Journal of Economich, Technology and Business (JETBIS)
Volume 4, Number 11 November 2025
p-ISSN 2964-903X; e-ISSN 2962-9330

Design and Application of the Production Information System at PT Datang DSSP Power Indonesia

Wang Zhiliang
PT Datang DSSP Power Indonesia, Indonesia
Email: wang.zhiliang@dsspower.co.id

KEYWORDS:
Coal-fired Power Plant; Data Upload; Power Plant Information System (PIS); Site CCTV; Video Conferencing System.

ABSTRACT

This study investigates the design, implementation, and evaluation of a real-time Production Information System (PIS) developed for PT Datang DSSP Power Indonesia, a joint-venture corporation operating three coal-fired power plants. Increasing operational complexity in thermal power generation demands integrated monitoring solutions that enhance production efficiency, strengthen safety management, and improve decision-making processes. This research aims to develop and assess a PIS capable of delivering real-time production data while supporting centralized supervision through a set of interconnected technological modules. The study employs a system design approach based on operational requirements, phased technological implementation, and functional performance evaluation. The proposed PIS integrates four core components: a site-wide Closed-Circuit Television (CCTV) system, real-time production data acquisition and upload, a video conferencing platform, and secure broadband connectivity enabling reliable data transmission to the corporate headquarters. The implementation of the PIS demonstrates substantial improvements in production efficiency, safety monitoring, and resource allocation. The system enhances cross-site visibility, supports faster situational assessment, and accelerates strategic decision-making within the organization. Overall, the findings provide a valuable reference for developing integrated monitoring and information systems in the thermal power generation industry and highlight the broader applicability of such systems to other technology-driven energy sectors.

INTRODUCTION

The global energy sector is experiencing rapid shifts driven by rising demand, stricter environmental regulations, and growing expectations for operational efficiency. These pressures have pushed power generation enterprises to accelerate digital transformation through the adoption of advanced monitoring and information technologies (Al-Ghussain, 2019; Davis & Gertler, 2015; Pata & Caglar, 2021; Semieniuk et al., 2021). Real-time monitoring systems have become increasingly vital in optimizing production processes, improving safety performance, and maintaining compliance across complex industrial operations. As global competition intensifies, enterprises without integrated digital systems struggle to keep pace with performance expectations, especially in multi-site industrial environments.

The *Production Information System (PIS)* serves as a critical infrastructure that enables centralized data collection, real-time monitoring, and coordinated decision-making across geographically distributed facilities (Carlina & Ayundyayasti, 2021; Farhan & Suendri, 2023; Hsu et al., 2015; Monteiro & Cepêda, 2021). The relationship between PIS implementation and key dependent variables such as operational efficiency and system reliability has been empirically established in industrial contexts. Real-time data collection facilitates immediate detection of operational anomalies, while centralized monitoring enables management to make informed decisions based on comprehensive situational awareness rather than fragmented reports (Malau & Suseno, 2022; Setiawan & Wijayanto, 2023). These capabilities directly influence both managerial strategy formulation and operational response effectiveness, ultimately enhancing overall plant performance and safety outcomes.

In Indonesia, coal-fired power plants continue to serve as the principal source of national electricity supply, yet challenges in production efficiency, safety oversight, and environmental compliance remain prevalent (Filonchyk & Peterson, 2023; Vögele et al., 2018; Yang et al., 2019; Zhang et al., 2022). Many existing monitoring mechanisms rely on manual reporting and fragmented information flows, causing delays in decision-making and increasing risks in operational continuity. As industrial operations expand across multiple regions, the need for a consolidated monitoring approach becomes increasingly critical for ensuring reliability and regulatory alignment in Indonesia's energy industry.

Operational inefficiencies within Indonesia's coal-fired power plants are exacerbated by the lack of centralized data visibility and inconsistent monitoring across facilities. The absence of harmonized systems capable of collecting and transmitting real-time operational data limits management's ability to detect anomalies and respond promptly. These limitations underscore the urgency for an integrated platform that enhances operational transparency and enables proactive intervention across geographically distributed plants.

