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Performance Evaluation of the Supply Chain for Investment-Based Electricity Connection Services using SCOR, IPA, and RCA

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Abstract

This research evaluated the supply chain performance of new electricity connections and capacity upgrades requiring network investment at PLN UP3 Sanggau. The observed problems included project completion delays, application backlogs, deferred connected capacity, and unrealized energy sales. Performance was assessed using a questionnaire completed by 35 respondents directly involved in the process, covering 17 indicators across six SCOR processes: Plan, Source, Make, Deliver, Return, and Enable. The data were analyzed through validity and reliability tests, gap analysis, Importance-Performance Analysis (IPA), in-depth interviews, and 5M+1E-based Root Cause Analysis (RCA). The overall performance score was 3.659, while the importance score was 4.528. Source recorded the lowest performance score (3.10) and the largest gap value (1.45). IPA identified three main priority areas: critical material availability (SRC2), procurement process timeliness (SRC1), and timely and complete material distribution to work sites (DLV3). RCA indicated inadequate inventory control, long replenishment lead times, dependence on external suppliers, limited transportation capacity, and insufficient distribution visibility. Operational evidence showed that 29.17% of project feasibility plans were delayed, 481 applications exceeded 40 working days, 4,773,300 VA of capacity remained deferred, and the estimated opportunity loss reached 32,458 kWh per day. The proposed improvements emphasized critical material control, procurement monitoring, pre-dispatch completeness verification, and end-to-end material visibility. The SCOR–IPA–RCA integration provided a concise diagnostic framework for evaluating project-based utility services.

INTRODUCTION

The Customer Service Implementation Unit (UP3) serves as the frontline unit for electricity distribution services and energy sales growth (Ali & Toaha, 2026; He et al., 2026; Jaluka, 2022; Mashitoa, 2024). Two services that directly contribute to customer-base expansion and increased electricity consumption are New Connections (PB) and Power Capacity Upgrades (PD) (Jones, 2026; Kadir et al., 2025; M. Singh et al., 2022; Turoń et al., 2025). Simple requests can be fulfilled using standard materials; however, requests requiring network expansion or investment become project-based processes involving technical planning, Project Feasibility Studies (KKP), procurement of materials and services, construction, material distribution, connection, and administrative closure. Because these processes involve multiple functions across UP3 and ULP units, overall performance is determined not by a single unit but by the continuity of the workflow from upstream to downstream (Satzer et al., 2022; Schmidt et al., 2024; Seyyedsar et al., 2026).

The quality of PB/PD services is measured against Customer Service Days (HPL) and the completion targets specified in the KKP. HPL provides customers with certainty regarding service duration, while the KKP serves as the technical and economic benchmark and implementation timeline for projects requiring investment. Deviations from these benchmarks can increase backlogs, delay customer activation, and postpone potential energy sales. Consequently, delay evaluation should move beyond measuring final outcomes toward diagnosing processes that identify cross-functional bottlenecks (Hossain & Mahmood, 2022; Khurjekar et al., 2026; Mahajan, 2025).

The situation at PLN UP3 Sanggau illustrates this urgency. Of the 24 KKP projects analyzed, seven (29.17%) exceeded their completion targets, while 17 (70.83%) were completed on schedule. In aggregate, 481 requests exceeded the 40-working-day threshold, comprising 479 PB requests and two PD requests. The total delayed connected capacity reached 4,773,300 VA, consisting of 3,543,300 VA from PB requests and a net increase of 1,230,000 VA from PD requests. Assuming a power factor of 0.85 and eight hours of daily usage, this condition represented an estimated energy sales opportunity loss of approximately 32,458 kWh per day. This figure demonstrates that delays are not merely administrative issues but also affect investment utilization, revenue realization, and customer experience.

The Supply Chain Operations Reference (SCOR) framework is relevant because it conceptualizes performance as the outcome of interconnected processes: Plan, Source, Make, Deliver, Return, and Enable. In the context of investment-based PB/PD services, Plan encompasses technical planning, scheduling, and target setting; Source concerns procurement and material availability; Make represents construction and work readiness; Deliver covers material distribution and service activation; Return includes residual materials, nonconformities, and feedback; while Enable encompasses data, applications, standard operating procedures (SOPs), competencies, and governance. This perspective helps avoid oversimplifying delays as solely field-level problems (Hassan et al., 2025; Hinov, 2026; Li et al., 2026; R. Singh et al., 2025).

