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Project Performance Analysis from a Financial Sustainability Perspective: A Case Study of Schedule, Cost, and Risk Performance in a 2×31 MW Coal-Fired Power Plant Project

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Abstract

Large-scale energy infrastructure projects face significant challenges in achieving schedule, cost, and financial sustainability targets amid increasing technical complexity, uncertainty, and project risk. Deviations during project execution, particularly schedule delays and cost overruns, can significantly affect project continuity and long-term financial performance. This study aims to analyze project performance from a financial sustainability perspective by examining the interaction between schedule performance, cost performance, project risk, and project control on a 2×31 MW coal-fired power plant project located in the Karimun Free Trade Zone, Riau Islands. The study employed a qualitative approach with a holistic single case study design, supported by limited descriptive and nonparametric quantitative analysis. Data were collected through in-depth interviews with five key informants, non-participant observation, project documentation, and a focus group discussion (FGD) used to confirm and deepen the findings, complemented by 60 monthly periods of Plan Progress, Actual Progress, Plan Cost, and Actual Cost data (July 2019-June 2024). Qualitative data were analyzed thematically with reference to the Miles and Huberman interactive model, assisted by NVivo software for coding and triangulation, while quantitative data were tested using descriptive statistics, the Shapiro-Wilk normality test, the Wilcoxon Signed-Rank Test, and Spearman correlation. The findings show that the project experienced a 21-month schedule delay, increasing the planned duration from 39 to 60 months (53.85%), accompanied by a cost overrun of 55.50% (planned cost index of 100.00 rising to an actual cost index of 155.50). The Wilcoxon test showed that the difference between planned and actual costs was at the borderline of the 5% significance level ($Z = -1.995$; $p = 0.046$), so the result is used as supporting quantitative evidence and interpreted with caution. These deviations were primarily driven by procurement delays, design changes, technical constraints, weak coordination, rework, and ineffective integrated project control. The results indicate that project risk acted both as a trigger and reinforcer of schedule and cost deviations, which in turn affected financial sustainability through cash flow pressure, increased financing costs, and margin erosion. This study concludes that financial sustainability in infrastructure projects requires an integrated control system linking schedule, cost, risk, and financial monitoring throughout the project life cycle.

INTRODUCTION

The development of energy infrastructure plays a strategic role in supporting economic growth, industrial activity, and national sustainable development. Within the framework of the Sustainable Development Goals (SDGs), energy projects are linked to Goal 7 on affordable and reliable access to energy and Goal 9 on building resilient and sustainable infrastructure (United Nations, 2015). Accordingly, power generation projects, including coal-fired power plants (CFPPs), are required not only to be physically completed but also to be managed efficiently so that they can deliver long-term economic and financial benefits (Atmo et al., 2015; Hamdi et al., 2021; Wijaya, 2022).

In project management, project success was initially measured largely through the fulfillment of time, cost, and quality targets, known as the triple constraint (Kerzner, 2017). However, the measure of project success has since evolved beyond operational achievement to encompass the ability to create economic value and sustain long-term financial performance (Shenhar & Dvir, 2007). Project performance therefore needs to be analyzed not only from the perspective of schedule and cost, but also in terms of its implications for the project's financial stability.

In practice, many infrastructure projects do not proceed entirely as planned. Schedule and cost deviations are frequently found in large-scale projects due to the complex interaction of technical, managerial, organizational, and external factors. Flyvbjerg et al. (2004) explain that delays and cost overruns are systemic issues in infrastructure projects, while Love et al. (2012) assert that cost overruns can be triggered by a combination of technical, managerial, and project execution factors. A similar phenomenon is found in construction projects in Indonesia, where cost overruns are influenced by weak cost planning, low labor productivity, changing project conditions, and suboptimal execution control (Ilhamsyah Siregar et al., 2025; Sofyan et al., 2024).

The interrelationship between schedule deviation, cost overrun, and financial sustainability is critically important because project performance directly affects cash flow and investment feasibility. Schedule delays can postpone revenue recognition or progress billing, while cost overruns increase funding requirements and financing costs. From a project finance perspective, financial sustainability is determined by the ability to maintain cash flow stability, cost efficiency, and long-term investment feasibility (Yescombe, 2018). Analysis of project performance therefore needs to be directed toward understanding how schedule and cost deviations affect a project's financial condition.

