the approach proposed by Manurung and Putro (2024). These objectives were validated to establish the criteria and subcriteria for the subsequent multicriteria analysis.

The validated decision structure was developed into an Analytic Hierarchy Process (AHP) hierarchy consisting of a goal, criteria, subcriteria, and three O&M alternatives. Expert respondents conducted pairwise comparisons using Saaty's 1–9 fundamental scale (Saaty, 1980, 2008), and each comparison matrix was evaluated for consistency. Only judgments with acceptable Consistency Ratios were included in the aggregation process. Super Decisions software was used to calculate local and global priorities and rank the alternatives (Mu & Pereyra-Rojas, 2018). The selected alternative was then interpreted alongside OEE comparisons, Pareto loss analysis, and validated root causes, and translated into an implementation plan covering priority locations, responsibilities, schedules, key performance indicators, risks, and monitoring mechanisms.

The methodological sequence was supported by established approaches in operational-performance research. OEE, which originated from Total Productive Maintenance, has been widely applied to evaluate operational performance and identify sources of effectiveness losses in power-generation units (Nusraningrum & Arifin, 2018). Based on OEE results, Pareto analysis was used to rank loss categories and prioritize dominant contributors within the cumulative 80% threshold for further root-cause investigation. Prioritizing key loss factors has been shown to improve availability, performance, quality, and overall OEE performance (Tayal et al., 2021). In this study, the Pareto analysis did not recalculate OEE values but utilized the loss components generated under PT PLN (Persero) Board of Directors Regulation No. 0779.K/DIR/2013, including Planned Outage Hours, Maintenance Outage Hours, Forced Outage Hours, Scheduled Outage Extension, and equivalent planned, maintenance, and forced derating hours.

RESULT AND DISCUSSION

Profile of the O&M Schemes and Research Data

Three O&M schemes were analyzed: Mandiri O&M, Mandiri O&M with LTSA, and Sharing O&M, which differ primarily in the allocation of resource responsibilities, OEM technical support, spare-parts provision, and cost structure (Table 3). During the observation period, the Mandiri scheme was implemented at eight units, Mandiri O&M with LTSA at nine units, and Sharing O&M at one unit; the aggregate results for Sharing O&M should therefore be interpreted as single-case evidence rather than as a population estimate generalizable to all PLTMGs.

Table 3. Characteristics of the PLTMG O&M Schemes

Aspect	Mandiri O&M	Mandiri O&M with LTSA	Sharing O&M
Resources & Advisory	Subholding provides operators and technicians	Subholding provides operators, technicians, engineers, and advisory support	Subholding provides operators, technicians, engineers, and advisory support
OEM Role	OEM provides engineers and advisory support (fixed-cost component)	OEM provides routine and major spare parts under the LTSA scheme	OEM provides routine and major spare parts under the Sharing O&M Agreement
Spare Parts & Materials	Subholding provides consumable materials	Subholding provides consumable materials, lubricants, and chemicals	Subholding provides consumable materials, routine and major spare parts, lubricants, and chemicals
Cost Structure	Fixed-Cost Component	Variable-Cost Component	Variable-Cost Component
Implementing Entity	PLN Nusantara Power	PLN Indonesia Power	PLN Nusantara Power

Source: Internal research documents, 2026.

Overall Equipment Effectiveness Evaluation

Aggregate Availability was 89.67% under Mandiri O&M, 93.15% under Mandiri O&M with LTSA, and 96.84% under Sharing O&M (Table 5). At unit level, Langgur and Bima recorded the lowest Availability, at 67.99% and 63.06% respectively, both below the 90% SLA threshold and both operating under the Mandiri scheme. Performance, which reflects the proportion of Net Availability actually converted into Net Production, is strongly influenced by dispatch requirements in isolated systems and therefore is used to explain the utilization of available energy rather than as a stand-alone indicator of O&M quality. Combining both components, OEE ranged from 71.11% at Sumbawa down to 24.63% at Seram Peaker, illustrating that units with high Availability can still record low OEE when Performance is constrained by dispatch (Table 4).