Previous research indicates that SCOR has been widely applied in manufacturing, agro-industry, warehousing, and goods distribution. Putri et al. (2025) applied the Green SCOR framework to assess supply chain performance in offset printing, demonstrating the framework's adaptability to environmental performance assessment. Fauzia and Zamzamy (2021) developed performance improvement strategies in automotive companies using the SCOR model and Importance-Performance Analysis (IPA), demonstrating the effectiveness of combining SCOR with IPA for priority setting. Santoso et al. (2020) evaluated the performance of PT PLN's Jakarta Raya distribution unit using SCOR, providing early evidence of the framework's applicability in the electricity utility sector. Imtihan et al. (2025) examined electricity supply chain resilience using a SCOR-based approach for vertically integrated utilities, focusing on resilience rather than service performance. However, the application of SCOR in the electricity utility sector remains relatively limited, particularly for project-based, make-to-order services requiring coordination among service units, procurement, warehousing, vendors, and field personnel.

Some previous studies have stopped at performance measurement without linking mapping results to root causes or actionable improvement measures. This study addresses that gap by integrating SCOR, Importance-Performance Analysis (IPA), and Root Cause Analysis (RCA). SCOR serves as the process framework, IPA identifies improvement priorities based on the combination of performance and importance, and RCA ensures that recommendations are derived from identified root causes. In addition, the integration of operational key performance indicators (KPIs), such as KKP accuracy, backlog, delayed connected capacity, and opportunity loss, with perceptual assessment results provides a more comprehensive diagnostic approach that has not been extensively applied in electricity utility service contexts. This study also focuses specifically on investment-based connection services, which involve more complex material and process coordination than standard connections.

The novelty of this research lies in three main contributions. First, this study is among the first to integrate SCOR, IPA, and RCA simultaneously in the context of investment-based, make-to-order electricity services, where cross-functional coordination and material dependencies are critical. Second, this study links perceptual findings from questionnaire scores with operational evidence, including KKP performance, backlog, delayed capacity, and opportunity loss, to strengthen diagnostic validity and illustrate the business consequences of process bottlenecks, an approach rarely applied in previous studies. Third, this study adapts the SCOR framework to project-based services by incorporating all six processes, including Return and Enable, which have more commonly been applied in manufacturing and goods distribution contexts. This adaptation provides a methodological contribution to supply chain research in the utility sector.

Given this context, the study aims to: (1) assess and map the performance of investment-based PB/PD processes using the six SCOR processes; (2) identify priority improvement indicators using IPA; (3) determine the root causes of these priority indicators through in-depth interviews and RCA; and (4) formulate recommendations to support timely completion, backlog reduction, and improved visibility across the service supply chain. This research is expected to provide both theoretical and practical contributions. Theoretically, it contributes to the supply chain management literature by extending the application of SCOR to the electricity utility sector, particularly in make-to-order, project-based services, and by integrating IPA and RCA into a diagnostic framework that remains limited in the service supply chain literature. In addition, this study enhances understanding of how the SCOR model can be adapted to service contexts involving cross-functional coordination and critical material dependencies. Practically, this research provides PLN UP3 Sanggau management with a basis for prioritizing process improvement interventions related to critical materials, procurement processes, and distribution, supported by root cause analysis. It also offers structured and measurable improvement recommendations for operational teams, including logistics, procurement, and construction personnel; a replicable diagnostic framework for other PLN units facing similar challenges; and input for corporate-level policymakers in developing more integrated performance measurement standards for investment-based supply chains.

METHOD

The research employed a quantitative descriptive design with qualitative elaboration. The unit of analysis was the investment-based new connection/service expansion (PB/PD) process at PLN UP3 Sanggau and its subordinate ULPs. The unit of observation consisted of key personnel directly involved in planning, procurement, material management, construction, distribution, connection, and work control.

The accessible population comprised structural officials and process managers who met the inclusion criteria: having responsibility or authority over relevant processes, understanding the investment-based PB/PD workflow, and being involved during the study period. A total of 35 personnel met the criteria and provided complete responses. Respondents included Team Leaders/Supervisors, ULP Managers, and UP3 Assistant Managers. This respondent selection positioned them as subject matter experts; therefore, the findings were contextual and were not intended for probabilistic generalization across all PLN units.

