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Workload Analysis to Determine Mechanical Workforce Requirements (Fulltime Equivalents) in Mining Projects: A Case Study of PT TMP

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ABSTRACT

The mining industry requires an optimal mechanical workforce to ensure equipment reliability, operational efficiency, and sustainable productivity. However, workforce allocation is often determined using conventional approaches that may not adequately reflect actual workload variations, resulting in potential overstaffing or understaffing. This study aimed to determine the optimal number of mechanical personnel required in the Asset Management Group (AMG) Department of PT TMP by applying the Full-Time Equivalent (FTE) method and integrating the results with Key Performance Indicators (KPIs), the Balanced Scorecard (BSC), Strategic Workforce Planning (SWP), and expert judgment. A quantitative descriptive approach was employed using historical maintenance data collected from April to December 2025, including work orders, maintenance duration, manpower requirements, and effective working hours. The workload was converted into FTE values, validated through expert judgment, and subsequently evaluated against departmental performance indicators. The findings revealed that the average ideal workforce requirement was 21.8 mechanics, with a peak demand of 39 mechanics, while the actual workforce averaged 37.9 mechanics. Nevertheless, expert validation recommended maintaining a workforce level of 45–48 mechanics as a strategic manpower buffer to accommodate operational uncertainties during the project transition period. Integration with KPIs demonstrated improvements in Physical Availability (98.6%), Mean Time Between Stoppages (118.3 hours), Mean Time to Repair (3.2 hours), and Manpower Cost per Hour (USD 5.66). The study concluded that integrating FTE analysis with performance management and strategic workforce planning provided a comprehensive, evidence-based framework for optimizing workforce allocation and supporting long-term operational sustainability in mining projects.

INTRODUCTION

In the mining industry, the availability of qualified human resources (HR) aligned with operational requirements is a key factor determining project success (Anggraini & Gustomo, 2025; Geethanjali et al., 2024; López-Lemus et al., 2024; Mamudu et al., 2025; Rathor et al., 2026). Labor efficiency, particularly within the mechanical maintenance function, significantly influences production continuity and heavy equipment productivity in operational areas, considering that mechanical teams are responsible for maintaining and repairing heavy equipment units and supporting vehicles used in mining operations.

However, an imbalance often exists between the available mechanical workforce and the actual workload conditions in the field (Cai et al., 2025; Kurnia & Juwita, 2026; Rafiee et al., 2025; Su et al., 2022). Excessive staffing may lead to inefficient labor costs, whereas insufficient mechanical personnel may increase equipment maintenance duration, delay repairs, and reduce equipment reliability (Asamoah et al., 2025; Krynke et al., 2022; Mihalj et al., 2022). To address these challenges, a quantitative approach is required to objectively evaluate the relationship between actual workload and workforce requirements. One relevant approach is Workload Analysis using the Full-Time Equivalent (FTE) method, which measures total workload against employees' effective working capacity to determine the optimal workforce requirement for achieving operational productivity targets (Kurniawan, 2020).

According to Amri (2023), the FTE approach provides a clear representation of actual work capacity and can support workforce design, particularly in preventing overstaffing and understaffing. Similarly, Alvin (2024) demonstrated that workload analysis within engineering divisions improves workforce planning accuracy compared with conventional estimation approaches. In several mining projects, labor requirements are still commonly estimated using simplified approaches, such as equipment-to-mechanic ratios or limited time studies, which may not fully represent the relationship between workload volume and effective labor capacity.

Without a systematic calculation of workforce requirements using the FTE method, uncertainty in manpower allocation may continue to affect project productivity and achievement of organizational Key Performance Indicator (KPI) targets. Therefore, this study not only addressed short-term operational challenges but also integrated FTE analysis with Key Performance Indicators (KPIs), Balanced Scorecard (BSC), and Strategic Workforce Planning (SWP) to support data-driven human resource decisions and long-term business strategies. These analyses were further validated through expert judgment. The novelty of this research lies in the simultaneous integration of these approaches within the mechanical function of the Asset Management Group (AMG) Department in the mining industry, including technical validation through expert judgment during temporary operational standby conditions.