Table 4. Cumulative OEE by PLTMG Unit during the Observation Period

Unit	O&M Scheme	Availability (%)	Performance (%)	OEE (%)
Sumbawa	Mandiri	99.47	71.49	71.11
Bau-Bau	Mandiri	99.06	63.14	62.54

Unit	O&M Scheme	Availability (%)	Performance (%)	OEE (%)
Lombok Peaker	Sharing	96.84	62.78	60.80
Jayapura Peaker	LTSA	94.99	65.22	61.95
Jayapura	LTSA	94.13	63.87	60.12
Ambon Peaker	LTSA	91.81	62.70	57.57
Ternate (Kastella)	Mandiri	95.61	56.97	54.47
Nabire	LTSA	93.19	50.50	47.06
Flores (Rangko)	Mandiri	93.44	47.82	44.68
Bima	Mandiri	63.06	66.31	41.81
Merauke	LTSA	96.43	43.97	42.40
Kendari (Nii Tanasa)	Mandiri	98.16	35.37	34.73
Tanjung Selor	LTSA	87.69	53.11	46.57
Maumere	LTSA	88.61	40.51	35.89
Kupang Peaker	LTSA	95.19	39.46	37.56
Biak	LTSA	94.99	36.88	35.04
Langgur	Mandiri	67.99	39.07	26.56
Seram Peaker (Masohi)	Mandiri	99.10	24.86	24.63

Source: Author, processed from the 2025 PLTMG OEE dataset.

Table 5. Comparison of Cumulative Performance by O&M Scheme

O&M Scheme	Number of Units	Availability (%)	Performance (%)	OEE (%)
Mandiri	8	89.67	52.80	47.34
LTSA	9	93.15	52.41	48.82
Sharing O&M	1	96.84	62.78	60.80

Source: Author.

Descriptively, Sharing O&M recorded the highest Availability and OEE, while LTSA ranked second in Availability and Mandiri recorded the lowest. Because Sharing O&M is represented by only one unit, this ranking is treated as an initial indication that must be tested through a pilot project and monitoring rather than as causal evidence of superiority.

Pareto Analysis of OEE Losses

Pareto analysis measures the dominance of loss duration in equivalent hours rather than the amount of energy lost in MWh. Maintenance Outage was the dominant category, accounting for 61.65% of total loss hours; together with Planned Outage and Forced Outage, the three leading categories account for 91.39% of the total (Table 6). This finding directs the root-cause analysis toward the duration of maintenance-work completion, the readiness of technical support, and the availability of materials and spare parts.

Table 6. Pareto Analysis of Equivalent OEE Loss Hours during the Observation Period

Rank	Loss Category	Hours	Proportion (%)	Cumulative (%)
1	Maintenance Outage (MOH)	33,389.9	61.65	61.65
2	Planned Outage (POH)	11,658.4	21.53	83.17
3	Forced Outage (FOH)	4,448.4	8.21	91.39
4	Forced Derating (EFDH)	2,325.8	4.29	95.68
5	Maintenance Derating (EMDH)	1,758.0	3.25	98.93
6	Scheduled Outage Extension (SE)	550.2	1.02	99.94
7	Planned Derating (EPDH)	31.2	0.06	100.00

Source: Author.

Table 7. Proportion of Maintenance Outage by O&M Scheme

O&M Scheme	Total Loss Hours	MOH (Hours)	MOH Proportion (%)
Mandiri	24,583.7	18,472.7	75.14
LTSA	20,850.6	13,540.0	64.94
Sharing O&M	3,993.6	992.3	24.85

Source: Author.

The proportion of Maintenance Outage was 75.14% under Mandiri, 64.94% under LTSA, and 24.85% under Sharing O&M, consistent with the proposition that technical-support arrangements and maintenance practices affect outage duration, and reinforced by PLTMG Bima and PLTMG Langgur being the largest contributors to Maintenance Outage losses.