The research instrument consisted of 17 indicators covering six SCOR processes. Each indicator was assessed using two dimensions: performance (V1) and importance (V2). The V1 scale ranged from 1 (very frequently problematic) to 5 (almost never problematic), while the V2 scale ranged from 1 (very unimportant) to 5 (very important). A higher V1 score indicated a more consistent process with fewer operational issues.

Item validity was tested using Pearson correlation with an r-table value of 0.334 (n = 35, 5% significance level). Internal reliability was assessed using Cronbach's Alpha for each pillar. Descriptive analysis calculated the mean values of V1 and V2 as well as the V2–V1 gap. Importance-Performance Analysis (IPA) used the grand means of V1 and V2 as cut-off points for quadrant classification. Operational key performance indicators (KPIs), including KKP accuracy, backlog, delayed power connections, and opportunity loss, were used as contextual evidence and were not mathematically combined with questionnaire scores. In-depth purposive interviews were conducted with three key informants representing planning, logistics/warehousing, and construction/field supervision functions. The interview results were used to explain the causes of low performance in priority indicators and to identify root causes using the 5M+1E framework. The analysis process followed the sequence of instrument testing, descriptive statistics, gap analysis, IPA mapping, qualitative confirmation, RCA, and recommendation formulation.

RESULTS AND DISCUSSION

Respondent Profile and Instrument Quality

The composition of respondents reflects a range of cross-level and cross-functional perspectives. A total of 26 respondents were from the ULP, while nine were from the UP3. In terms of primary functions, the respondents covered Plan, Source, Make, Deliver, and Enable. The majority possessed extensive organizational experience and high levels of work exposure: 68.57% had more than ten years of tenure, and 51.43% had been involved in over ten procurement/distribution (PB/PD) assignments within the last six months. These characteristics reinforce the validity of relying on professional perceptions, as the assessments were provided by personnel who understand the processes and their operational consequences.

Table 1. Respondent Profile

Characteristic	Category	Count	Percentage
Work unit	ULP	26	74.29%
Work unit	UP3	9	25.71%
Length of service	>10 years	24	68.57%
Length of service	7-10 years	5	14.29%
Involvement in past 6 months	>10 assignments	18	51.43%
Involvement in past 6 months	6-10 assignments	8	22.86%

Source: Primary data processed (2026)

All indicators are valid, as the item-total correlation values exceed 0.334. Cronbach's Alpha values range from 0.686 to 0.825 for performance and from 0.766 to 0.919 for importance. Although the values for the "Plan" and "Make" performance dimensions fall slightly below 0.70, they remain acceptable given that each pillar comprises only three indicators. Overall, the instrument demonstrates adequate internal consistency for descriptive analysis and IPA.

Table 2. Reliability Test Results by SCOR Pillar

Pillar	Performance Alpha	Importance Alpha	Remarks
Plan	0.688	0.766	Reliable
Source	0.795	0.919	Reliable
Make	0.686	0.819	Reliable
Deliver	0.811	0.844	Reliable
Return	0.825	0.845	Reliable
Enable	0.797	0.854	Reliable

Source: Primary data processed (2026)

Performance and Gaps by SCOR Pillar

The aggregate performance score is 3.659, while the importance score is 4.528. The performance score indicates that, overall, the processes approach the "rarely problematic" category but lack consistency. The high importance rating reflects the respondents' view that all processes are relevant to service success. The disparity between the two scores highlights opportunities for improvement, particularly in pillars exhibiting low performance and significant gaps.

Table 3. Performance and Gaps by SCOR Pillar

SCOR Pillar	Mean V1	Mean V2	Gap	Rank
Source	3.10	4.55	1.45	1
Return	3.60	4.47	0.87	2
Deliver	3.71	4.51	0.80	3
Plan	3.72	4.50	0.78	4
Make	3.90	4.60	0.70	5
Enable	3.89	4.50	0.62	6

Source: Primary data processed (2026)

The "Source" pillar exhibits the lowest performance and the largest gap. These findings indicate that service continuity is heavily influenced by the processes of procuring materials and services. When critical materials are unavailable or procurement lead times are prolonged, construction and connection phases cannot proceed according to plan. This situation aligns with the nature of investment-based projects (PB/PD), which require specific materials that cannot always be supplied from routine stock.

"Return" ranks second in terms of the gap. Although not the primary priority in the Importance-Performance Analysis (IPA), these results highlight the need for proper management of surplus materials, non-conforming items, documentation, and field feedback. Weaknesses in the "Return" process can compromise inventory accuracy and lead to recurring issues. "Deliver" ranks third, demonstrating that material availability does not automatically guarantee work readiness if distribution is delayed, partial, or incomplete.