This phenomenon is reflected in the 2×31 MW coal-fired power plant project examined in this study, located in the Karimun Free Trade Zone (FTZ), Riau Islands. With a nominal capacity of approximately 60 MW, the project supports the electricity supply for an industrial area. The project was planned for completion within 39 months from the start of construction in July 2019 (targeted for September 2022), but actual implementation took 60 months, until June 2024, meaning a delay of 21 months, or 53.85% of the planned duration. In addition, the project experienced a cost overrun of 55.50% compared to the initial plan (Plan Cost Index of 100.00 rising to an Actual Cost Index of 155.50). These deviations indicate that the project's problems were not limited to delays in physical completion but also affected cost efficiency and financial sustainability.

Several research gaps underlie this study. Most prior research has focused on identifying the causes of delays and cost overruns but has not sufficiently explained how such deviations form within the context of real project execution. Schedule delays and cost overruns are often examined separately, even though in practice the two influence one another. Research on project risk generally treats risk as a cause of deviation without integrating it with project control systems and financial sustainability. Studies on power generation infrastructure projects in Indonesia that integrate schedule performance, cost performance, project risk, project control, and financial sustainability within a single analytical framework also remain limited.

This study aims to analyze project performance from a financial sustainability perspective through a case study of the 2×31 MW coal-fired power plant project, focusing on how schedule performance, cost performance, and project risk interact with one another, and how this interaction affects the project's financial sustainability. The novelty of this study lies in integrating the analysis of schedule, cost, and risk within a financial sustainability perspective; the study does not merely identify the causes of delay and cost overrun, but also explains how risk triggers schedule deviation, how delay increases cost, and how cost overrun puts pressure on cash flow and the project's financial feasibility.

This study offers several specific contributions. Theoretically, it enriches the project management literature through a more integrative approach that combines operational, risk, and financial sustainability aspects. Practically, it provides insight for project managers as well as the engineering, procurement, construction, cost control, and finance functions regarding the importance of an integrated cross-functional control system. This study also serves as a reference for project owners, investors, and similar future projects in developing more realistic planning, integrated monitoring, and financial risk management strategies (Atkinson, 1999; Project Management Institute, 2021).

METHOD

Research Approach and Design

This study employs a qualitative approach with a holistic single case study design, supported by limited descriptive and nonparametric quantitative analysis. This approach was chosen because the study aims to develop an in-depth understanding of how the performance of the 2×31 MW coal-fired power plant project was formed, particularly regarding schedule delays, cost overruns, project risk, project control, and their impact on financial sustainability. The descriptive and nonparametric quantitative analysis serves as supporting evidence, while the in-depth exploration of the experiences, perceptions, and understanding of project actors regarding the dynamics of project execution remains the study's primary focus.

Philosophically, this study is situated within the constructivist paradigm, which views social reality as something formed through the experience, interaction, and interpretation of individuals involved in a particular context (Creswell, 2017). In this study, project performance is understood not merely as figures representing schedule delay or cost overrun, but as a phenomenon shaped by the decision-making process, coordination among parties, risk management, and management's response to project deviations.

The research design is a holistic single case study that is exploratory and interpretive in nature. The 2×31 MW coal-fired power plant project is regarded as an information-rich case that provides in-depth information on the phenomenon under study. The unit of analysis in this study is the performance of the 2×31 MW project as a whole, specifically as it relates to schedule performance, cost performance, project risk, project control, and financial sustainability.

Key Conceptual Definitions

Schedule performance refers to a project's ability to carry out and complete work within the planned time frame, analyzed through an understanding of work delays, deviations from the baseline schedule, delays in the procurement of materials and equipment, and delays in project handover. Cost performance refers to a project's ability to manage financial resources within the planned budget limits, analyzed through increases in labor costs, equipment costs, operational costs, overhead, rework, idle time, financing, and additional costs arising from the extension of the project duration.