Root-Cause Analysis Using the Current Reality Tree

The Current Reality Tree (CRT), developed from semi-structured interviews and FGDs, identifies a mismatch between the O&M implementation model and unit-specific requirements as the core problem, with limited OEM/advisory technical support and limitations in spare-parts availability and knowledge transfer as two recurring groups of causes (Figure 1). These limitations slow the technical response and increase Mean Time to Repair (MTTR), which subsequently extends Maintenance Outage, reduces Availability and EAF, and increases cost and supply-adequacy risks — a pattern consistent with the Pareto results and with the low Availability recorded at Bima and Langgur. The CRT represents an expert-knowledge-based explanation of the observed patterns; recommendations derived from it must therefore be tested through limited implementation and measurable performance indicators.

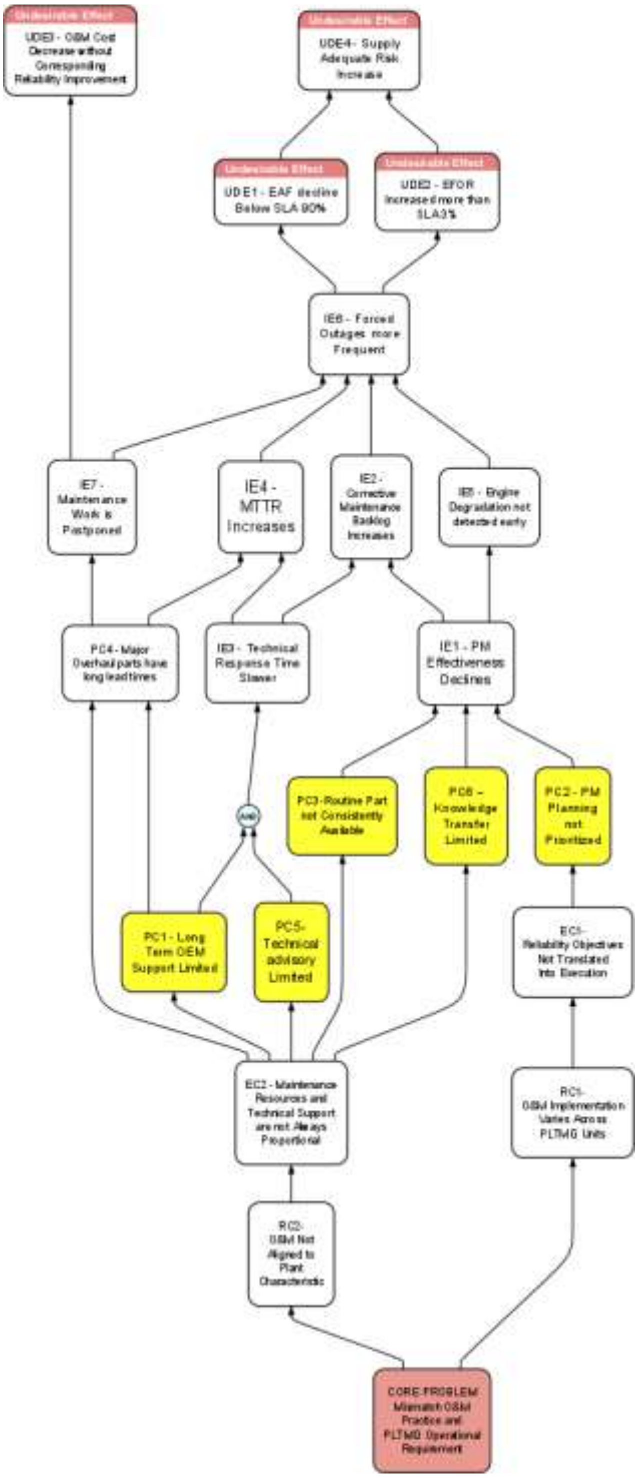

Figure 1. Summary of Cause-and-Effect Relationships in the Current Reality Tree

Source: Adapted from interviews, FGDs, and internal research documents, 2026.