"Make" and "Enable" show relatively high performance levels, indicating that work methods, quality, application support, and administrative processes are generally stable. However, their importance scores remain high, necessitating the continued maintenance of these pillars. From a managerial perspective, these results support shifting the focus of improvement efforts toward "Source" and "Deliver" without compromising the discipline applied to processes that are already functioning well.

Gap Analysis and Importance-Performance Analysis

Indicator-level analysis reveals the five largest gaps in SRC2, SRC1, DLV3, SRC3, and PLAN1. The prevalence of "Source" indicators reinforces the findings observed at the pillar level. However, priorities are not determined solely by the magnitude of the gap. The IPA utilizes a performance grand mean of 3.659 and an importance grand mean of 4.528 as cut-off lines. Mapping results place SRC2, SRC1, and DLV3 firmly within the "Concentrate Here" quadrant. PLAN1 has a performance mean of 3.657—just 0.002 below the grand mean—placing it in a borderline position; consequently, it was not selected as a focus for Root Cause Analysis (RCA).

Table 4. Gap Analysis and IPA Results by Indicator

Indicator	Assessment Object	V1	V2	Gap	IPA Status
SRC2	Availability of critical materials	2.857	4.600	1.743	Priority
SRC1	Procurement process accuracy	3.086	4.600	1.514	Priority
DLV3	Accuracy and completeness of distribution	3.457	4.629	1.171	Priority
SRC3	Conformity of vendor materials/services	3.371	4.457	1.086	Low Priority
PLAN1	Conformity of BoQ and working drawings	3.657	4.657	1.000	Borderline
RTN1	Control of surplus/non-conforming materials	3.514	4.457	0.943	Low Priority

Source: Primary data processed (2026)

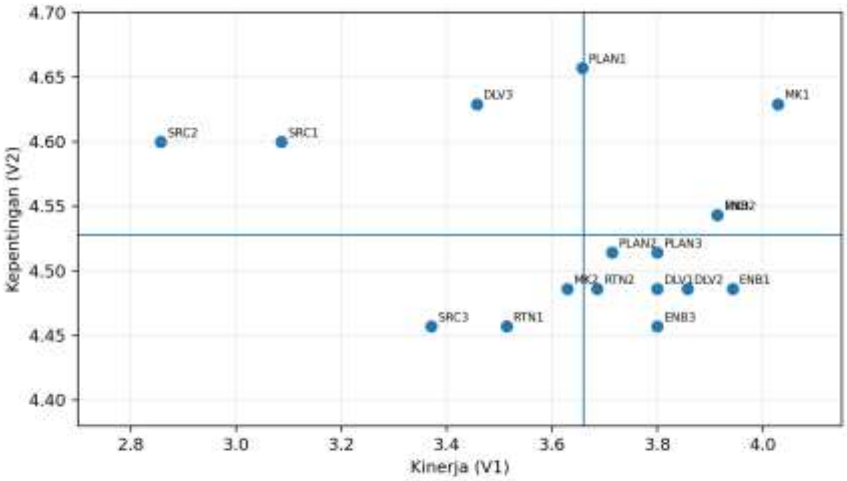

Figure 1. Importance-Performance Analysis mapping.
Source: Research analysis results (2026)

SRC2 is the highest priority because the availability of critical materials is deemed crucial yet currently shows the poorest performance. Materials such as transformers, cables, conductors, poles, and protection devices are physical prerequisites for the work. Stockouts prevent work from starting, force it to be performed partially, or necessitate rescheduling. Furthermore, discrepancies between system records and physical stock can lead to flawed planning decisions.

SRC1 ranks second in priority. The speed of requesting, ordering, fulfilling, and following up with providers is influenced by lengthy administrative stages, contract availability, supplier capacity, and reliance on external supplies. Delays at this stage extend the lead time before work can commence and increase the risk of misalignment between field schedules and material readiness.

DLV3 is the third priority because available materials must still be delivered to the work site in a timely and complete manner. Partial deliveries, fleet limitations, geographical distances, and coordination of loading and shipping can hinder operations. If a single key component fails to arrive, field teams cannot complete the job, even if the majority of materials are already on hand.