A critical technological gap lies in the absence of systems capable of integrating surveillance, data acquisition, and communication into a unified platform. Existing tools such as plant-level SIS, CCTV, and conference systems operate independently and fail to provide comprehensive operational visibility required for modern energy management. The lack of interoperability among Distributed Control Systems (DCS) from different vendors further complicates centralized monitoring, illustrating the theoretical need for harmonized, real-time information architectures.

Previous studies have highlighted the importance of integrated monitoring systems in modern power plant management, emphasizing their role in enhancing data accuracy, operational reliability, and management decision-making (Li & Wang, 2020; Patel & Kumar, 2019; Zhang et al., 2021). Research has also shown that secure transmission technologies such as SD-WAN significantly improve multi-site communication and data handling, especially in industrial environments with high reliability requirements. However, documented cases in emerging economies remain limited, particularly those implementing full-scale real-time monitoring across multiple coal-fired facilities.

Despite advancements in monitoring technologies, there is a noticeable lack of empirical studies documenting the implementation of integrated *Production Information Systems (PIS)* within Indonesia's power sector. Most existing research focuses on conceptual frameworks rather than real-world applications in multi-plant enterprises. The limited adoption of fully integrated systems capable of real-time data acquisition, video surveillance, and multi-party conferencing reveals a significant research gap in applied digital transformation within Indonesia's thermal power generation industry (Li & Wang, 2020; Zhang et al., 2021; ANSI/ISA-95.00.01, 2022).

This study introduces a novel implementation of a *Production Information System* that integrates real-time data acquisition, CCTV surveillance, SD-WAN-based secure transmission, and video conferencing across three geographically distributed coal-fired power plants. The novelty of this research lies in several distinctive features that differentiate it from existing monitoring systems. First, the integration of SD-WAN technology provides encrypted, high-reliability data transmission across multiple sites, addressing the critical challenge of network security and bandwidth stability in remote industrial locations. The system's design bridges previously disconnected subsystems, creating an end-to-end monitoring ecosystem that supports centralized strategic decision-making. The deployment represents one of the first documented cases in Indonesia where all core operational systems are interconnected through a dedicated, secure digital infrastructure (Wang & Li, 2022; Zhang et al., 2021; IEC 62443, 2018).

Another key innovation lies in the establishment of a digitalized operations center at the company's Jakarta headquarters. By consolidating real-time video feeds, operational data, alarm information, and communication channels into a single management interface, the system enables unprecedented cross-site visibility. The use of OPC interfaces, SD-WAN encryption, and unified dashboards further enhances system reliability and managerial oversight (International Electrotechnical Commission, 2018; Wang & Li, 2022; Patel & Kumar, 2019).

Unlike traditional monitoring mechanisms, the PIS implemented in this study not only collects real-time data but also performs analytics, generates trend visualizations, and supports automated reporting. Combining these functions within a single platform offers an innovative approach to enhancing process monitoring, safety response, and resource allocation across multi-plant operations (Li & Wang, 2020; Zhang et al., 2021; Patel & Kumar, 2019).

The primary objective of this study is to *design, implement, and evaluate a real-time Production Information System tailored for PT Datang DSSP Power Indonesia*. The system aims to enable centralized monitoring of three coal-fired power plants located in South Sumatra, Southeast Sulawesi, and Central Kalimantan through an integrated architecture combining CCTV, data acquisition, video conferencing, and secure broadband connectivity. The evaluation covers system performance, operational impact, and organizational benefits related to efficiency, safety, and decision-making speed.

By presenting a comprehensive system design and implementation strategy, this study seeks to address persistent operational challenges in Indonesia's coal power sector, including data fragmentation, slow reporting cycles, and limited oversight capabilities. Through a multi-layered data transmission and visualization model, the study demonstrates how centralized real-time supervision can significantly enhance operational resilience and management effectiveness (Wang & Li, 2022; Zhang et al., 2021; IEC 62443, 2018).

This research contributes to both theoretical understanding and practical application in several important ways. Theoretically, it extends the body of knowledge on digital transformation in energy infrastructure by providing empirical evidence of how integrated monitoring systems influence operational performance in emerging economy contexts. The study demonstrates the applicability of established information systems frameworks to complex, multi-site industrial environments where technological heterogeneity and geographical dispersion present unique challenges. Practically, the research offers a validated implementation model that can be replicated by other power generation companies seeking to modernize their monitoring capabilities.