Analytic Hierarchy Process Results

Stakeholder values were translated through Value-Focused Thinking into three decision criteria Operational Reliability, Optimize O&M Cost, and Sustainable Capability — each with two subcriteria, and evaluated against the three O&M alternatives using AHP processed in Super Decisions (Figure 2). At the criteria level, Operational Reliability received the highest weight (0.6955), followed by Optimize O&M Cost (0.2290) and Sustainable Capability (0.0754), with a Consistency Ratio of 0.07348 indicating acceptable judgments (Table 8). At the subcriterion level, Increasing EAF (0.7500 within Reliability), Reducing O&M Cost (0.8000 within Cost), and Improving Technical Competence (0.8333 within Capability) received the largest local weights.

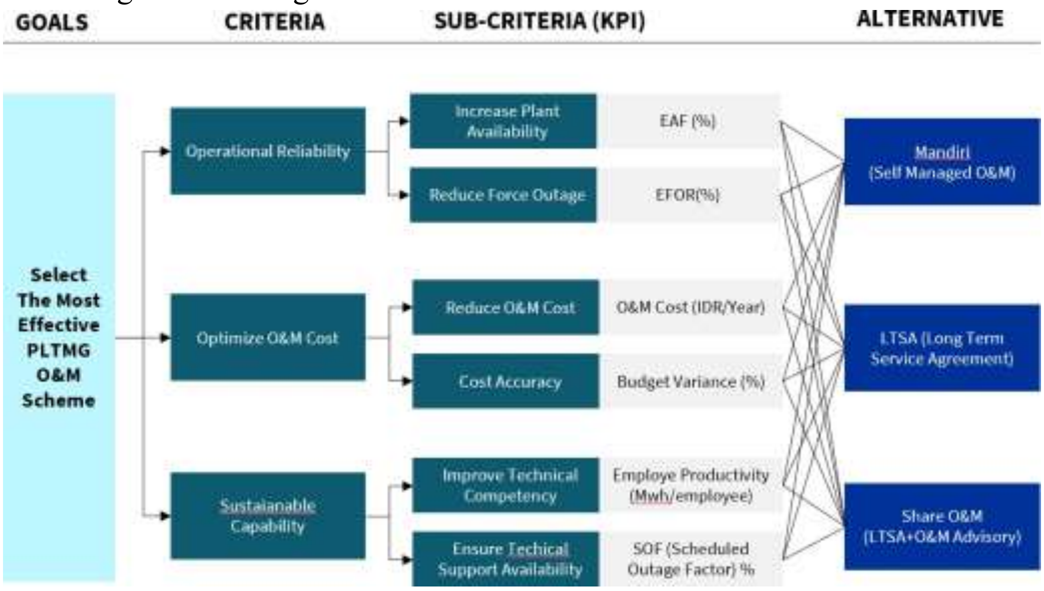

Figure 2. AHP Hierarchy for Selecting the Most Effective PLTMG O&M Scheme

Source: Author.

Table 8. Pairwise Comparison Matrix and Priority Weights of the Criteria

Criteria	Reliability	Cost Efficiency	Capability	Priority Weight
Reliability	1	4	7	0.6955
Cost Efficiency	1/4	1	1/4	0.2290
Capability	1/7	1/4	1	0.0754

Source: Author, based on Super Decisions processing.

Each criterion was further decomposed into two subcriteria and compared using the same pairwise procedure (Tables 9–11). Within Operational Reliability, Increasing EAF was judged more important than Reducing EFOR (0.7500 vs 0.2500); within Optimize O&M Cost, Reducing O&M Cost dominated O&M Cost Accuracy (0.8000 vs 0.2000); and within Sustainable Capability, Improving Technical Competence dominated Availability of Technical Support (0.8333 vs 0.1667).