Workforce planning is particularly important in heavy equipment maintenance because the mechanical function directly affects mining production continuity (Galatia, n.d.; Mhonsiwa, 2024; Sahiner & Golbasi, 2026; Senses, 2025; Werbinska-Wojciechowska & Rogowski, 2025). Mechanical personnel perform preventive maintenance, corrective repairs, inspections, troubleshooting, component replacement, major overhauls, and emergency breakdown recovery. An insufficient number of mechanics may prolong equipment downtime, increase Mean Time to Repair (MTTR), delay scheduled maintenance, and reduce Physical Availability (PA). Conversely, maintaining a workforce beyond actual workload requirements may create idle capacity, increase labor costs, and reduce manpower productivity. This challenge is intensified by monthly workload fluctuations caused by fleet mobilization, changes in equipment utilization, component fatigue accumulation, major maintenance schedules, unplanned failures, weather conditions, and spare-part availability. Therefore, mechanical workforce requirements cannot be determined solely through fixed equipment-to-mechanic ratios, managerial assumptions, or historical headcount data, as these approaches may not accurately represent the relationship between workload demand and productive labor capacity.

This issue was observed in the Asset Management Group Department of PT TMP, where the mechanical workforce was responsible for supporting the maintenance of excavators, haul trucks, and supporting equipment units. The company's maintenance workload was recorded through Work Orders classified into Planned Orders and Unplanned Orders, including information on breakdown duration, manpower requirements, component descriptions, work schedules, and completion times. However, the project experienced a temporary standby and transition period, resulting in significant workload fluctuations during the April–December 2025 observation period. The study recorded a total maintenance workload of 34,782 man-hours, with monthly workloads ranging from 312 man-hours in April to 7,026 man-hours in November. During the same period, the actual number of mechanics ranged from 18 to 45 personnel, while the calculated workforce requirements varied between 2 and 39 mechanics. These conditions indicate that static workforce allocation may generate excess capacity during low-demand periods while providing insufficient flexibility when maintenance demand reaches peak levels.

Previous research has established the Full-Time Equivalent method as a practical approach for converting workload requirements into measurable workforce needs. Amri's study on workforce design in an industrial company applied FTE calculations to identify overloaded and underloaded workstations, demonstrating that workload conversion can reveal workforce imbalances that may not be apparent through conventional staffing assessments. Another study involving laboratory and sample-house employees in a mining company applied the FTE method following increased production activities that affected employee workload. The study concluded that FTE analysis could support workforce planning, recruitment cost evaluation, workload balancing, and safer working conditions. Research in production environments has similarly demonstrated that FTE analysis can determine optimal staffing levels by comparing required activity time with employees' effective working capacity. Collectively, these findings support the use of FTE as an objective basis for workforce determination rather than relying solely on subjective managerial estimation.

Several studies have also applied workload-based calculations to maintenance functions. A 2024 study on maintenance personnel requirements developed an FTE-based approach and validated it within a mining maintenance environment. The study indicated that FTE values exceeding available capacity represent workload overutilization, whereas lower values indicate underutilization, providing useful information for operational decision-making. Other research involving operational and maintenance departments has applied FTE analysis to evaluate employee workload and determine whether staffing levels correspond with available working hours. Furthermore, current workforce planning literature emphasizes the importance of aligning staffing decisions with scheduling, employee competencies, digital data utilization, productivity objectives, and long-term organizational requirements. These studies demonstrate that workload measurement improves workforce decision-making; however, most focus primarily on employee quantity determination, workload classification, or staffing adjustment without comprehensively connecting workforce requirements with strategic operational performance.

Despite increasing research attention, several gaps remain. First, many FTE studies focus on manufacturing, administrative, healthcare, or production-line environments where workload patterns are relatively stable, whereas mining maintenance workloads are highly dynamic and influenced by equipment failures, overhaul schedules, fleet mobilization, and operational transitions. Second, existing studies often treat FTE results as the final workforce recommendation without evaluating whether mathematically calculated requirements are operationally sufficient under uncertain conditions. Third, limited research integrates FTE calculations with departmental KPIs, including Physical Availability, Mean Time Between Stoppages (MTBS), Mean Time to Repair, and Manpower Cost per Hour. Fourth, the relationship between workforce planning and the four Balanced Scorecard perspectives—learning and growth, internal processes, customers, and financial performance—remains insufficiently explored within mining maintenance contexts. Finally, FTE calculations are rarely incorporated into broader Strategic Workforce Planning frameworks involving recruitment, retention, competency development, multi-skilling, contingent labor, digitalization, and periodic workforce evaluation.

