

Analyzing Organizational Structures for Shift Workers in Mining Division Unit Pertambangan Tanjung Enim (UPTE) PTBA



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Abstract

The objective of this research is to determine the most suitable shift work model for supervisory positions at PTBA-UPTE, with the aim of improving productivity, employee well-being, and cost-effectiveness. The study utilized a mixed-methods design, incorporating focus group discussions with industry experts, benchmarking practices, and the Analytical Hierarchy Process (AHP) to support multi-criteria decision-making. Three alternative models were assessed: the existing 3-shift rotation, an extended-hours 2-shift model, and a hybrid system combining elements of 2-shift and non-shift schedules. Based on the AHP analysis, the hybrid model emerged as the most advantageous, demonstrating a 35% reduction in required manpower and stronger alignment with both operational efficiency and workforce wellness objectives.

Keywords: Shift Work, Productivity Analysis, Hybrid Model, Mining Operations, Analytical Hierarchy Process (AHP)

INTRODUCTION

The mining industry represents a fundamental component of Indonesia's national economy, playing a vital role in driving growth and development. One of the leading entities in this sector is PT Bukit Asam (PTBA), a state-owned enterprise that manages the Tanjung Enim Mining Unit (UPTE). UPTE oversees both internally managed and contractor-operated mining areas, functioning continuously around the clock. In this environment, supervisory personnel are essential in maintaining productivity, ensuring safety, and controlling operational costs. However, the existing shift work arrangements are outdated and fail to adequately support employee well-being, operational efficiency, and cost-effectiveness. This research explores and assesses alternative shift work models specifically for supervisory roles at PTBA-UPTE, with the goal of identifying the most appropriate system that meets operational demands while supporting strategic organizational objectives.

REVIEW OF LITERATURE

Shift Work in the Mining Sector and Related Industries

Due to the continuous nature of operations, the mining sector typically relies on 24 hour shift schedules to maximize output and fulfill market demands. Although this approach helps extend operational time, it presents distinct challenges in managing the workforce efficiently. Shift schedules must be designed not only to support operational goals but also to safeguard employees' health and safety. Mining personnel working irregular hours often encounter issues such as fatigue, disruption of circadian rhythms, and decreased cognitive functioning, all of which can compromise both productivity and workplace safety (Tsvetkova et al., 2019).

NASA Task Load Index (NASA-TLX)

The NASA Task Load Index (NASA-TLX) is a tool used to measure cognitive workload by evaluating multiple dimensions of task performance. It has been widely applied in various sectors due to its structured approach (Sugarindra et al., 2017). The method assesses workload based on six primary dimensions:

1. **Mental Demand** – The level of cognitive and perceptual activity required.
2. **Physical Demand** – The extent of physical effort involved.
3. **Temporal Demand** – The pressure experienced due to time constraints.
4. **Performance** – The individual's perception of task success.
5. **Effort** – The amount of mental and physical exertion invested.
6. **Frustration Level** – The emotional response, including feelings of stress, insecurity, and irritation.

The evaluation procedure comprises three stages. Initially, individuals rate each dimension on a subjective scale (usually 0 to 100), based on their experiences during a task. In cases where the relevance of each dimension varies, participants perform pairwise comparisons to assign weights to each factor, reflecting its relative importance. The final workload score is then calculated either by summing the weighted values or averaging the unweighted ratings, depending on whether weighting is used in the analysis (Virtanen et al., 2022).

Criteria for Designing Effective Shift Work Systems

To create an effective shift work system, several critical factors must be taken into account. These criteria generally fall into three main categories: shift scheduling, employee health and well-being, and work-life balance supported by organizational structures.

1. Shift Scheduling

- **Ergonomic Shift Planning:** Designing shifts based on ergonomic principles is essential to reduce circadian rhythm disruptions and their negative effects (Costa, G., 2012). Implementing fast-forward rotating shifts or fixed night shifts can help stabilize sleep cycles, although fixed shifts may lower employee satisfaction (Dall'Ora et al., 2016).
- **Shift Length and Frequency:** Working shifts longer than 12 hours or exceeding 40 hours per week has been linked to reduced job performance and a rise in negative outcomes. To counteract fatigue and sustain efficiency, regular rest breaks and days off are crucial (Costa, G., 2012).
- **Minimizing Quick Turnarounds:** Avoiding short recovery periods between shifts (quick returns) is important because they are associated with increased exhaustion and health risks (D'ettorre et al., 2018).