Table 9. Pairwise Comparison Matrix of the Operational Reliability Subcriteria

Subcriteria	Increasing EAF	Reducing EFOR	Priority Weight
Increasing EAF	1	3	0.7500
Reducing EFOR	1/3	1	0.2500

Source: Author, based on Super Decisions processing.

Table 10. Pairwise Comparison Matrix of the Optimize O&M Cost Subcriteria

Subcriteria	Reducing O&M Cost	O&M Cost Accuracy	Priority Weight
Reducing O&M Cost	1	4	0.8000
O&M Cost Accuracy	1/4	1	0.2000

Source: Author, based on Super Decisions processing.

Table 11. Pairwise Comparison Matrix of the Sustainable Capability Subcriteria

Subcriteria	Improving Technical Competence	Availability of Technical Support	Priority Weight
Improving Technical Competence	1	5	0.8333
Availability of Technical Support	1/5	1	0.1667

Source: Author, based on Super Decisions processing.

Combining the criteria weights with the local subcriteria weights produced the global subcriteria weights shown in Table 12. Increasing EAF received the largest global weight (0.5216), followed by Reducing O&M Cost (0.1832) and Reducing EFOR (0.1738).

Table 12. Global Weights of the Subcriteria

Criteria	Criterion Weight	Subcriteria	Local Weight	Global Weight
Operational Reliability	0.6955	Increasing EAF	0.7500	0.5216
Operational Reliability	0.6955	Reducing EFOR	0.2500	0.1738
Optimize O&M Cost	0.2290	Reducing O&M Cost	0.8000	0.1832
Optimize O&M Cost	0.2290	O&M Cost Accuracy	0.2000	0.0458
Sustainable Capability	0.0754	Improving Technical Competence	0.8333	0.0628
Sustainable Capability	0.0754	Availability of Technical Support	0.1667	0.0125

Source: Author, based on Super Decisions processing.

At the alternative level, pairwise comparisons were also performed separately for each subcriterion (Table 13). Sharing O&M received the highest local priority for all six subcriteria, ranging from 0.6955 to 0.7071, followed consistently by Mandiri O&M with LTSA and then Mandiri O&M. Because this judgment pattern is highly uniform across subcriteria, its interpretation should consider the possibility of perceptual dominance among respondents and should be confirmed through the empirical operational evidence presented earlier.

Table 13. Local Priority of the Alternatives for Each Subcriterion

Subcriterion	Mandiri	Mandiri + LTSA	Sharing O&M
Increasing EAF	0.0643	0.2370	0.6986
Reducing EFOR	0.0698	0.2370	0.6986
Reducing O&M Cost	0.0754	0.2290	0.6955
O&M Cost Accuracy	0.0754	0.2290	0.6955
Improving Technical Competence	0.0701	0.2227	0.7071
Availability of Technical Support	0.0643	0.2370	0.6986

Source: Author, based on Super Decisions processing.

All comparison matrices were tested for consistency, and every matrix returned a Consistency Ratio below the 0.10 acceptance threshold (Table 14), indicating acceptable internal consistency. This result confirms the internal reliability of the pairwise judgments but does not by itself establish external validity or eliminate the potential for common bias among respondents.

Table 14. Summary of the Consistency Ratio for Each Comparison Matrix

Comparison Matrix	λmax	CI	CR	Result
Criteria (Reliability, Cost, Capability)	3.0851	0.0426	0.0734	Consistent
Subcriteria – Operational Reliability	2.0000	0.0000	0.0000	Consistent
Subcriteria – Optimize O&M Cost	2.0000	0.0000	0.0000	Consistent
Subcriteria – Sustainable Capability	2.0000	0.0000	0.0000	Consistent
Alternatives – Increasing EAF	3.1049	0.0524	0.0904	Consistent

Comparison Matrix	λmax	CI	CR	Result
Alternatives – Reducing EFOR	3.1049	0.0524	0.0904	Consistent
Alternatives – Reducing O&M Cost	3.0851	0.0426	0.0734	Consistent
Alternatives – O&M Cost Accuracy	3.0851	0.0426	0.0734	Consistent
Alternatives – Improving Technical Competence	3.0597	0.0299	0.0515	Consistent
Alternatives – Availability of Technical Support	3.1049	0.0524	0.0904	Consistent

Source: Author, based on Super Decisions processing.

