



Explaining Investment Budget Realization in Remote Electricity Infrastructure Projects: Evidence from Maluku and Papua

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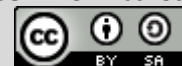
ABSTRACT

Converting an approved capital allocation into usable electricity assets is particularly difficult in remote project environments. This research evaluates whether financial planning, procurement, employee competence, project control, and contractor performance explain investment budget realization at PT PLN (Persero) Maluku and Papua Development Main Unit. A cross-sectional questionnaire produced 132 valid observations from a population of 159 employees with project-management experience. Multiple linear regression was used to estimate individual and joint relationships. Project control was positive, significant, and the largest predictor in the equation ($B = 0.957$; $p < 0.001$). Financial planning was significant but negative after the other variables were held constant ($B = -0.580$; $p = 0.001$), while procurement, employee competence, and contractor performance were not significant individually. The full model was significant ($F = 74.773$; $p < 0.001$) and accounted for 74.8% of the outcome variance. Because planning retained a positive zero-order association and displayed high collinearity with adjacent constructs, its negative partial sign is interpreted as suppression or unstable variance partitioning rather than evidence that sound planning reduces realization. The results support readiness-based allocation, integrated physical-financial control, procurement tied to the critical path, and contractor monitoring based on early-warning indicators.

Keywords

Electricity Infrastructure
Investment Realization
Project Control
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**Introduction**

Capital expenditure creates public value only after approved funds are transformed into completed works, commissioned assets, and reliable electricity services. For a power-utility development unit, the investment realization ratio therefore reflects the performance of an entire delivery chain rather than a purely accounting outcome. Design completion, contracting, construction, inspection, document approval, and payment must occur in the correct sequence before an allocation can be recognized as realized. A break at any stage can postpone asset utilization even when financing is available.

That delivery chain is unusually demanding across Maluku and Papua. Project sites are dispersed over islands, mountainous areas, and locations with limited transport links. Equipment and construction materials often travel through several logistical nodes, while supervision teams and contractors operate far from administrative centers. Weather disruption, lengthy mobilization, scarce local suppliers, and uneven contractor resources can consequently separate the financial calendar from actual site readiness. In this setting, an unspent allocation may signal unfinished prerequisites rather than weak demand for investment.

The unit's annual figures illustrate this instability. Realization represented 75.22% of the 2023 allocation, rose to 96.89% in 2024, and then fell to 81.19% in 2025 [1]. The movement from a near-complete realization year to a substantially lower rate in the following period suggests that allocation size alone cannot explain performance. The relevant managerial question is how package maturity, sourcing, employee capability, execution control, and contractor delivery combine to determine when expenditure can be recognized.

Most Indonesian studies of budget absorption have examined ministries, local governments, or other public-sector work units. Their findings associate realization with planning, procurement, implementation procedures, and human-resource quality, but the evidence is not uniform [2]-[12]. Some models report direct positive relationships [2], [3], [7], whereas other models show that planning or competence loses explanatory power after related implementation variables are introduced [4], [8], [11]. Such divergence indicates that coefficients are sensitive to institutional setting and to the degree of overlap among operational constructs.

Electricity construction also differs from routine administrative spending because payment rights are created by verified physical achievement. Contemporary project-management frameworks treat schedule, cost, quality, scope, risk, and stakeholder coordination as an interdependent control system [13]-[15]. Contractor behavior is equally relevant: workforce deployment, material availability, working capital, technical compliance, and recovery capability affect the attainment of contractual milestones [16]. Yet these execution variables are seldom analyzed together with budget-related factors in studies of remote utility projects.

The study addresses that omission by estimating one model that combines financial planning, procurement, employee competence, project control, and contractor performance. Its contextual contribution is evidence from an electricity development organization responsible for two of Indonesia's most logistically difficult regions. Its analytical contribution is the simultaneous identification of project control as the most influential predictor and a negative partial coefficient for planning. Because the zero-order association for planning is positive while collinearity is high, the negative sign is examined as a conditional statistical result rather than interpreted literally as a harmful effect of sound planning.