Addressing these gaps is important because inaccurate mechanical workforce planning may create consequences beyond labor expenditure. Understaffing may increase repair backlogs, employee fatigue, overtime dependency, unsafe maintenance practices, and production losses caused by prolonged equipment downtime. Conversely, overstaffing may reduce labor utilization and increase unnecessary fixed costs, particularly during standby, mobilization, or reduced-production periods. In the PT TMP case, preliminary calculations indicated an average ideal requirement of 21.8 mechanics compared with an average actual workforce of 37.9 mechanics. Nevertheless, expert validation suggested that a purely mathematical average would not sufficiently accommodate unexpected equipment failures, spare-part waiting times, limited tools, and project-transition risks. This difference highlights the importance of combining quantitative workload analysis with structured expert judgment. Workforce efficiency should therefore not be interpreted solely as headcount reduction but as the development of an adaptive staffing strategy that maintains equipment reliability, cost efficiency, operational resilience, and employee safety.

The novelty of this research lies in the integrated application of Full-Time Equivalent analysis, expert judgment, Key Performance Indicators, Balanced Scorecard, and Strategic Workforce Planning within a mining mechanical-maintenance context. Unlike previous studies that focus only on workload classification or workforce estimation, this research evaluates whether calculated workforce requirements align with actual departmental performance. The analysis connects manpower capacity with equipment reliability indicators, including Physical Availability, Mean Time Between Stoppages, and Mean Time to Repair, as well as financial performance indicators such as Manpower Cost per Hour. Expert judgment was applied not only to validate calculations but also to translate workload results into realistic strategic manpower requirements. Furthermore, the study extends workforce analysis into eight strategic workforce planning areas, including recruitment, retention, learning and development, digital work methods, role redesign, productivity planning, outsourcing, and workforce control. This integrated framework provides a more comprehensive approach for managing fluctuating maintenance demand compared with using FTE as an isolated numerical calculation.

Accordingly, this study aimed to determine the optimal mechanical workforce requirement for the Asset Management Group Department of PT TMP based on actual maintenance workload data collected from April to December 2025. Specifically, this study aimed to calculate monthly mechanical workforce requirements using the Full-Time Equivalent method, compare calculated requirements with actual workforce levels, validate workload standards and staffing recommendations through expert judgment, examine the relationship between workforce allocation and departmental KPIs, integrate findings into the Balanced Scorecard framework, and formulate Strategic Workforce Planning recommendations for future operational conditions. Academically, this research contributes an integrated model connecting workload measurement, performance management, and strategic human resource planning within the mining industry. Practically, the findings provide PT TMP with an evidence-based foundation for recruitment planning, workforce deployment, competency development, flexible staffing strategies, budgeting, and workforce evaluation. The results may also benefit mining contractors and other asset-intensive organizations seeking to balance labor efficiency with equipment reliability, operational flexibility, safety, and sustainable business performance.

METHOD

This study employed a quantitative descriptive approach to measure and analyze the workload of mechanical personnel and determine the ideal workforce requirement using the Full-Time Equivalent (FTE) method. The quantitative approach was selected because the study focused on analyzing actual work activity data that could be processed mathematically to support objective workforce planning. According to Tajudin (2024), quantitative descriptive research is useful for systematically describing managerial phenomena based on numerical data. This study was not intended to test hypotheses but rather to map existing conditions and provide a foundation for data-driven strategic decision-making.

The research was conducted at PT TMP, a mining contractor operating large-scale projects involving technical personnel across mechanical, operational, and support functions. The study focused on the mechanical function under the Senior Maintenance Superintendent and Maintenance Foreman within the Asset Management Group (AMG) Department, which was responsible for maintaining mining equipment units. This study examined two main variables: workload, defined as the total time required to complete mechanical work activities within a specific period, and ideal workforce requirement measured through Full-Time Equivalent (FTE), calculated as the ratio between total workload hours and the effective working capacity of one full-time employee. The operational definitions of these variables are presented in Table 1.