Project risk refers to uncertainty that has the potential to affect the achievement of project objectives in terms of schedule, cost, quality, control, and financial condition, encompassing procurement risk, technical risk, managerial risk, and financial risk (Hillson, 2024; Chapman, 2003). Project control refers to the process of monitoring, evaluation, and corrective action to ensure that project execution remains within planned limits. Financial sustainability refers to a project's ability to maintain a stable financial condition throughout execution, analyzed through cash flow stability, progress billing, cost-to-complete, claims or variation orders, financing costs, project margin, and the potential loss arising from delayed handover (Yescombe, 2018).

Social Setting and Key Informants

The social setting of this study is the 2×31 MW coal-fired power plant project, characterized as a large-scale infrastructure project involving the engineering, procurement, construction, commercial, cost control, and finance functions. Five key informants were selected through purposive sampling, not for statistical representativeness, but to select informants with in-depth knowledge, direct experience, and genuine involvement relevant to the research context (Turner et al., 2014). The informant categories are presented in Table 1.

Table 1. Key Informant Categories

Code	Function	Role in the Project	Relevance to Research Focus
I1	Engineering	Technical planning, design management, drawing verification	Impact of design changes on schedule; engineering-procurement coordination
I2	Procurement / Commercial	Procurement, vendor management, claims, variation orders	Procurement risk; material/equipment delays; claim and VO management
I3	Construction	Field construction execution, subcontractor coordination	Field constraints, rework, labor and equipment productivity
I4	Cost Control	Budget monitoring, cost deviation analysis, cost-to-complete	Drivers of cost overrun; cost performance monitoring; cost deviation analysis
I5	Finance	Cash flow management, progress billing, financing	Financial sustainability; cash flow pressure; financing cost analysis

Data Collection and Analysis

Data were collected through in-depth interviews with five key informants, non-participant observation, project documentation, and a focus group discussion (FGD) used to confirm and deepen the findings. In-depth interviews used a semi-structured interview guide focusing on schedule performance, cost performance, project risk, project control, financial impact, and improvement strategies. Non-participant observation was conducted on the project execution context, coordination patterns, and monitoring activities. Project documentation covered progress reports, project schedules, budget and cost realization data, contract documents, variation order documents, meeting minutes, and internal project reports. The FGD was conducted at the final stage of data collection to clarify differences in information among informants, deepen the relationships among themes, and confirm the researcher's initial interpretations.

Data were analyzed thematically through a process of coding, grouping codes into categories and sub-themes, developing main themes, displaying data in matrices, and drawing and verifying conclusions with reference to the Miles and Huberman interactive analysis model. The coding process (open coding, axial coding, and selective coding) was carried out with the assistance of NVivo software. Triangulation was conducted by comparing information from various informant functions, cross-checking interview results with project documents and FGD results, and linking observation findings with schedule, cost, and work-progress data (Creswell, 2017).

Data validity was maintained through four trustworthiness criteria: credibility, through source and method triangulation as well as member checking; transferability, through thick description of the research context; dependability, through systematic audit-trail documentation; and confirmability, by tracing findings back to the source data.

RESULTS AND DISCUSSION

Project Overview

The 2×31 MW coal-fired power plant project is located in the Karimun Free Trade Zone (FTZ), Riau Islands Province, and was built to support the electricity supply needs of an industrial area. The project uses Circulating Fluidized Bed Combustion (CFBC) technology and covers the engineering, procurement, construction, commissioning, and handover stages, reflecting a high level of technical and managerial complexity.

The project commenced in July 2019 with a planned duration of 39 months, targeting completion in September 2022. Cost values were normalized into an index, with the planned-cost baseline set at 100.00. However, in actual execution, the project experienced significant deviations from both a schedule and cost perspective, as presented in Table 2.

Table 2. Summary of Project Performance Deviations

Performance Indicator	Plan	Actual Realization	Deviation	Deviation (%)
Project Duration	39 months	60 months	+21 months (delay)	53.85%
Project Cost (Index)	100.00	155.50	+55.50 points (overrun)	55.50%
Project Start	July 2019	July 2019	-	-

Performance Indicator	Plan	Actual Realization	Deviation	Deviation (%)
Completion Target	September 2022 (Month 39)	June 2024 (Month 60)	Delayed 21 months	-

Note: Cost values were normalized into an index, with the planned-cost baseline set at 100.00. The S-Curve comparison between plan and actual confirms this deviation, showing that the project, originally planned for completion at month 39, was extended to month 60.