Accordingly, the research evaluates both the individual and joint relationships between the five explanatory variables and investment budget realization. The next section develops the theoretical expectations, followed by the research design, empirical findings, interpretation, managerial priorities, conclusions, and study limitations.

Conceptual Background and Hypotheses

A. Budget Realization as a Project Outcome

Investment budget realization expresses the share of an authorized capital program that has progressed far enough to generate an eligible expenditure. In an infrastructure contract, eligibility commonly follows completed quantities, technical acceptance, supporting documentation, and approval of a payment claim. The ratio is therefore best viewed as a downstream indicator of coordinated delivery. A high percentage is desirable only when it is accompanied by compliant outputs, acceptable quality, and timely asset availability; accelerating expenditure without those safeguards would weaken rather than improve investment performance.

B. Planning Quality and Package Maturity

Planning translates strategic priorities into cost estimates, schedules, funding profiles, technical packages, and accountable responsibilities. Previous evidence generally suggests that realistic plans reduce revisions and implementation delays [2]-[10]. For complex capital projects, however, planning quality should be distinguished from the formal completeness of a budget document. An allocation may appear well prepared while the underlying package still

lacks land access, a final design, permits, or a workable procurement route. On this basis, H1 proposes that budget planning is associated with investment budget realization.

C. Procurement as an Execution Gateway

Procurement converts an approved package into an enforceable delivery arrangement. Specification clarity, evaluation speed, process integrity, supplier capability, and contract timing determine whether mobilization can begin when required. Prior studies frequently connect timely procurement with stronger absorption [2], [3], [7]. In eastern Indonesian projects, the same process must anticipate long manufacturing and shipping lead times as well as a limited pool of qualified providers. H2 therefore predicts an association between procurement performance and investment budget realization.

D. Employee Competence as an Enabling Capability

Project employees require technical understanding, administrative accuracy, contractual literacy, coordination skills, and the ability to resolve exceptions. Empirical results regarding competence are mixed [2], [4]-[12], which is plausible because capability does not create expenditure by itself. Its effect emerges through faster decisions, reliable records, effective coordination, and timely corrective action. H3 states that employee competence is related to investment budget realization.

E. Project Control as a Feedback Mechanism

Control provides the feedback loop that connects field conditions with managerial intervention. It compares actual physical and financial progress with the approved baseline, forecasts completion, isolates causes of deviation, and assigns corrective measures. Integrated control of time, cost, quality, risk, and communication is central to current project-management practice [13]-[15]. This function is especially important when sites are remote and problems cannot be observed continuously by senior management. H4 proposes that stronger project control is associated with higher investment budget realization.

F. Contractor Execution

Contractors supply the labor, equipment, logistics, and site management required to convert a contract into measurable progress. Relevant performance dimensions include schedule adherence, conformity with technical requirements, workmanship, safety, resource sufficiency, and responsiveness to site constraints. Evidence from infrastructure settings links contractor outcomes to financial capacity, market conditions, and payment arrangements [16]. Because contractor progress precedes certification and payment, H5 predicts an association with budget realization. H6 further predicts that the five explanatory variables are jointly related to the outcome.

Material and Methods

An explanatory, cross-sectional survey was undertaken within PT PLN (Persero) Maluku and Papua Development Main Unit and the associated implementation units located in Ambon, Ternate, Jayapura, and Sorong. The target population consisted of 159 employees. Purposive inclusion required current employment in the organization, prior participation in an investment project, familiarity with at least one principal delivery process, and a fully completed questionnaire.

Sample adequacy was checked using Green's multiple-regression guidelines [17]. For five predictors, the recommended minimum is 90 observations for the overall equation ($50 + 8m$) and 109 observations for individual coefficients ($104 + m$). The final dataset contained 132 valid responses and therefore exceeded both thresholds. Every participant was a permanent employee with experience in investment-project activities.