Table 1. Operational Definition of Research Variables

Yes	Variable	Operational Definition	Units	Data Source
1	Workload	Total time required to complete all mechanical work activities	Working hours/year	Mechanical activity recap (Excel)
2	FTE	Comparison between actual workload and effective working time per person per year	People	Effective activity and hours data

Data were obtained from internal company documents, including asset identity (functional location and unit model), job classification (planned order and unplanned order), time parameters (start/end downtime date and time), technical workload (manpower requirements and standard duration), maintenance objects (component and sub-component descriptions), and operational data (shift date and shift type). Data collection was conducted through the compilation of daily and weekly activity reports recorded in PT TMP's internal system, supplemented by limited interviews with the Senior Maintenance Superintendent for technical validation of data accuracy and FTE calculation results.

The FTE method was selected over other workload measurement approaches, such as NASA-TLX and Work Sampling, based on three main considerations: its quantitative capability to convert workload volume into measurable workforce requirements, its compatibility with historical Work Order data as the primary data source, and its widespread application in workforce sizing analysis within industrial environments. A comparison of the three methods is presented in Table 2.

Table 2. Comparison of Workload Measurement Methods

Comparison Criteria	Full-Time Equivalent (FTE)	NASA-TLX	Work Sampling
Key Focus	Conversion of total workload to headcount	Measurement of mental workload and subjective stress levels	Proportion of productive vs non-productive time of personnel
Data Source	Secondary data (Work Order, technical time standard)	Questionnaire/survey directly to workers	Random live observation during business hours
Strategic Output	Figures of Workforce Need for Budget Planning (Budgeting)	Evaluation of individual fatigue and work comfort	Identification of inefficiencies or idle time
Objectivity	High (based on historical quantitative data of occupations)	Low (depending on the individual's subjective perception)	Medium (depending on observer accuracy)
Industry Suitability	Suitable for heavy equipment/mining industry with thousands of WO	More suitable for operators with high concentration focus	Suitable for manufacturing production line process optimization

Data analysis is carried out through four main stages. First, the identification and categorization of workloads from the secondary data of the SAP system for the April-December 2025 period, which is cleaned (data cleaning) and grouped into Planned Maintenance and Unplanned Repair. Second, the validation of the standard time (Normal Duration) through Expert Judgment involving a panel of experts with the following criteria: minimum 10 years of work experience in the field of heavy equipment maintenance, having or currently occupying a managerial position (Foreman/Supervisor/Superintendent), having relevant technical certifications, and mastering the maintenance management system (SAP/CMMS) and departmental KPI parameters. Third, the calculation of Full-Time Equivalent (FTE) by comparing the Total Actual Working Time (TWKA) to the Effective Working Time (WKE); The FTE index > 1.2 indicates overload. An example of the calculation format is presented in Table 3. Fourth, the gap analysis between FTE results and the availability of existing mechanics and their integration into the achievement of KPIs and BSC perspectives, which subsequently became the basis for the preparation of Strategic Workforce Planning (SWP) recommendations.

Table 3. Example of FTE Calculation Format

Yes	Departments	TWKA (Hours/Year)	WKE (Hours/Year)	FTE Value	Actual Amount	Difference (Ideal vs. Actual)
1	Mechanic	2.420	2.000	1,21	10	+2
2	Helper	1.860	2.000	0,93	8	-1

The reliability of the analysis results is guaranteed through expert validation, where the calculation results are submitted to the authorities in the maintenance department to obtain technical verification and adjustments to the actual field conditions, considering that the operational conditions of the project that are in the temporary standby phase make the direct observation method (stopwatch time study) unrepresentative to use. In summary, the research flow follows five strategic stages as shown in Figure 1, namely workload identification and categorization, standard time validation through expert judgment, FTE calculation, gap analysis and KPI/BSC integration, and the formulation of Strategic Workforce Planning.

Figure 1. Research Flow Diagram

RESULTS AND DISCUSSION

Data Overview and Validation

The object of this research is the maintenance management system of the heavy equipment fleet in the PT TMP mining project, which consists of the Excavator class (digging-loading equipment), the Truck class (transportation equipment), and the supporting equipment class such as Dozer, Grader, and Loader. Each maintenance activity is based on the Work Order (WO) which is divided into Planned Order (planned maintenance) and Unplanned Order (emergency repair due to breakdown), with time parameters in the form of Total Breakdown Hours, Delay Hours, and Breakdown Duration/Normal Duration.