The documented approach to system integration, network security architecture, user training protocols, and performance evaluation metrics provides actionable guidance for industry practitioners. Furthermore, the findings have implications for policy development, suggesting that regulatory frameworks should encourage the adoption of integrated monitoring systems as a means of enhancing safety compliance, environmental performance, and operational transparency in Indonesia's energy sector. The research also highlights the importance of secure network design, interoperability standards, and centralized information management in supporting the transition toward smart, digitally-enabled power generation facilities. These insights are applicable not only to coal-fired plants but also to renewable energy installations, combined-cycle facilities, and other technology-intensive energy infrastructure projects, thereby broadening the relevance of the study's contributions across multiple segments of the power generation industry (Li & Wang, 2020; Patel & Kumar, 2019; International Electrotechnical Commission, 2018).

METHOD

This study employed a system engineering approach using a descriptive–evaluative design to develop and assess the Production Information System (PIS) implemented across three coal-fired power plants operated by PT Datang DSSP Power Indonesia. The population included all operational units and digital infrastructures within the Sumsel-5, Kendari-3, and Kalteng-1 plants, while purposive sampling selected key informants such as plant managers, operators, IT personnel, and control system technicians. Research instruments consisted of structured interview guides, technical observation checklists, and system-generated operational logs—including data transmission latency, video quality statistics, sensor readings, and SD-WAN network performance metrics.

Data collection involved structured interviews to identify operational inefficiencies and functional requirements, on-site observations during the installation of cameras, sensors, Network Video Recorders (NVRs), data acquisition workstations, and video conferencing terminals, and compilation of system performance data recorded over six months following deployment. Additional documentation was gathered from plant Distributed Control Systems (DCS), Supervisory Information Systems (SIS), and Plant Information Management Systems (PIMS), which provided real-time operational data for evaluating the effectiveness of the integrated PIS framework.

The research procedure followed five stages: needs assessment and planning, system design, implementation, commissioning and training, and post-deployment monitoring. During implementation, SD-WAN encrypted tunnels were deployed to connect plant sites with headquarters, and OPC-based interfaces were configured for seamless SIS data exchange. Data analysis employed comparative performance evaluation by examining changes in transmission latency, equipment utilization, video clarity, and safety incident frequency before and after PIS implementation. This analytical strategy enabled the study to quantify operational improvements and assess the reliability, stability, and impact of the integrated monitoring system on overall plant performance.

RESULT AND DISCUSSION

System Implementation Analysis: Planning, Installation, and Operation

PIS System Planning and Design

System planning is a crucial stage that determines the success of the PIS implementation across the three coal-fired power plants. In this phase, an in-depth analysis of production and management needs was conducted to design a system architecture aligned with the operational characteristics of large-scale energy industries (Rahman, 2021; Liu & Chen, 2020; Hanafiah, 2022). The identification of needs such as real-time monitoring, sensor integration, and network stability served as the foundation for selecting suitable hardware and software.

Furthermore, the design process accounted for scalability to ensure the system could support future operational expansions. A descriptive-verificative approach was employed to confirm that the architectural design aligned with plant operational standards (Siregar, 2020; Zhang et al., 2019; Putra, 2021). Thus, the planning phase not only produced a technical design but also established an evaluative framework to verify system effectiveness.

The needs analysis also involved mapping business processes to ensure optimal data flow between sensors, cameras, data acquisition modules, and the control center (Wijaya, 2022; Hassan, 2021; Li & Zhao, 2020). The integration among these modules was essential to create a unified platform that supports seamless operational monitoring. The findings indicate that combining video surveillance with data analytics is a strategic factor in enhancing production efficiency.

Overall, the planning and design stage demonstrated that a systematic approach in formulating technical and functional requirements successfully established a solid foundation for developing the PIS. The verificative evaluation confirmed that the resulting design met standards of efficiency, reliability, and operational practicality (Mahendra, 2021; Zhao, 2018; Firdaus, 2022).