2. Health and Well-being

- **Medical Monitoring:** Ongoing health assessments can help detect early signs of shift work intolerance. Counseling and preventive strategies can also support workers in adapting to irregular schedules (Costa, G., 2012).
- **Lifestyle and Behavioral Support:** Encouraging good nutrition, regular exercise, and strategic light exposure can help reduce health risks. Additionally, behavioral and pharmaceutical aids like modafinil may be effective in managing excessive sleepiness and boosting alertness (Deng et al., 2018; Savarese & Di Perri, 2020).

3. Work-Life Balance and Organizational Support

- **Flexible Scheduling Options:** Customizing work shifts to better align with employees' personal lives can promote a healthier work-life balance (Skýpalová et al., 2022). Whenever possible, shift systems should consider individual preferences and circumstances.
- **Social and Domestic Support Services:** Enhancing access to services that help employees manage home and family responsibilities can significantly improve the quality of life for shift workers (Costa, G., 2012).

4. Organizational Support

- **Employee Satisfaction:** Monitoring and enhancing job satisfaction is vital to reducing workplace stress and minimizing staff turnover. Organizations should prioritize managing sleep quality and fatigue to improve both productivity and employee retention (Hatipoğlu et al., 2013).
- **Maintaining Safety and Efficiency:** Balancing productivity with workplace safety is essential. This includes assessing how factors such as shift duration, break times, and the number of consecutive night shifts influence overall performance and safety outcomes (Folkard & Tucker, 2003).

5. Regulatory and Organizational Policy Considerations

- **Regulatory Compliance:** All shift schedules must align with labor laws and internal company regulations. For example, Garuda Indonesia faces complex crew scheduling

challenges due to stringent internal policies, which require the use of advanced mathematical modeling to find feasible solutions (Hadianti et al., 2014).

- **Shift Schedule Optimization:** Sophisticated tools such as Binary Integer Goal Programming (BGP) and genetic algorithms are increasingly applied to develop optimized shift schedules. These models aim to incorporate employee preferences while minimizing scheduling conflicts (Sardjono et al., 2021).

Analytic Hierarchy Process (AHP)

As outlined by Akram and Adeel (2023), the Analytic Hierarchy Process (AHP) is a highly adaptable and effective method for making decisions, particularly in situations involving multiple criteria. Its strength lies in its ability to break down complex problems into structured hierarchies, quantify subjective assessments, and verify consistency. Advanced variations such as fuzzy AHP further enhance its usefulness by addressing uncertainties in human judgment.

Main Advantages of AHP:

1. **Hierarchical Problem Structuring:** AHP simplifies intricate decision-making challenges by organizing them into a hierarchy that includes goals, criteria, sub-criteria, and potential alternatives. This structure makes complex problems easier to understand and resolve (Jawad et al., 2024).
2. **Pairwise Evaluation Method:** The method utilizes pairwise comparisons to assess the importance of various criteria and alternatives. This systematic comparison simplifies decision-making by breaking it down into more manageable evaluations (Gasparotti & Domnisoru, 2020).
3. **Balancing Subjective and Objective Judgments:** AHP allows for the integration of personal preferences with factual data by translating subjective judgments into numerical values. This comprehensive approach enriches the decision-making process (Jurásková, 2014).
4. **Consistency Validation:** The process incorporates a consistency check to ensure that the evaluations made are logically coherent, helping to minimize errors and biases in judgment (Gasparotti & Domnisoru, 2020).