The cumulative comparison between planned and actual progress is presented through the S-Curve in Figure 1. At the end of the baseline period (September 2022, month 39), planned progress had reached 100%, while actual progress had only reached 89%, leaving a progress gap of 11%. Actual progress subsequently increased gradually until reaching 100% in June 2024 (month 60), indicating that the schedule gap had already formed before the end of the planned period and did not emerge only at the final completion stage.

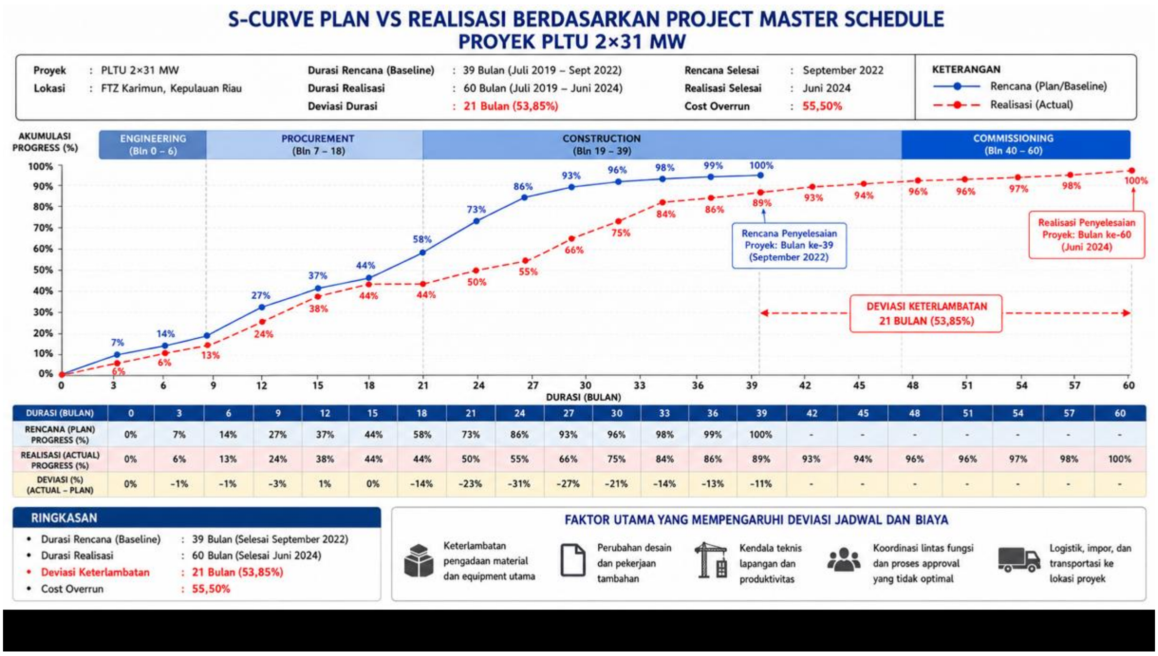

Figure 1. S-Curve of Plan vs. Actual for the 2×31 MW Coal-Fired Power Plant Project

Source: 2×31 MW project documentation data (2026)

Informant Description

The informant description is presented to show the position and contribution of each informant in providing empirical data. To maintain data confidentiality while enabling systematic thematic analysis, informant identities are presented in coded form. A description of each key informant is presented in Table 3.

Table 3. Key Informant Description

Informant Code	Function	Position/Role	Duration of Involvement
I1	Engineering	Engineering representative responsible for technical planning, design coordination, and drawing verification	Involved during most of the project execution period
I2	Procurement/Commercial	Procurement/Commercial representative responsible for procurement management, vendor coordination, claims, and variation orders	Involved during most of the project execution period
I3	Construction	Construction representative responsible for field construction execution and subcontractor coordination	Construction phase through handover
I4	Cost Control	Cost Control representative responsible for budget monitoring, cost deviation analysis, and cost-to-complete estimation	Involved during most of the project execution period
I5	Finance	Finance representative responsible for cash flow management, progress billing, and project financing	Involved during most of the project execution period

Supporting Quantitative Analysis

To strengthen the empirical evidence regarding the magnitude and pattern of project performance deviation, this study also conducted a limited descriptive and nonparametric quantitative analysis of the monthly Plan Progress, Actual Progress, Plan Cost, and Actual Cost data over 60 observation periods (July 2019-June 2024). This analysis is not intended to establish causal relationships, but rather to serve as supporting empirical evidence that reinforces the qualitative findings regarding the pattern and magnitude of schedule and cost deviation.