Six constructs were represented by six indicators each and rated on a five-point Likert scale. Financial planning covered target definition, estimate realism, need alignment, schedule linkage, document readiness, and coordination. Procurement addressed timing, requirement fit, clarity, transparency, provider capability, and delivery conformity. Employee competence captured knowledge, practical skill, administration, coordination, work behavior, and problem solving. Project control measured progress tracking, schedule, cost, quality, constraint review, and recovery action. Contractor performance covered timeliness, specification compliance, quality, resources, occupational safety, and issue resolution. The dependent construct captured allocation usability, timing, plan conformity, payment continuity, output delivery, and effective use of investment funds.

The statistical sequence included item-total validity tests, Cronbach's alpha, descriptive analysis, residual normality, heteroscedasticity testing, collinearity diagnostics, multiple linear regression, partial tests, the omnibus F test, and the coefficient of determination. A 0.05 significance threshold was applied. In line with multivariate interpretation, coefficient signs were assessed together with zero-order relationships and variance inflation factors [18]. The fitted specification was $Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + e$. Because the OLS diagnostics indicated substantial multicollinearity, two sensitivity checks were added. First, leave-one-predictor-out OLS specifications were estimated to examine the stability of the coefficients. Second, ridge regression was fitted to standardized variables, with the penalty parameter selected by 10-fold cross-validation. These analyses were used as robustness checks and did not replace the prespecified OLS model used for hypothesis testing.

No intervention was administered. Participation was voluntary and the analytical dataset did not retain respondent identities. The source thesis did not report a separate institutional ethics-approval number.

Table 1. Constructs and measurement domains

Construct	Measurement domain	Indicators
Financial Planning (X1)	Targets, estimates, need fit, schedule linkage, readiness documents, coordination	6
Procurement Performance (X2)	Timing, requirement fit, clarity, transparency, provider capability, delivery conformity	6
Employee Competence (X3)	Knowledge, practical skill, administration, coordination, work behavior, problem solving	6
Project Control (X4)	Progress visibility, schedule, cost, quality, constraint review, recovery action	6
Contractor Performance (X5)	Timeliness, specification compliance, quality, resources, safety, issue resolution	6
Investment Budget Realization (Y)	Allocation usability, timing, plan conformity, payment continuity, outputs, fund effectiveness	6

Results and Discussion

A. Year-to-Year Realization Pattern

Table 2 shows a pronounced change in realization across the three reporting years. The 2024 result was close to the authorized amount, yet this improvement was not sustained in 2025. Nominal allocation and realization percentage also moved differently, demonstrating that a larger or smaller budget does not by itself determine the rate achieved. Performance review should consequently separate the approved ceiling, verified physical progress, and the timing of payment recognition.

Table 2. Annual investment budget realization, 2023-2025

Year	Authorized budget (IDR trillion)	Realized expenditure (IDR trillion)	Realization rate (%)
2023	1.076	0.809	75.22
2024	1.320	1.279	96.89
2025	0.839	0.681	81.19

Source: Internal records of PT PLN (Persero) Maluku and Papua Development Main Unit [1].

B. Profile of the Analytical Sample

The sample consisted largely of experienced project personnel. Men accounted for 108 responses (81.82%), employees aged 31-40 formed the largest age group, and three quarters of the sample had served for at least six years. All 132 participants held permanent appointments and had previously worked in investment-project management. Their occupational exposure supports the substantive relevance of the assessments used in the model.

Table 3. Dominant respondent characteristics (n = 132)

Attribute	Largest category	Frequency	Share (%)
Gender	Male	108	81.82
Age	31-40 years	70	53.03
Education	Bachelor's degree	78	59.09
Length of service	>10 years	57	43.18
Position	Staff	105	79.55
Investment-project experience	4-6 years	62	46.97

Source: Questionnaire dataset, analyzed in 2026.

C. Measurement Performance

Each of the 36 statements satisfied the adopted item-validity requirement: the corrected relationship exceeded the critical value and the probability was below 0.05. Reliability estimates ranged from 0.653 to 0.928. The contractor construct produced the lowest alpha (0.653) but remained above the 0.60 criterion used in the original research. Means above 4.00 across all constructs indicate favorable assessments and relatively compressed responses. This limited dispersion is relevant because highly similar ratings can strengthen correlations between conceptually adjacent variables.