Before being analyzed, historical data for the April-December 2025 period was validated through expert judgment by Mr. Jepi Kemba as Senior Maintenance Superintendent (Department Head of AMG) who has more than 15 years of experience in the field of mining heavy equipment maintenance. This validation is necessary because data collection is carried out when the AMG Department is in the temporary standby phase, so the stopwatch time study method is directly considered unrepresentative. Based on the instrument validation statement sheet signed on January 15, 2026, the expert stated that the table of maintenance activities and estimated working time prepared was appropriate and sufficiently representative of actual operational conditions, including the effective working time of 180.5 hours per month which was considered realistic as a divider base in the conversion of workload into FTE values.

Distribution of Maintenance Activity Workload in 2025

The total accumulated work volume during the April-December 2025 period was recorded at 34,782 man-hours, with a monthly average of 3,864.67 man-hours. As presented in Table 4, the lowest workload occurred in April (312 man-hours or 0.90% of the total) reflecting the initial phase of fleet mobilization, then increased sharply until it peaked in November (7,026 man-hours or 20.20% of the total) due to the simultaneous implementation of major overhaul and replacement of major components, before declining again in December (3,168 man-hours) as year-end operational stabilization.

Table 4. Monthly Maintenance Activity Workload Distribution in 2025

Moon	Total Man-Hours	Percentage (%)
April	312	0,90
May	1.904	5,47
June	2.846	8,18
July	3.832	11,02
August	5.822	16,74
September	5.426	15,60
October	4.446	12,78
November	7.026	20,20
December	3.168	9,11
Total	34.782	100,00

In terms of the nature of work, the average volume of work is 619 jobs per month, with planned orders dominating at an average of 399.2 jobs per month or 54.9%. Table 5 shows that the percentage of planned orders increased gradually from 32% in April (the initial mobilization phase) to a peak of 75% in December, although it had decreased in September–October (49%) due to fleet fatigue after extreme utilities in the previous months. The sharp increase in planned orders in November–December represents the implementation of large-scale maintenance programs that are scheduled centrally, such as major overhaul and component replacement programs.

Table 5. Number of Monthly Planned and Unplanned Jobs in 2025

Moon	Planned Order	Unplanned Order	Total Work	Planned Percentage (%)
April	12	25	37	32
May	96	113	209	46
June	137	120	257	53
July	214	151	365	59
August	291	204	495	59
September	272	280	552	49
October	216	225	441	49
November	1.144	447	1.591	72
December	1.211	414	1.625	75

Effective Working Time Calculation and FTE Calculation

Effective Working Time (WKE) is calculated by multiplying the total days in a month by four reduction factors, namely the OFF work pattern (13:1) of 0.92857, the work schedule pattern (9:2) of 0.81818, the attendance rate of 0.99, and the wrench time of 0.80 (Palmer, 2007). As presented in Table 6, the calculation results show an effective working day of 18.05143 days per month, which is equivalent to 180.51429 effective working hours per month.

This number is used as a denominator in the FTE formula and has been validated by expert judgment as a realistic representation of productive working time.

Table 6. Effective Working Time Calculation

Parameters	Value	Remarks
Work Cycle (A)	0,92857	13 Weekdays & 1 Holiday
Breezeblock Pattern (B)	0,81818	9 Work Weeks & 2 Weeks Off
Attendance History (C)	0,99000	99% (reducing factors: pain, permission, and alpha)
Wrench Time 80% (D)	0,80000	References: Palmer, 2007
Effective Business Days/Months	18,05143	Multiply the number of days in 1 month by A, B, C, and D
Effective Working Hours/Month	180,51429	Multiply daily effective working time by effective working days/month

Based on the division of the total monthly workload (Table 4) by the effective working time (Table 6), the Ideal FTE value is obtained each month which is then compared to the actual number of mechanics deployed in the field. Table 7 shows that the number of actual mechanics is consistently well above the ideal requirement: the average FTE Ideal is only 21.8 mechanics per month, while the average actual mechanic is 37.9 people, so the average utility ratio is 279% and the average potential overwork (gap analysis) is 179% per month. The most extreme gap occurred in April (FTE Ideal 2 compared to Actual 18, ratio of 1041%, potential surplus 941%) as a consequence of the standby manpower policy in the pre-mobilization phase. The best efficiency point was reached in November (FTE Ideal 39 vs. Actual 44, ratio of 113%, potential surplus only 13%), which shows that the utilization of mechanical work capacity has been close to optimal as the fleet repair workload is high.