Table 4. Descriptive Statistics of Monthly Project Progress and Cost Data (N = 60)

Variable	Minimum	Maximum	Mean	Std. Deviation
Plan Progress (monthly)	0.000000	0.057600	0.01666333	0.019263868
Actual Progress (monthly)	0.000270	0.085550	0.01666700	0.017097641
Plan Cost (monthly)	0.000000	0.057600	0.01666670	0.019264248
Actual Cost (monthly)	0.000120	0.123060	0.02591800	0.025918094

Source: Researcher's data processing results (2026)

The descriptive statistics show that the monthly average Plan Progress and Actual Progress are nearly equal (0.01666 versus 0.01667), indicating that overall total progress at the end of the period is similarly close to 100% completion. However, this similarity in averages does not reflect similarity in schedule performance, as actual progress was achieved with a different time distribution and a longer completion duration than planned. In terms of cost, the monthly average Actual Cost (0.02592) is higher than the monthly average Plan Cost (0.01667), with the standard deviation of Actual Cost (0.02592) also being larger than that of Plan Cost (0.01926), indicating greater monthly variation in actual costs. The maximum monthly Actual Cost value (0.123060) is even more than twice the maximum Plan Cost value (0.057600).

The Shapiro-Wilk normality test was conducted on the paired differences between planned and actual data (Different Progress and Different Cost) to determine the appropriate paired-difference test method, as presented in Figure 2.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Different Progress	.203	60	<.001	.915	60	<.001
Different Cost	.088	60	.200*	.960	60	.048

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 2. Shapiro-Wilk Normality Test Output for Progress and Cost Difference Data
Source: Researcher's data processing results (2026)

The Shapiro-Wilk test results show that Different Progress has a statistic value of 0.915 ($p < 0.001$) and Different Cost has a value of 0.960 ($p = 0.048$). Both significance values are below the 0.05 threshold, indicating that the distribution of the paired differences for both progress and cost does not meet the assumption of normality. Based on these results, the test of the difference between planned and actual cost was conducted using the Wilcoxon Signed-Rank Test as a nonparametric method for two paired samples, as presented in Figure 3.

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Actual Cost Bulanan - Plan Cost Bulanan	Negative Ranks	19[a]	33.89	644.00
	Positive Ranks	41[b]	28.93	1186.00
	Ties	0[c]		
	Total	60		

a. Actual Cost Bulanan < Plan Cost Bulanan

b. Actual Cost Bulanan > Plan Cost Bulanan

c. Actual Cost Bulanan = Plan Cost Bulanan

Test Statistics[a]

	Actual Cost Bulanan - Plan Cost Bulanan
Z	-1.995[b]
Asymp. Sig. (2-tailed)	.046

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Figure 3. Wilcoxon Signed-Rank Test Output between Plan Cost and Actual Cost

Source: Researcher's data processing results (2026)

The Wilcoxon Signed-Rank Test results show that, of the 60 monthly periods analyzed, there were 41 periods in which Actual Cost was higher than Plan Cost (positive ranks; mean rank 28.93) and 19 periods in which Actual Cost was lower (negative ranks; mean rank 33.89), with no ties. The Wilcoxon test showed that the difference between planned and actual costs was at the borderline of the 5% significance level ($Z = -1.995$; $p = 0.046$), so the result should be interpreted with caution and used as supporting quantitative evidence. The substantive interpretation continues to rest on the magnitude of the cumulative cost deviation, namely the increase from a planned cost index of 100.00 to an actual cost index of 155.50 (a cost overrun of 55.50%), which is supported by project documentation and the qualitative findings.