Table 4. Construct scores and internal consistency

Construct	Mean	SD	Cronbach's alpha	Reliability decision
Financial planning (X1)	4.381	0.627	0.760	Acceptable
Procurement performance (X2)	4.378	0.646	0.846	Acceptable
Employee competence (X3)	4.479	0.618	0.928	Acceptable
Project control (X4)	4.255	0.677	0.775	Acceptable
Contractor performance (X5)	4.390	0.608	0.653	Acceptable
Investment budget realization (Y)	4.124	0.626	0.800	Acceptable

Source: Questionnaire dataset, analyzed in 2026.

D. Model Fit, Diagnostics, and Hypothesis Tests

The residual normality test returned $p = 0.061$, satisfying the criterion adopted for the analysis. The regression equation was significant as a whole ($F = 74.773$; $p < 0.001$). A multiple correlation of 0.865 and R^2 of 0.748 (adjusted $R^2 = 0.738$) indicate that the five predictors accounted for 74.8% of observed variation in budget realization. Unmeasured variation may reflect land availability, licensing, weather, design changes, geographic accessibility, material supply, and other project-specific conditions.

The estimated equation was $Y = 5.200 - 0.580X_1 + 0.306X_2 + 0.073X_3 + 0.957X_4 + 0.013X_5$. As reported in Table 5, only planning and project control reached the 5% threshold. The diagnostics also revealed substantial shared variance: VIF values were 12.821 for planning, 16.277 for procurement, and 9.747 for project control. The partial estimates must therefore be read as conditional relationships within this specification, not as isolated causal effects.

Table 5. Regression coefficients and hypothesis outcomes

Explanatory variable	B	SE	Standardized beta	t	p	VIF	Inference
Intercept	5.200	1.960	-	2.653	0.009	-	-
Financial planning (X1)	-0.580	0.167	-0.556	-3.469	0.001	12.821	Supported at 5%
Procurement performance (X2)	0.306	0.166	0.333	1.846	0.067	16.277	Not supported at 5%
Employee competence (X3)	0.073	0.106	0.087	0.686	0.494	8.054	Not supported at 5%

Explanatory variable	B	SE	Standardized beta	t	p	VIF	Inference
Project control (X4)	0.957	0.132	1.015	7.266	<0.001	9.747	Supported at 5%
Contractor performance (X5)	0.013	0.058	0.010	0.218	0.828	1.005	Not supported at 5%

Source: Questionnaire dataset, analyzed in 2026. Overall model: $F = 74.773$; $p < 0.001$; $R^2 = 0.748$; adjusted $R^2 = 0.738$.

E. Multicollinearity and Robustness Analysis

The OLS diagnostics showed VIF values of 12.821 for financial planning, 16.277 for procurement performance, 8.054 for employee competence, 9.747 for project control, and 1.005 for contractor performance. To assess whether the principal interpretation depended on a single model specification, each predictor was removed in turn and the reduced OLS model was re-estimated. Project control remained positive and statistically significant in every alternative specification in which it was retained. When project control was excluded, however, the financial-planning coefficient changed from -0.580 ($p = 0.001$) in the full model to +0.292 ($p = 0.037$), while R^2 declined from 0.748 to 0.642. This sign reversal confirms that the planning coefficient is sensitive to the strong shared variance between planning and project control rather than representing a stable standalone negative relationship.

Table 6. Alternative OLS specifications for coefficient-stability assessment

Specification	Planning B	Planning p	Project control B	Project control p	R ²
Full model (X1-X5)	-0.580	0.001	0.957	<0.001	0.748
Without X1	-	-	0.629	<0.001	0.724
Without X2	-0.502	0.003	1.037	<0.001	0.741
Without X3	-0.566	0.001	0.924	<0.001	0.747
Without X4	0.292	0.037	-	-	0.642
Without X5	-0.580	0.001	0.957	<0.001	0.748

Note: OLS coefficients are unstandardized. A dash indicates that the relevant predictor was omitted from that specification.
Source: Reanalysis of the questionnaire dataset, 2026.