These three indicators form a sequential chain of bottlenecks: material fulfillment and availability at the "Source" stage affect distribution readiness, while the quality of distribution impacts the smooth execution of construction and connection work. Consequently, improvements cannot be made piecemeal. Increasing stock levels without disciplined distribution fails to solve the problem, while expediting delivery is ineffective if the materials are not yet available.

Linkage to Operational KPIs

Operational KPI data serves to reinforce the context of the survey results. Seven out of 24 KKP (Customer Connection Projects) were delayed, the backlog reached 481 requests, and 4,773,300 VA of power capacity was pending connection. These figures are not used to statistically prove a causal relationship but rather to demonstrate that respondents' perceptions regarding material bottlenecks are relevant to the actual conditions of work completion.

Table 5. Operational KPI Results

KPI	Actual Result	Interpretation
KKP on time	17/24 (70.83%)	Most were on time, but nearly a third did not meet the target
KKP delayed	7/24 (29.17%)	Indicates a material deviation from target
Backlog >=40 working days	481 requests	Indicates an aggregate bottleneck in the completion process
Deferred power capacity	4,773,300 VA	Capacity not yet able to be realized
Energy opportunity loss	32,458 kWh/day	Deferred potential energy sales

Source: Operational data at PLN UP3 Sanggau (2026)

The interdependencies of these processes can be explained operationally. Low material availability stalls work and extends completion times. Slow procurement processes prolong stock replenishment and the fulfillment of orders for specialized materials. Incomplete distribution can lead to idle time or the rescheduling of planned work. The cumulative effect of these three conditions potentially increases the number of requests exceeding the KKP target or the 40-working-day threshold.

Based on an average sales rate of IDR 1,273/kWh, the estimated energy-related opportunity loss—representing deferred gross revenue—is approximately IDR 41.32 million per day. This figure does not represent a net loss, as it excludes factors such as load factors, tariff variations, supply costs, and actual consumption post-connection. Nevertheless, the estimate suffices to illustrate the business consequences of delays and underscores the urgent need for process improvements.

Interview Results and Root Cause Analysis

In-depth interviews confirmed that material-related bottlenecks stem from multiple causes. Regarding planning, changing requirements and information misalignment can affect the Bill of Quantities (BoQ) and fulfillment timelines. On the logistics side, consistency remains an issue regarding stock accuracy, reservations, goods issues, and safety stock determination. In construction, partial deliveries, geographical conditions, and fleet limitations impact the readiness of work sites. These findings have been mapped against the 5M+1E framework as follows.

Table 6. Root Cause Analysis Mapping (5M+1E)

Priority	5M+1E Category	Dominant Root Cause	Process Impact
SRC2	Method/Measurement	Reservation and goods-issue processes are not yet consistent; stock reconciliation is not yet routine	System stock does not always reflect physical conditions
SRC2	Material	Safety stock and reorder points for critical materials are not yet based on demand patterns	Stockouts and delayed work
SRC2	Machine/Tools	Stock and demand-pipeline visibility is not yet integrated	Fulfillment decisions are reactive

Priority	5M+1E Category	Dominant Root Cause	Process Impact
SRC1	Method/Man	Procurement stages are lengthy and follow-up is not yet standardized	Increased fulfillment lead time
SRC1	Material/Environment	Vendor limitations and dependence on external supply	Risk of supplier delays
DLV3	Machine/Environment	Fleet limitations, distance, weather, and site access	Delayed or partial delivery
DLV3	Method/Man	Completeness checklist and pre-dispatch coordination are not yet disciplined	Materials arrive incomplete

Source: In-depth interview results and research analysis (2026)

For SRC2, the primary root cause lies not merely in inventory volume, but in the quality of inventory control. Inaccuracies in system stock levels hinder planners and operational teams from ensuring material readiness. Without critical material classification, reorder points, and cycle counting, the organization tends to react only after stockouts occur. This pattern reduces responsiveness and increases lead-time variability.

For SRC1, the root cause relates to process complexity and supplier market capacity. Procuring specialized materials can entail lengthy administrative procedures and production times. Reliance on specific vendors or supply sources amplifies risk in the event of delays in contracting, production, or transportation. Consequently, improvements require monitoring lead times at each stage and evaluating supplier performance, rather than simply expediting administrative tasks.

For DLV3, distribution issues are influenced by both internal and external factors. Fleet limitations and distances between locations necessitate route planning and shipment consolidation. Furthermore, pre-dispatch checklists and confirmation of site readiness are essential to prevent partial shipments or the arrival of materials before the work site is prepared. Information integration across the warehouse, procurement, and field operations serves as a key factor.