Spearman correlation was used exploratively to assess the pattern of association between monthly progress deviation (Different Progress) and monthly cost deviation (Different Cost) within the same period, as presented in Figure 4.

Correlations

			Different Progress	Different Cost
Spearman's rho	Different Progress	Correlation Coefficient	1.000	-.525**
		Sig. (2-tailed)	.	<.001
		N	60	60
	Different Cost	Correlation Coefficient	-.525**	1.000
		Sig. (2-tailed)	<.001	.
		N	60	60

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4. Spearman Correlation Output between Monthly Progress Deviation and Cost Deviation

Source: Researcher's data processing results (2026)

The Spearman correlation test results show a coefficient of -0.525 with a significance value of $p < 0.001$ ($N = 60$), indicating a moderate negative relationship between Different Progress and Different Cost. This negative direction does not imply that delays reduce project cost; rather, it is presumed to be related to a time lag between work execution, progress recognition, receipt of materials or vendor/subcontractor invoices, and cost recording - in periods when progress lags, some costs may not yet have been realized or recorded, and vice versa. This correlation is used exploratively, not as evidence of a causal relationship, given the monthly time-series nature of the data, which is not fully independent across periods, and given that this study did not conduct lagged correlation testing.

Overall, the supporting quantitative analysis provides initial evidence regarding the magnitude, difference, and pattern of project performance deviation, but does not yet explain in depth the process and factors that shaped this deviation. These quantitative findings are therefore further deepened through NVivo-assisted qualitative analysis in the following section.

NVivo Data Processing Results

Data from five interview transcripts, one observation record, and one documentation study were processed using NVivo software. Six main nodes were constructed based on the research focus: schedule performance, cost performance, project risk, project control, financial sustainability, and improvement strategy. Each node was given an operational definition and key coding indicators to ensure consistent and systematic coding at the open, axial, and selective coding stages. The NVivo node structure and thematic coding results are presented in Table 5.

Table 5. NVivo Node Structure and Thematic Coding

Node (Main Theme)	Operational Definition	Key Coding Indicators
Schedule Performance	A project's ability to carry out and complete work within the planned time frame	Schedule delay, baseline deviation, procurement delay, engineering hold, coordination delay, critical-path disruption, commissioning delay
Cost Performance	The ability to manage a project's financial resources within the planned budget	Cost overrun, increased labor cost, equipment cost, overhead, idle cost, rework cost, financing cost, increased cost-to-complete
Project Risk	Uncertainty with the potential to affect project objectives in terms of schedule, cost, quality, and finance	Procurement risk, technical risk, managerial risk, financial risk, vendor performance, design changes, logistics constraints
Project Control	The process of monitoring, evaluation, and corrective action to keep project execution within planned parameters	Progress monitoring, deviation detection, reporting system, early warning, cross-functional coordination
Financial Sustainability	The ability to maintain a stable financial condition throughout project execution	Cash flow stability, delayed progress billing, cost-to-complete, claims, variation orders, project margin, financing cost, bank guarantee extension
Improvement Strategy	Strategies to prevent or minimize deviation and strengthen project control	Integrated control system, design freeze, strengthened procurement, vendor management, early cost control involvement, documentation discipline

Based on this node structure, the results of theme grouping from the NVivo analysis are presented in Table 6, which shows the main themes along with the related sub-themes generated from the coding process.

Table 6. Theme Grouping Results

Main Theme	Identified Sub-Themes
Schedule Performance	Procurement delays, impact of design changes, field constraints, coordination delays among engineering-procurement-construction, rework duration, commissioning delays, handover postponement
Cost Performance	Labor cost overrun, increased equipment/rental cost, higher overhead cost, idle-time cost, rework cost, increased financing cost, rising cost-to-complete estimates

Main Theme	Identified Sub-Themes
Project Risk	Procurement and vendor risk, technical risk and design changes, managerial and coordination risk, financial risk (cash flow pressure, margin erosion, increased financing cost)
Project Control	Schedule monitoring, cost monitoring, physical progress reporting, deviation analysis, early warning system effectiveness, cross-functional data integration
Financial Sustainability	Cash flow gap (cash-out vs. cash-in), delayed progress billing, increased cost-to-complete, unclaimable additional costs, declining project margin, bank guarantee extension
Improvement Strategy	Integrated project control system, realistic baseline planning, strengthened procurement and vendor management, design-freeze policy, early involvement of finance/cost control functions, claim documentation discipline

A data-source triangulation matrix was constructed to show the alignment between the main coding themes and the research data sources. As presented in Table 7, each main theme is confirmed by at least two of the three data sources (interviews, observation, documentation), which strengthens the credibility of the research findings.