In the final synthesis, Sharing O&M obtained the highest global priority (0.6956 or 69.56%), followed by Mandiri O&M with LTSA (0.2359 or 23.59%) and Mandiri O&M (0.0681 or 6.81%), and ranked first under every individual criterion (Table 15). The largest contributor to this result is Increasing EAF, with a global weight of 0.5216. The AHP results and the operational results therefore point in the same direction, although Sharing O&M is represented by only one unit and the two forms of evidence are not multiplied because they are derived from different measurement constructs.

Table 15. Synthesis of AHP Global Priorities of the O&M Alternatives

Subcriteria (Global Weight)	Mandiri	Mandiri + LTSA	Sharing O&M
Increasing EAF (0.5216)	0.0643	0.2370	0.6986
Reducing EFOR (0.1783)	0.0643	0.2370	0.6986
Reducing O&M Cost (0.1832)	0.0805	0.2385	0.6810
O&M Cost Accuracy (0.0458)	0.0754	0.2290	0.6955
Improving Technical Competence (0.0628)	0.0701	0.2227	0.7071

Subcriteria (Global Weight)	Mandiri	Mandiri + LTSA	Sharing O&M
Availability of Technical Support (0.0125)	0.0643	0.2370	0.6986
Global Priority (Rank)	0.0681 (3)	0.2359 (2)	0.6956 (1)

Source: Author, based on Super Decisions processing.

Implementation Plan

Three lines of evidence converge on the same recommendation: the operational results show that Sharing O&M has the highest aggregate Availability; the Pareto analysis and CRT indicate that Maintenance Outage, technical support, and MTTR are the principal areas for improvement; and the AHP ranks Sharing O&M as the priority alternative across all criteria. Sharing O&M is therefore recommended for testing through a limited pilot rather than an immediate migration of all units. Bima and Langgur were selected as the initial pilot locations because both operate under the Mandiri scheme, record the lowest Availability, and together account for 48.5% of the total Maintenance Outage hours under that scheme (Table 16); selecting both units in parallel also allows the pilot to be tested across different capacities and system contexts.

Table 16. Unit Performance and Priority Ranking under the Mandiri O&M Scheme

Unit	Availability (%)	MOH (Hours)	Availability Rank	MOH Rank
Bima	63.06	9,643	1 (lowest)	2
Langgur	67.99	6,575	2 (lowest)	1 (highest)
Ternate (Kastella)	95.61	1,621	3	3
Kendari (Nii Tanasa)	98.16	329	4	4
Seram Peaker (Masohi)	99.10	156.1	5	5
Sumbawa	99.47	129.4	6	6
Bau-Bau	99.06	18.4	7	7
Flores (Rangko)	93.44	0.0	8	8

Source: Author.

The pilot is planned for twelve months, from business-case development and contract negotiation through OEM onboarding, a parallel transition period at both units, monthly monitoring, and a final go, revise, or stop decision on scaling up to other Mandiri units (Table 17). Monitoring is conducted monthly and evaluated in months 10–12 against a pre-pilot baseline, covering reliability, operating performance, cost, and capability indicators, with the decision on replication made by a steering committee (Table 18).