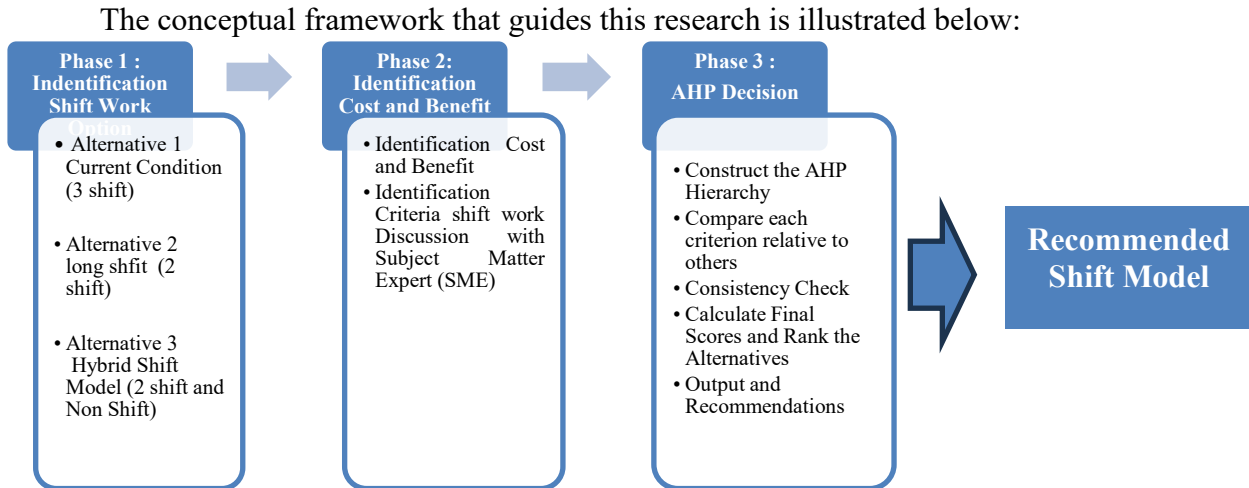


Figure 1
Conceptual Framework of Analyzing Organizational Structures for Shift Workers In Mining Division Unit Pertambangan Tanjung Enim (UPTE) PTBA.

RESEARCH METHOD

This study employed a mixed-methods approach, gathering data through focus group discussions (FGDs) with subject matter experts (SMEs), analysis of internal documents, and benchmarking against best practices from top-performing mining companies.

The Analytic Hierarchy Process (AHP) was applied to assess three shift work alternatives:

- **Option 1:** The current 3-shift arrangement (3 shifts of 8 hours each)
- **Option 2:** A 2-shift extended-hour model (2 shifts of 12 hours each)
- **Option 3:** A hybrid model combining a 2-shift system for company-managed areas and a non-shift setup for contractor-managed zones

Based on input from SMEs, five primary evaluation criteria were established: Occupational Health and Safety, Productivity and Efficiency, Regulatory Compliance, Employee Well-being, and Operational Costs. These criteria were further detailed into sub-criteria, and their relative importance was determined through pairwise comparison using the AHP method.