Table 7. Data-Source Triangulation Matrix

Main Theme	In-depth Interviews (I1–I5)	Non-participant Observation	Project Documentation	Confirmation Status
Schedule Performance	✓ All informants	✓ Field conditions observed	✓ Progress reports, project schedule	Confirmed
Cost Performance	✓ All informants	✓ Resource utilization observed	✓ Cost realization, budget reports	Confirmed
Project Risk	✓ All informants	✓ Risk conditions observed	✓ Risk log, change orders	Confirmed
Project Control	✓ All informants	✓ Monitoring activities observed	✓ Control reports, meeting minutes	Confirmed
Financial Sustainability	✓ I4, I5 primary; I2, I3 supporting	(not directly observable)	✓ Financial records, billing documents	Confirmed
Improvement Strategy	✓ All informants	(not directly observable)	✓ Lessons-learned documents	Confirmed

The inter-theme relationship matrix presents the pattern of connections among the six main themes resulting from the NVivo analysis, showing how each theme influences the others in explaining project dynamics (Table 8).

Table 8. Inter-Theme Relationship Matrix

Theme	Directly Influences	Influenced By	Relationship Description
Project Risk	Schedule Performance; Cost Performance	Project Control (risk mitigation)	Risk triggers schedule and cost deviation; effective control can mitigate risk impact
Schedule Performance	Cost Performance; Financial Sustainability	Project Risk; Project Control	Schedule delay directly increases time-based costs and puts pressure on financial sustainability
Cost Performance	Financial Sustainability	Schedule Performance; Project Risk; Project Control	Cost overrun reduces margin, puts pressure on cash flow, and increases funding requirements
Project Control	All themes (deviation mitigation)	Schedule Performance; Cost Performance (indicating control needs)	Integrated control detects deviation early and enables corrective action
Financial Sustainability	N/A (outcome variable)	Schedule Performance; Cost Performance; Project Control	Financial condition is a cumulative outcome of the interaction among all other themes
Improvement Strategy	All themes (strengthening management)	All themes (lessons from deviation)	Strategy is derived from weaknesses observed across all project execution themes

The coding results were also visualized in the form of a mind map showing the connections between the main themes and sub-themes (Figure 5). This visualization confirms that the performance of the 2×31 MW project is influenced by six interconnected main themes, with project risk, schedule performance, and cost performance forming a cascading relationship that ultimately determines financial sustainability.

Figure 5. Mind Map of NVivo Coding Results

Source: Researcher's data processing results (2026)

Schedule Deviation as a Result of Interaction Among Project Stages

The research findings show that the 2×31 MW project experienced a delay of 21 months, with the planned duration of 39 months extending to an actual realization of 60 months (53.85%). This delay did not occur suddenly, but developed cumulatively from several interrelated disruptions: delays in the procurement of key materials and equipment, design changes, vendor constraints, field conditions, equipment limitations, and suboptimal cross-functional coordination.

Interpretively, this schedule deviation shows that in an EPC-type project, the engineering, procurement, and construction stages are interdependent rather than standing alone. When design documents or technical specifications change, the procurement process is also delayed. When key materials or equipment arrive late, construction cannot proceed as planned. Schedule delay is thus formed through a chain effect that develops throughout project execution. This finding is consistent with prior research by Frimpong et al. and Sambasivan and Soon, who identified material delays, weak coordination, design changes, and decision-making constraints as major factors in schedule delay. This finding also supports Kerzner's (2017) assertion that large-scale projects require the integration of planning, coordination, and cross-functional control.

From a systems thinking perspective (Turner et al., 2014), project performance cannot be explained by a single factor. A delay in one activity affects subsequent activities through dependency relationships within the project network (Vazquez et al., 2024). Schedule control is therefore inadequate if limited to periodic progress monitoring; it must be linked to design readiness, procurement status, field conditions, and vendor performance.