A standardized ridge regression provided a second robustness check. With the penalty selected by 10-fold cross-validation (λ approximately 0.758), the standardized coefficients were -0.470 for financial planning, +0.320 for procurement performance, +0.079 for employee competence, +0.946 for project control, and +0.010 for contractor performance; the fitted R^2 was 0.747. Project control therefore remained the largest positive coefficient after regularization. The negative planning sign also remained under ridge shrinkage, so the robustness analysis does not establish that suppression is the only explanation. Taken together, the checks indicate that the project-control finding is comparatively stable, whereas the financial-planning coefficient is specification-sensitive and should be interpreted cautiously.

F. Interpreting the Planning Coefficient

Planning displayed a statistically significant negative partial coefficient. This differs from the positive direction commonly reported in earlier work [2], [3], [6]-[10], [12]. A literal

conclusion that better planning reduces realization would nevertheless be misleading. Planning correlated positively with the dependent variable at the bivariate level ($r = 0.771$), and its relationship with project control was very strong ($r = 0.939$). The additional specification checks reinforce this caution: removing project control changed the planning coefficient from -0.580 ($p = 0.001$) to $+0.292$ ($p = 0.037$), whereas the ridge model retained a negative standardized coefficient for planning (-0.470). The evidence therefore shows that the planning coefficient is highly conditional on how overlapping implementation constructs are partitioned. It should not be interpreted as evidence that sound planning is harmful to budget realization.

The practical lesson concerns the content of readiness, not the desirability of planning. Budget authorization should follow a documented maturity review covering land, design, permits, procurement route, material lead time, baseline schedule, risk ownership, and a feasible payment curve. Such a gate can prevent funds from being assigned to packages that are administratively approved but not yet executable.

G. Procurement and the Transition to Execution

Procurement was positive but did not meet the conventional significance level ($p = 0.067$). The near-threshold probability indicates operational relevance even though its independent statistical contribution became small after planning and control were considered. Unlike studies finding a direct effect [2], [3], [7], the present result suggests that contracting is necessary but insufficient: a signed contract will not produce expenditure when mobilization, material delivery, field access, or measurable progress remains delayed.

Procurement performance should therefore be followed beyond award and contract signature. Useful indicators include readiness to mobilize, manufacturing and shipping status, availability of substitute suppliers, alignment with the critical path, and compatibility between contractual milestones and the monthly funding profile.

H. Employee Capability and Conversion into Action

Employee competence had a positive but non-significant coefficient. Comparable studies also show that competence can lose a direct relationship when implementation and governance variables are modeled simultaneously [4], [8], [11]. Capability functions as an enabling resource; it affects realization only when knowledge is converted into timely decisions, accurate documents, coordinated approvals, and rapid resolution of constraints. High and homogeneous competence scores in this sample further limited the construct's discriminating power.

Development programs should emphasize observable project behaviors rather than attendance alone. Priority capabilities include recovery scheduling, analysis of time and cost

variance, contract administration, change management, logistics-risk treatment, evidence-based reporting, and negotiation across organizational and external stakeholders.

I. Project Control as the Principal Operational Lever

Project control produced the largest coefficient ($B = 0.957$; $p < 0.001$). This result accords with frameworks that base project decisions on approved baselines, current progress evidence, completion forecasts, and corrective measures [13]-[15]. Where projects are geographically scattered, a control system becomes the bridge between field events and managerial authority. Timely visibility enables escalation, resource reallocation, accelerated approvals, and preservation of the documentation needed for progress claims.

The standardized coefficient of 1.015 and VIF of 9.747 also show that the estimate is intertwined with planning and procurement. Project control can reasonably be treated as the leading operational priority in the tested equation, but its magnitude should not be presented as a collinearity-free causal effect.

J. Contractor Performance within the Control System

Contractor performance yielded a very small, non-significant partial coefficient. The result may reflect restricted response variation or an indirect pathway through project control and certification [19]. Prior infrastructure evidence emphasizes the importance of contractor financing, competition, and client payment conditions [16], [20]. In this organizational process, contractor weakness affects financial realization after it appears as missed milestones, nonconforming work, unresolved defects, or delayed supporting documents [21]. The variable therefore remains managerially important despite its insignificant coefficient.