Table 7. Comparison of Ideal FTE with Actual Mechanical Numbers by 2025

Moon	FTE Ideal	Actual Mechanics	Actual vs. Ideal FTE Ratio (%)	Excess Mechanical Potential (%)
April	2	18	1041	941
May	11	28	257	157
June	16	34	216	116
July	22	41	187	87
August	33	43	129	29
September	30	45	150	50
October	25	45	177	77
November	39	44	113	13
December	18	43	237	137
Average	21,8	37,9	279	179

Integration of FTE Results with Key Performance Indicators and Balanced Scorecard

The Balanced Scorecard (BSC) is integrated not only as a historical performance evaluation tool, but also as a strategic validation instrument to test the suitability of mechanical FTE results to the performance of the AMG Department in four perspectives, namely Learning & Growth, Internal Business Processes, Customers, and Finance. A summary of the achievements of each perspective towards the 2025 target is presented in Table 8.

Table 8. Balanced Scorecard Performance Achievements in 2025

Perspective	Metrics	Target	Actual	Remarks
Learning & Growth	Realization of competency development program (upskilling)	Minimum 1 program/level	2 programs/level	Exceeding targets
Internal Business Processes	Mean Time Between Stoppages (MTBS)	≥ 65 hours	118.3 hours	Exceeding targets
Internal Business Processes	Mean Time To Repair (MTTR)	≤ 10 hours	3.2 hours	Exceeding targets
Customers	Physical Availability (PA)	≥ 92.0%	98,6%	Exceeding targets
Finance	Manpower Cost per Hour (CPH)	≤ \$7.82/Hour	\$5.66/hour	Exceeding target (efficiency 27.6%)

From a Learning & Growth perspective, the competency development program successfully promoted 1 mechanic to Senior Mechanic/PMT (from the previous vacancy at that level) as well as promoted 1st grade mechanic from Mech/PMT 2 to Mech/PMT 1, out of a total population of 43 personnel. This competency improvement is a key enabler for improvement from an Internal Business Process perspective: fleet reliability (MTBS) increased to 118.3 hours, far exceeding the 65-hour target, while the repair speed (MTTR) was successfully reduced to 3.2 hours from the 10-hour tolerance limit. The combination of high MTBS and low MTTR directly drove the achievement of Physical Availability (PA) from the customer's perspective to reach 98.6%, far above the target of 92.0%, with a breakdown ratio that was successfully reduced to 1.4%. During the nine months of observation, the actual PA was always above the target line, with an average achievement index against the target of 107.12%, although there was a slight downward trend in the year-end quarter (from 99.2% in August to 97.3% in December) indicating the accumulation of component fatigue as cumulative hours increased.

Mean Time Between Stoppages (MTBS) Monthly

Monthly MTBS data throughout 2025 (Table 9) shows a positive growth trend from 51.80 hours in April to a peak of 156.80 hours in September, before fluctuating in the last quarter. The average MTBS achievement of 118.28 hours per month with a standard deviation of 33.68 hours confirms that preventive and predictive maintenance policies are effective, although the high inter-month variability indicates the need to pay attention to external factors such as weather and the supply of critical components.