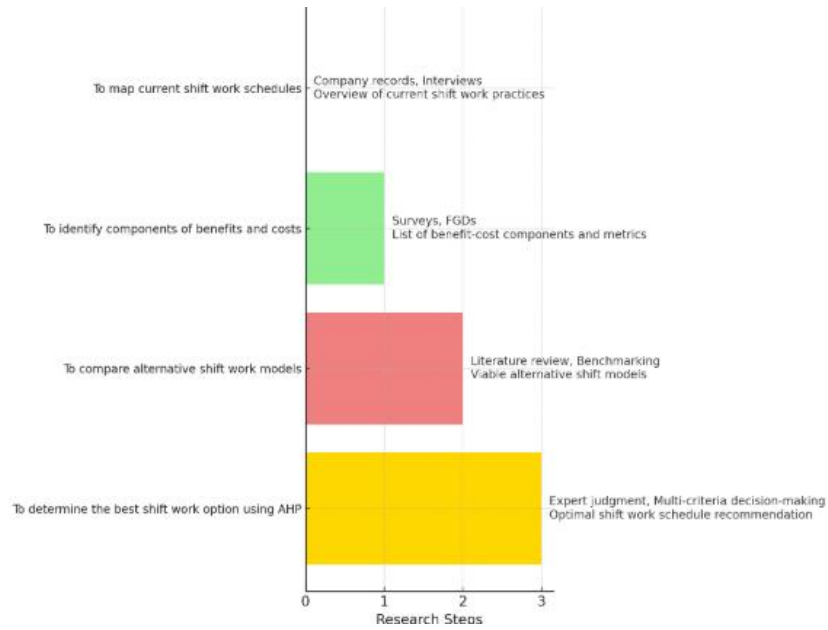


Figure 2.
Research Methodology Framework

RESULTS AND DISCUSSION

In evaluating the best shift work system for operational supervision within the mining division, three shift options were analyzed:

- Option 1: The existing 3-shift system
- Option 2: A 2-shift system with extended hours
- Option 3: A hybrid model featuring 2 shifts for self-managed areas and a non-shift system for contractor supervision

The analysis compares the number of supervisory staff required at each site for each option, along with the corresponding impact on human resource expenses.

The table below presents a summary of the staffing requirements for each shift alternative:

Table 1.
Employee Requirements for Each Alternative

Location	Option 1	Option 2	Option 3
TAL	24	18	14
MTB	24	18	14
BANKO 1	24	18	14
BANKO 2	24	18	14
Self-managed Mining 1	32	24	24
Self-managed Mining 2	32	24	24
TOTAL	160	120	104

Cost-Benefit Analysis

Using internal company data, the average monthly salary for an operational supervisor is IDR 8,450,288. Based on this figure, the following cost comparisons were computed:

Table 2
Cost Comparison

Option	Supervisors Needed	Monthly Labor Cost (IDR)	Annual Labor Cost (IDR)
Option 1	160	1,352,046,080	16,224,552,960
Option 2	120	1,014,034,560	12,168,414,720
Option 3	104	878,429,952	10,541,159,424

Business Solution

Drawing from the literature review and insights gained through Focus Group Discussions (FGDs) with Subject Matter Experts (SMEs) from PTBA-UPTE’s mining division, a systematic approach was applied to identify the most pertinent criteria and sub-criteria for assessing and choosing the optimal shift work system.

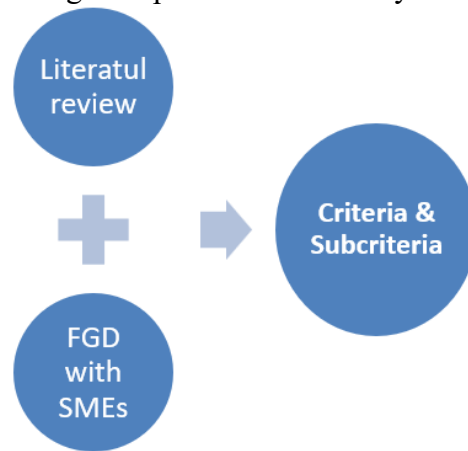


Figure 3
Determination of Criteria and Sub-Criteria for Shift Work System

The decision-making hierarchy includes five main criteria :

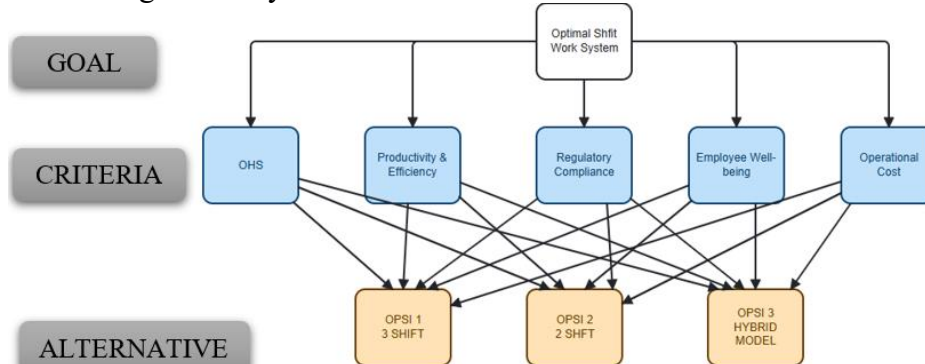


Figure 4
AHP Method Hierarchy Structure

Based on the outcomes of the Focus Group Discussion (FGD), a definitive set of five primary criteria and fifteen sub-criteria was developed. These criteria were subsequently incorporated into the Analytic Hierarchy Process (AHP) model to assess the three proposed shift work options. The finalized framework is outlined below:

Table 3
Criteria and Sub-Criteria for Selecting the Work Shift System

Main Criteria	Sub-Criteria	Description
1. Occupational Health and Safety (OHS)	Fatigue Risk	The extent to which the shift pattern may cause physical or mental fatigue, affecting performance, alertness, and safety.
	Workplace Accidents	The probability of incidents or accidents is associated with shift duration, frequency, or insufficient rest.
	Rest Time	Adequacy of rest periods between shifts to ensure recovery and prevent cumulative fatigue.
2. Productivity and Efficiency	Responsiveness to Incidents	The ability of the shift system to ensure a quick response to operational emergencies or issues.
	Operational Monitoring	The effectiveness of monitoring activities across all operational hours.
	Supervision Output per Shift	The measurable contribution or output of supervision and control during each shift.
3. Regulatory Compliance	Labor Law Compliance	Compliance with national labor laws, such as limits on work hours, mandatory rest, and working conditions.
	Ministry of Energy (ESDM) Regulations	Conformance with technical and administrative rules from ESDM related to mining operations.
	Golden Rules PTBA	Adherence to internal company policies and core safety standards, such as PTBA's "Golden Rules".
4. Employee Well-Being	Work-Life Balance	The extent to which the shift schedule supports a healthy

Main Criteria	Sub-Criteria	Description
5. Operational Cost		balance between work duties and personal/family life.
	Personal Preferences	The level of consideration given to individual employee preferences or constraints when assigning shifts.
	Stress Level	The psychological stress experienced due to shift characteristics (e.g., night work, quick returns, irregular schedules)
	Costs	Financial burden from additional hours worked beyond standard shifts.
	Transportation and Logistics	Costs for transporting workers, providing meals, or accommodations during off-peak hours or remote operations.
	HR Efficiency	The optimal deployment of personnel to minimize redundancy and maximize labor productivity per shift.

AHP Results:

The combined findings from the Analytic Hierarchy Process (AHP) analysis, conducted through Focus Group Discussions (FGD) with Subject Matter Experts, are shown below:

Cat		Priority	Rank
1	Current 3-shift system	29.2%	2
2	Long-shift 2-shift system	27.1%	3
3	Hybrid model	43.7%	1

Figure 5.

AHP Priority Ranking of Shift Alternatives (using the application at www.bpmsg.com)

The hybrid shift model, which implements a 2-shift schedule for self-managed mining areas and a fixed (non-shift) schedule for contractor supervision, emerged as the most balanced solution based on the AHP analysis. This model effectively meets operational demands while significantly enhancing human resource efficiency.

Key advantages include:

- Improved operational control in core mining zones through an optimized 12-hour shift rotation.

- Enhanced employee well-being by eliminating night shifts for contractor-related positions, thereby reducing fatigue and supporting better work-life balance (Costa, 2012).
- Cost savings resulting from a reduced number of supervisors (from 160 to 104), along with decreased overtime and logistical expenses (Wang et al., 2024).
- Compliance with labor laws and PTBA's internal safety standards (Hadianti et al., 2014).

The AHP findings, reinforced by expert insights from the FGDs, provide strong managerial support for transitioning from the current 3-shift system to the hybrid model to boost productivity, safety, and cost-effectiveness.

CONCLUSION

The AHP analysis concluded that the hybrid model (Option 3) offers the most balanced advantages across all criteria. It effectively addresses operational, regulatory, and human capital concerns, delivering a cost-efficient solution that does not compromise safety or productivity. It is recommended that management implement the hybrid model initially as a pilot program in selected areas before full-scale deployment. Comprehensive training, updates to standard operating procedures (SOPs), and active stakeholder engagement are essential to ensure a smooth and successful adoption.

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