Table 17. Stages of Sharing O&M Implementation at PLTMG Bima and Langgur

No	Activity	PIC	Month(s)
1	Technical study and finalization of the justification for selecting Bima and Langgur as pilot projects	Manager O&M PLN Nusantara Power	1–2
2	Approval of the business case and allocation of the scheme-transition budget	GM PLN Nusantara Power (Sponsor)	2
3	Negotiation and preparation of the Sharing O&M Agreement with the OEM	Senior Manager O&M & VP O&M PLN Nusantara Power	3–4
4	Onboarding of the OEM advisory team and alignment of maintenance SOPs	VP O&M & Field O&M Personnel	5–6
5	Parallel piloting of the Sharing O&M scheme at both units (transition period)	Field O&M Personnel (with OEM Advisory)	6–9
6	Monitoring of initial performance (monthly Availability, MOH, and EFOR)	Manager O&M PLN Nusantara Power	9–10
7	Evaluation of pilot results and decision on scaling up to other Mandiri units	Senior Manager O&M & PLN Holding Operations and Control	11–12

Source: Author.

Table 18. Pilot Monitoring and Evaluation Framework

Dimension	Indicator	Frequency	PIC	Evaluation Criteria
Reliability	Availability, EAF, EFOR, MOH, MTTR	Monthly	Manager O&M	Improving trend and SLA fulfillment
Operating Performance	OEE and Net Production	Monthly	Unit and Manager O&M	Improvement vs. baseline, with dispatch explanation
Cost	O&M cost, cost per MWh, budget variance	Monthly/Quarterly	Finance and O&M	Within business case and budget limits
Capability	OEM response time, knowledge transfer, spare-parts fulfillment	Monthly	Subholding and OEM	Fulfillment of contractual SLA

Dimension	Indicator	Frequency	PIC	Evaluation Criteria
Decision	Evaluation of benefits, costs, risks, replication	Months 10–12	Steering committee	Go, revise, or stop

Source: Author.

CONCLUSION

PLTMG operational effectiveness is primarily determined by each unit's ability to maintain availability and control operational losses. Aggregate Availability reached 89.67% under Mandiri O&M, 93.15% under Mandiri O&M with LTSA, and 96.84% under Sharing O&M, with the lowest performance observed at Langgur (67.99%) and Bima (63.06%). Maintenance Outage was the dominant loss category, accounting for 61.65% of total equivalent loss hours. The Current Reality Tree analysis linked this pattern to limited OEM technical and advisory support, insufficient spare-parts readiness, gaps in knowledge transfer, and misalignment between the selected O&M model and plant characteristics. These factors collectively contributed to slower technical response, longer Mean Time to Repair (MTTR), and reduced Availability and Equivalent Availability Factor (EAF). However, these findings should be interpreted with consideration of potential inconsistencies in outage-event classification within the available data.

Improving PLTMG performance therefore requires an integrated approach rather than relying solely on increased expenditure or contractual adjustments. The Analytic Hierarchy Process (AHP) results assigned weights of 69.55% to Operational Reliability, 22.90% to O&M Cost Optimization, and 7.54% to Sustainable Capability, with Increasing EAF obtaining the highest global subcriterion weight at 52.16%. In the final synthesis, Sharing O&M achieved the highest global priority with a weight of 69.56% and ranked first across all evaluation criteria, followed by Mandiri O&M with LTSA at 23.59% and Mandiri O&M at 6.81%. These results were consistent with the operational performance assessment, although the representation of Sharing O&M was limited to only one unit.

Based on these findings, this study recommends a phased implementation approach consisting of strengthening OEE data governance and outage classification, improving Service Level Agreement (SLA) requirements for technical response time and spare-parts lead time, and conducting a 12-month pilot implementation of Sharing O&M at PLTMG Bima and Langgur. The pilot should be monitored using reliability, cost, and capability indicators before decisions are made regarding broader implementation. Future research should extend the observation period and include a larger number of Sharing O&M units, incorporate perspectives from engine manufacturers, and convert operational losses into energy and financial impacts to support more comprehensive and evidence-based decisions regarding O&M schemes across PLTMG units with different operational characteristics.

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