Table 9. Mean Time Between Stoppages (MTBS) Monthly in 2025

Moon	MTBS Actual (Hours)	MTBS Target (Hours)
April	51,80	65
May	79,90	65
June	95,30	65
July	142,10	65
August	151,00	65
September	156,80	65
October	123,70	65
November	143,50	65

Moon	MTBS Actual (Hours)	MTBS Target (Hours)
December	120,40	65
Average	118,28	65

Strategic Workforce Planning (SWP)

Based on the validation of expert judgment on the results of FTE, it was found that the pure requirement figure (average 21.8 mechanics, peak of 39 mechanics) has not fully accommodated operational risks in the project transition phase, so a more realistic number of workers of 45–48 mechanics is recommended as a strategic manpower buffer. The difference between the pure requirement figure and the expert's proposed figure serves to mitigate the limitation of tools, the risk of delays in the procurement of spare parts (waiting parts), and unpredictable unit damage. For long-term projections when operations enter the full normal phase of operation in 2026, experts assess that the need for manpower is expected to increase to around 60 mechanics.

Referring to these findings, this study formulates eight pillars of Strategic Workforce Planning (SWP) action as summarized in Table 10, which include a selective recruitment policy based on real needs, retention of competent mechanics through KPI-based incentive schemes, competency development towards predictive maintenance, digitalization of maintenance administration, implementation of multi-skilling for placement flexibility, standardization of work-time (standard job-time), utilization contingent workforce in the ramp-up phase, to periodic audits of the suitability of the size of the workforce with the number of active fleets.

Table 10. Strategic Workforce Planning (SWP) Recommendations

SWP Pillars	Strategic Action Focus
Recruitment	Selective and on-demand addition of permanent workforce
Retention	Providing incentives and awards associated with KPI achievements and K3LH compliance
Learning & Development	Upskilling program with a focus on predictive maintenance expertise
New Method of Work	Digitization of maintenance administration, including real-time work order closure
Redefining Roles	Multi-skilling skills development for deployment flexibility
Productivity Plan	Standard job-time as a reference for work efficiency
Outsourcing Plan	Utilization of contingent/short-term contract labor in the production ramp-up phase
Controlling Size	Periodic audit of the suitability of the size of the workforce with the number of active fleets

Recommendations for the Utilization of Digital Systems in Workload Measurement

This research also identifies opportunities to increase the objectivity of workload measurement through the use of the Asset Resources Management System (ARMS), which is a digital system for managing maintenance activities that has been implemented by PT TMP in other projects and integrated with Enterprise Resource Planning (ERP). Through mobile applications, mechanics can record timecards, update work progress, and document activity start and end times in real-time, so that the recorded data has a better level of traceability and validity than manual recording. The application of ARMS at the research site has the potential to increase the accuracy of effective working time and reduce subjectivity in the data collection process for FTE calculation in the future period.

CONCLUSION

The results of the Full-Time Equivalent (FTE) analysis showed that mechanical workforce requirements in the AMG Department of PT TMP fluctuated according to maintenance workload dynamics during April–December 2025. The average workforce requirement was 21.8 mechanics, with a peak demand of 39 mechanics. However, expert judgment validation recommended maintaining a more realistic workforce level of 45–48 mechanics as a strategic manpower buffer to accommodate operational risks during the project transition phase. The integration of FTE results with Key Performance Indicators (KPIs) and the Balanced Scorecard demonstrated that effective workforce management contributed to improved Physical Availability (98.6% compared with the 92.0% target), reduced Mean Time to Repair (3.2 hours compared with the 10-hour target), increased Mean Time Between Stoppages (118.3 hours compared with the 65-hour target), and improved Manpower Cost per Hour efficiency (USD 5.66 compared with the USD 7.82 per hour threshold).

Based on the Strategic Workforce Planning approach, this study recommended implementing a strategic manpower buffer, strengthening competency development through upskilling, cross-skilling, and multi-skilling programs, optimizing flexible workforce allocation according to workload fluctuations, and digitizing maintenance activity records through systems such as ARMS to improve data accuracy for future analysis. For PT TMP, the FTE analysis results are recommended as a basis for workforce planning combined with expert judgment to ensure that manpower decisions consider operational risks in the field. The AMG Department is also advised to apply the strategic manpower buffer adaptively and continuously improve upskilling and cross-skilling initiatives to maintain workforce flexibility and productivity sustainably. Future research is recommended to measure working time directly using methods such as Stopwatch Time Study or Work Sampling under normal operational conditions, as well as to develop Strategic Workforce Planning analyses supported by data analytics or Artificial Intelligence (AI) to improve the accuracy of workforce demand projections in the mining industry, which is characterized by dynamic and fluctuating workloads.

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