Assessment should combine early-warning and outcome measures [22]. Early indicators include labor deployment, equipment and material status, liquidity, weekly productivity, and unresolved technical queries. Outcome indicators include schedule variance, quality acceptance, safety performance, and claim timeliness [23]. These records should inform future qualification, risk allocation, and contract strategy.

K. Integrated Managerial Architecture

No single policy can stabilize budget realization because the outcome is produced by linked stages. The organization needs an operating architecture that connects package maturity, procurement timing, field execution, control, certification, and payment [24]. Immediate priorities are a physical-financial control dashboard, threshold-based warnings, and an issue register with accountable owners to support timely identification and response to emerging project deviations [24], [25]. Readiness-based allocation, procurement schedules tied to the baseline and cash-flow curve, case-based competence development, and risk-adjusted contractor management should further strengthen the integration of cost, schedule, and risk considerations in project execution [26].

Table 7. Recommended managerial priorities and monitoring signals

Order	Management intervention	Primary monitoring signal
1	Integrated project control: physical-financial dashboard, trigger limits, recovery plans	Schedule/cost variance and unresolved critical issues
2	Readiness-based budgeting: maturity gate for land, design, permits, schedule, and risk	Share of packages classified as executable
3	Critical-path procurement: tender and logistics milestones linked to the baseline	On-time award, mobilization, and material availability
4	Applied competence development: contract, variance, risk, and coordination cases	Resolution cycle time and quality of project records
5	Risk-adjusted contractor management: scorecards and liquidity/logistics mitigation	Productivity, quality, safety, and claim timeliness

Source: Managerial synthesis derived from the empirical results, 2026.

Conclusion

The regression model was significant and explained 74.8% of the variation in investment budget realization. Project control had a positive and significant coefficient and represented the strongest operational predictor in the equation. Planning was also significant but carried a negative partial sign. Procurement, employee competence, and contractor performance did not reach statistical significance individually. Sensitivity checks using leave-one-predictor-out specifications and ridge regression preserved project control as the strongest positive predictor, while the financial-planning coefficient remained sensitive to model specification.

The evidence reinforces a process-based interpretation of investment realization: expenditure follows the coordinated conversion of plans into verified progress. The unexpected planning sign should not be treated as proof that sound preparation is counterproductive. Its positive zero-order relationship, high VIF values, sign reversal when project control is omitted, and persistence under ridge shrinkage together show that the partial coefficient is specification-sensitive and should not be given a literal causal interpretation. The theoretical contribution is therefore the integration of budget, human, contractual, and control mechanisms within a remote electricity-project context, together with a caution against reading partial coefficients without diagnostic and robustness evidence. For practice, the unit should strengthen real-time physical-financial control, allocate budgets according to package maturity, synchronize procurement with the approved baseline, develop competencies linked to actual delivery problems, and evaluate contractors through leading as well as lagging indicators. These measures are intended to improve consistency of realization while preserving technical quality, compliance, safety, and the long-term value of the assets.

Limitations and Future Research

The evidence comes from one development unit, one survey period, and respondent perceptions. It cannot establish changes through time or fully separate organizational

perception from objective project performance. Moreover, X1-X4 were strongly intercorrelated, with VIF values above 10 for planning and procurement. The added alternative-specification and ridge analyses improve transparency about coefficient stability, but they do not eliminate the underlying overlap among the constructs or establish causal pathways. The financial-planning coefficient should therefore continue to be interpreted as conditional on the multivariate specification.

Subsequent research should combine survey measures with project-level longitudinal records, including contract value, monthly physical progress, certified payments, variation orders, delay days, land status, logistics exposure, and geographic accessibility. Project readiness could be modeled as a higher-order construct, while structural equation modeling, latent-variable approaches, or theoretically justified variable reduction could test whether the overlapping planning, procurement, competence, and control dimensions are better represented by a smaller number of underlying factors. Replication across other development units would also clarify the model's external validity.

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Conflict of Interest

The author declares that no conflict of interest exists.

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