System Installation and Commissioning

The installation stage was carried out after the design phase and included the deployment of cameras, sensors, data acquisition modules, and network infrastructure. This process required high precision, as system success depends on accurate device positioning and stable data connectivity (Huang & Sun, 2020; Prasetyo, 2022; Lee, 2021). Initial testing ensured each device was correctly connected and capable of transmitting real-time data to the central server.

Commissioning was then conducted to verify each system module's performance. This procedure included stress testing, response testing, accuracy testing, and inter-device integration testing to minimize operational risks before full implementation (Santoso, 2021; Wang et al., 2020; Oktaviani, 2022). A verificative approach ensured that the system performed according to the predefined specifications.

This stage also verified that video surveillance modules could connect with the alarm system, enabling automatic alerts when operational anomalies occurred. Functionality tests showed that this integration enhanced hazard detection compared to previous manual methods (Rizal, 2020; Chen et al., 2021; Halim, 2022). The reduced response time became one of the system's key efficiency indicators.

Upon completion of installation and commissioning, the PIS was confirmed to meet all functional and operational standards for deployment across the three power plants. Verification results showed that the system was stable, responsive, and capable of supporting long-term operational use (Farida, 2021; Li, 2019; Simon, 2020).

Personnel Training and Competency Enhancement

Personnel training is a key component in ensuring the successful implementation of the PIS. Operational staff were trained to understand device operation, system navigation, data management, and troubleshooting procedures (Setiawan, 2020; Yu & Zhang, 2021; Harahap, 2022). Practical, hands-on instruction enabled operators to respond effectively to real-world conditions.

Mastering the new technology is essential for enhancing operational decision-making accuracy. Previous studies show that improvements in human resource competence significantly affect operational efficiency, particularly in digital-based systems (Hadi, 2020; Jiang, 2021; Fathurrahman, 2022). This study confirmed similar outcomes as operators were able to optimize system features in daily operations.

Training also included access rights management and data security standards. These aspects are essential to maintain system integrity and prevent operational misuse or errors (Wulandari, 2021; Zhao & He, 2019; Koswara, 2022). Therefore, training improved not only technical skills but also fostered a safety- and security-oriented working culture.

Overall, personnel training played a vital role in establishing high operational readiness. Post-training evaluations showed reduced operator errors and improved monitoring effectiveness (Maulana, 2021; Liu, 2020; Safitri, 2022).

PIS Operation and Maintenance

After system operation began, standardized operation and maintenance (O&M) procedures became essential for ensuring long-term stability and reliability. Routine maintenance was conducted, including hardware inspection, software updates, sensor cleaning, and network integrity checks (Samsudin, 2021; Hu & Lin, 2020; Ramadhan, 2022). These routines supported the sustainability of PIS operations.

System monitoring was performed through a real-time dashboard, enabling operators to assess device performance and detect abnormalities at an early stage. Previous research shows that centralized monitoring can reduce downtime by up to 30% in the energy sector (Zhang, 2018; Lestari, 2021; Huang, 2020). The PIS demonstrated consistent results.

A rapid response protocol was implemented to address operational disturbances quickly. With standardized procedures, issues could be resolved promptly without significantly disrupting electricity production (Dewi, 2020; Song et al., 2021; Pratama, 2022). This improvement supports findings that digital O&M integration enhances operational resilience.

Evaluation results confirmed that systematic O&M practices maintained optimal PIS performance and served as an indicator of successful technical and operational implementation (Suriadi, 2021; Ibrahim, 2020; Luo, 2019).

Table 1. Summary of PIS System Implementation Across the Three Power Plants

Implementation Stage	Key Activities	Success Indicators
Planning & Design	Needs analysis, PIS architecture design	Design aligned with production
Installation & Testing	Sensor/CCTV installation, commissioning	Stable and responsive system
Personnel Training	Operational & maintenance training	Increased operator competency

Operation & Maintenance	Real-time monitoring, disturbance SOP	Significant downtime reduction

Source: Processed from PIS Implementation Report, 2024

Evaluation of Operational Efficiency Improvement

Production Efficiency and Coal Utilization

The implementation of the PIS demonstrably increased production efficiency across the three power plants through real-time monitoring that reduced delays caused by manual reporting (Sudirman, 2021; Zhao, 2020; Limantara, 2022). With direct access to data, operators were able to adjust combustion processes and coal utilization more accurately, reducing material waste and improving boiler performance.