Improvement Recommendations and Managerial Implications

Recommendations are structured across short-, medium-, and long-term horizons. Initial priorities focus on actions that can immediately improve inventory accuracy and distribution discipline. The medium-term phase focuses on strengthening inventory parameters, procurement monitoring, and vendor performance. The long-term phase targets end-to-end visibility integration and cross-functional governance.

Table 7. Improvement Recommendations

Horizon	Priority Actions	Monitoring KPI	Main PIC
0-3 months	Establish a critical materials list; cycle counting; system-physical reconciliation; pre-dispatch checklist	Stock accuracy; stockouts; delivery completeness; rescheduling	Logistics/Warehouse, Construction

Horizon	Priority Actions	Monitoring KPI	Main PIC
3-6 months	Establish reorder points and buffer stock; lead-time dashboard; vendor evaluation; shipment consolidation	Fulfillment lead time; supplier on-time rate; fill rate; distribution accuracy	Procurement, Logistics, Planning
6-12 months	Integration of the request-BoQ-stock-procurement-distribution pipeline; cross-functional governance	End-to-end visibility; schedule adherence; on-time KKP; backlog	UP3 and ULP Management

Source: Research analysis results (2026)

In the short term, organizations need to establish a list of critical materials based on usage frequency, the impact of stockouts, and lead times. Cycle counting and the reconciliation of system records with physical inventory must be prioritized for these items. Reservation and goods issue processes require clear timeframes and designated personnel responsible for execution. Prior to shipment, warehouse staff and operational teams must utilize a checklist to verify material type, quantity, specifications, documentation, vehicle suitability, and site readiness.

In the medium term, reorder points and buffer stock levels need to be established based on demand patterns, lead time variability, and criticality levels. Procurement dashboards should display the status of requisitions, contracts, production, shipments, receipts, and potential delay risks. Vendor evaluation must extend beyond mere contract compliance to include on-time delivery, order completeness, quality, responsiveness to changing requirements, and the resolution of non-conformities.

In the long term, supply chain visibility must integrate customer demand pipelines, Bills of Quantities (BoQ), available stock, reservations, procurement status, construction schedules, and distribution logistics. Such integration enables early detection of issues before critical project targets are compromised. Cross-functional teams should utilize standardized indicators and conduct regular reviews of high-risk activities, ensuring that improvements rely on systematic processes rather than informal communication or reactive responses to problems.

From an academic perspective, this study demonstrates that the SCOR model can be adapted as a diagnostic framework for project-based utility services. Integrating Importance-Performance Analysis (IPA) helps focus improvement efforts on the most critical indicators, while Root Cause Analysis (RCA) clarifies underlying causal mechanisms. Practically, the study links perceptual findings with operational KPIs and translates them into a monitorable improvement roadmap.

CONCLUSION

An assessment of 17 procurement and distribution process indicators yielded an aggregate performance score of 3.659 and an importance score of 4.528. The Source process emerged as the weakest area, with a mean performance score of 3.10 and the largest gap of 1.45. The study identified critical material availability (SRC2), procurement process timeliness (SRC1), and timely and complete material distribution (DLV3) as the highest-priority indicators. The PLAN1 indicator was excluded from the Root Cause Analysis (RCA) because its position was close to the grand mean and was therefore considered borderline.

The RCA revealed that these priority issues were driven by inconsistent inventory control, suboptimal safety stock and reorder point settings, long procurement lead times, reliance on external suppliers, limited transportation capacity, challenging geographical conditions, and insufficient integration of material information. Operational data—specifically a 29.17% rate of delayed KKP completion, a backlog of 481 requests, 4,773,300 VA of delayed connected capacity, and an estimated energy sales opportunity loss of 32,458 kWh per day—underscored the urgency of process improvements.

Key recommendations included classifying critical materials, conducting cycle counts and inventory reconciliations, establishing reorder points and buffer stocks, monitoring procurement lead times, evaluating supplier performance, implementing pre-dispatch checklists, consolidating material distribution, and improving end-to-end material visibility. This study was limited to a single UP3 unit and relied partly on professional perceptions. Future research could integrate actual transaction-level data for each job, statistically examine the relationships between process indicators and lead times, and compare multiple UP3 units to strengthen external validity.

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