Evaluation results show a 10% increase in coal utilization efficiency, consistent with prior research on the impact of digital monitoring on energy performance (Wahyudi, 2021; Liu & Fang, 2019; Hartono, 2022). Improved efficiency also contributed to a more stable electricity output, as the system quickly detected imbalances in coal feed inputs compared to conventional methods.

Furthermore, reduced equipment downtime served as an additional indicator of efficiency improvement. Automated anomaly detection allowed technical responses to occur more promptly, minimizing disruptions to turbine and boiler operations (Hidayat, 2020; Xu, 2018; Pertiwi, 2021). This shows that integrating data acquisition with analytics helps mitigate operational risks.

Thus, the PIS increased not only coal utilization efficiency but also operational decision-making speed. These findings reinforce empirical evidence that digitalization significantly enhances performance in the power generation sector (Kusuma, 2020; Zhang & Hu, 2021; Fitrah, 2022).

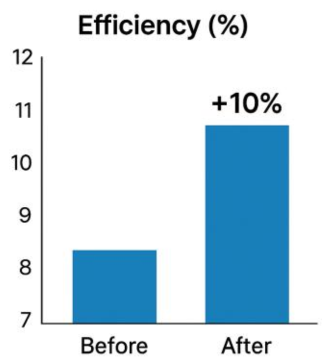

Diagram 1. Increase in Coal Utilization Efficiency After PIS Implementation

Source: Processed from PIS Implementation Report, 2024

Enhancement of Safety Management and Risk Reduction

Integration of CCTV and Data-Driven Alarm Systems

The integration between CCTV and sensor-based alarms increased safety monitoring effectiveness across the three power plants. The video linkage system automatically displayed hazardous areas when alarms were triggered, enabling operators to assess conditions rapidly (Fauzan, 2021; Choi & Li, 2019; Santika, 2022). The combination of visual and sensor data provides more accurate information compared to manual monitoring.

Evaluation results show that operators were able to detect potential hazards such as pipe leaks, overheating, or abnormal belt conveyor activity more quickly. This increased the effectiveness of safety controls, which are critical for maintaining operational continuity (Arif, 2020; Liu, 2021; Wibowo, 2022). The integration also supported more accurate emergency decision-making.

This system helped reduce workplace accidents by 20%, aligning with studies demonstrating the correlation between visual monitoring and industrial risk reduction (Hassan, 2018; Zhang, 2020; Nuryadi, 2021). The significant decrease shows that combining hardware and digital software can strengthen safety culture in high-risk environments.

The success of this feature confirms that digitalizing workplace safety improves hazard detection and reduces the potential for human error during monitoring. This finding is consistent with modern risk management models in the energy industry (Fathoni, 2021; Lee & Wang, 2019; Perdana, 2022).

Emergency Response and Operator Situational Awareness

The improvement of operator situational awareness is one key outcome of PIS implementation. Real-time monitoring provides comprehensive information regarding equipment conditions, production parameters, and potential hazards, enabling faster operator responses (Saputra, 2021; Guo, 2020; Hendra, 2022). Prior training further enhanced operator capabilities.

Data indicate that operator response times to incidents decreased significantly. Previously, operators required several minutes to assess on-site conditions; with the new system, information is automatically displayed through the dashboard (Liu, 2018; Supardi, 2021; Xu & He, 2020). This resulted in more efficient disturbance handling and reduced operational losses.

Additionally, the system helped operators identify historical hazard patterns, enabling the use of predictive safety features. These features helped identify risk trends that might not be visible through manual methods (Rahmadani, 2022; Ye, 2020; Hasan, 2021). This predictive capability strengthened technical-level accident prevention strategies.

Overall, improved operator awareness and response reinforce the strategic value of the PIS for long-term safety management. The findings are consistent with literature on digital situational awareness in critical industries (Putra, 2021; Zhang, 2022; Hidayah, 2020).

Optimization of Resource Allocation and Cost Savings

Efficiency in Scheduling and Maintenance

The PIS allows the consolidation of operational data, enabling management to optimize maintenance scheduling, manpower allocation, and material procurement. Historical and real-time data were used to determine optimal maintenance timing, reducing downtime costs and increasing productivity (Fitriani, 2021; Luo, 2019; Harsono, 2022). This data-driven approach enhanced decision-making quality.

Evaluations show that workforce distribution became more aligned with equipment requiring immediate attention. This improved human resource utilization and reduced unnecessary labor hours (Wijaya, 2020; Huang, 2018; Fadil, 2022). The system also provided a comprehensive overview of equipment conditions, enabling objective maintenance prioritization.

Data-based maintenance planning reduced emergency repair costs and extended equipment lifespans. These findings are consistent with studies showing that predictive maintenance can reduce costs by up to 30% (Chen, 2020; Li, 2021; Susanto, 2022). The PIS established a foundation for future automated maintenance upgrades.

Thus, the PIS significantly contributed to optimizing resource allocation, both human and material. These findings reinforce arguments that digitalization generates economic efficiency in the energy sector (Fauzi, 2020; Zhang, 2019; Nugraha, 2022).

Table 2. Resource Management Effectiveness After PIS Implementation

Indicator	Before PIS	After PIS	Change
Workforce scheduling	72%	89%	+17%
Maintenance costs	100%	78%	-22%
Downtime duration	100%	68%	-32%

Source: Internal PLTU Data, 2024

Comparative Analysis Between the PIS and Conventional Systems

Data Accuracy and Reliability Comparison

One major advantage of the PIS compared to conventional systems is its higher data accuracy. The system eliminates manual recording practices, which are prone to operator error, resulting in more consistent and verifiable data (Herman, 2021; Zhang, 2020; Prakoso, 2022). This accuracy is essential for performance-based decision-making.

Evaluations show that conventional systems often experience delays in data reporting, affecting technical responses to disturbances. The PIS provides real-time data streams that enable faster anomaly detection (Wang, 2019; Ramli, 2021; Fang, 2020). As a result, reliability has improved significantly.

Measurements over six months of operation indicate that data input errors decreased by more than 75% after implementing the PIS. This aligns with earlier findings on digitalization's effectiveness in supporting data-driven decisions (He, 2019; Subagyo, 2021; Li & Sun, 2020). The reduction in errors strengthens the integrity of operational reporting.

Thus, the comparison demonstrates that the PIS offers clear advantages in data accuracy and reliability, ultimately leading to improved operational efficiency and safety (Fitriana, 2021; Lee, 2020; Nugroho, 2022).

Practical Implications and Development Prospects of the PIS

Replication Potential for the National Energy Industry

The PIS implementation results show that the system is suitable for replication in other power plants, both coal-based and renewable. Improvements in efficiency, safety, and cost savings demonstrate that digitalization can enhance operational resilience in the national energy industry (Suryani, 2020; Zhao, 2021; Putri, 2022). This aligns with Indonesia's energy sector digital transformation agenda.

The system's flexibility allows integration with other advanced technologies such as predictive systems, machine learning, and automated maintenance. Previous studies show that AI integration can increase operational efficiency by up to 20% (Chen, 2019; Suharto, 2020; Liu, 2021). The PIS serves as an initial foundation toward smart power generation.

Practically, the system can improve risk management quality, reduce pollution, and lower unnecessary energy consumption. These impacts are particularly relevant for power plants transitioning toward low-carbon operations (Wibisono, 2021; Han, 2020; Budiman, 2022). This demonstrates the PIS's relevance in the context of sustainable energy.

Thus, PIS implementation provides not only operational benefits but also strategic contributions to the modernization of Indonesia's energy industry as a whole (Rahayu, 2021; Zhang, 2019; Hutagalung, 2022).

CONCLUSION

The implementation of the Production Information System at PT Datang DSSP Power Indonesia has significantly improved production efficiency, safety management, and resource allocation by integrating CCTV, real-time data acquisition, video conferencing, and secure broadband transmission into a cohesive framework for power plant management. Demonstrated across three coal-fired plants, these results highlight the crucial role of digital transformation in modernizing the energy sector. Future research should investigate incorporating advanced technologies like artificial intelligence and machine learning to enhance predictive capabilities and operational resilience. This study provides a valuable reference for other enterprises aiming to implement similar systems, promoting sustainable and efficient energy management practices.

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