Cost Overrun as a Consequence of Duration Extension

The project experienced a cost overrun of 55.50%, from a Plan Cost Index of 100.00 to an Actual Cost Index of 155.50. This overrun was primarily driven by the extension of the project duration, which resulted in the continuation of time-based costs: labor, equipment rental, field operations, overhead, financing, and additional costs for rework and design changes. Some additional costs could not be fully claimed to the project owner due to the absence of adequate contractual grounds, complete documentation, or formal approval, and therefore became a direct burden on the project.

Interpretively, cost performance is highly sensitive to schedule deviation. As the project duration extends, the cost structure changes because resources must remain available even though physical progress does not increase proportionally. This is consistent with the time-cost relationship concept and aligns with Flyvbjerg et al.'s (2004) finding that cost overruns in infrastructure projects are caused not only by initial estimation errors, but also by execution dynamics that push actual costs beyond the plan. Love et al.'s (2012) research emphasizes that rework and changes during execution are among the main drivers of cost increase; this finding is directly supported by the results of the present study, in which rework, design changes, work-method changes, and additional work that could not be fully claimed significantly reinforced cost pressure. Consistent with the findings of Limantoro et al. (2023), Mutiawati (2022), and Dapu et al. (2016), cost control cannot be carried out separately from schedule control - analysis that focuses solely on cost without considering schedule deviation, physical progress, design changes, procurement status, claims, and contractual risk will lag behind in detecting the sources of cost overrun.

Project Risk as a Trigger and Reinforcer of Deviation

Project risk plays an important role in influencing schedule and cost performance. Procurement risk is manifested in material delays, vendor constraints, import processes, shipping documentation, and delays in material approval. Technical risk arises through design changes, technical verification, field conditions, equipment limitations, and rework. Managerial risk relates to cross-functional coordination, human resource competence, and delays in decision-making. Financial risk emerges as a consequence of delays and cost overruns, including cash flow pressure, increased financing needs, financing costs, and the potential erosion of margin.

From a systems thinking perspective, these risks are interconnected and dynamic in nature. Procurement and technical risks can trigger schedule delays; schedule delays increase cost; increased cost puts pressure on cash flow; and cash flow pressure reinforces financial risk. This finding aligns with Adryani et al. (2024) and Budzier et al. (2018), who identify that the causal factors of time overrun and cost overrun mutually influence one another within a complex project environment. Risk management on similar projects therefore needs to shift from a reactive to a proactive and adaptive approach - risk must not only be identified at the project initiation stage, but also monitored throughout execution and linked to schedule, cost, physical progress, procurement status, claims, and financial condition (Hillson, 2024; Chapman, 2003). This finding is also consistent with the results of Mahta Taghi Zadeh and Kashef (2021) on IT projects, in which complexity reinforces cost and schedule risk in an interrelated manner.

Project Control as a Mechanism for Detecting and Correcting Deviation

Project control was carried out through progress monitoring, schedule evaluation, cost monitoring, project status reporting, and cross-functional coordination. However, the effectiveness of control remained suboptimal because information on schedule, cost, progress, risk, and financial condition had not been fully integrated into a single decision-making mechanism. Schedule and cost performance indicators were available but were used more for administrative reporting than as an active early warning system or a basis for corrective decision-making.

Interpretively, this finding confirms that project control had not yet fully functioned as an early warning system. The concept of Earned Value Management (EVM) (Project Management Institute, 2021) positions the integration of schedule, cost, and physical progress as the foundation for project performance evaluation - not merely for reporting, but to enable proactive corrective action. When data on physical progress, actual cost, cost-to-complete, procurement status, and risk are not integrated, early detection of potential delays and cost overruns becomes difficult. This finding also indicates that the cost control and finance functions need to be more actively involved from the early stages of the project, since any delay or change affects not only cost but also claims, progress billing, cash flow, and project margin. This is consistent with the findings of Algony et al. (2023) and Laela Akmalinda Assoraya et al. (2021) regarding the importance of integrative financial monitoring in infrastructure projects.

Impact of Deviation on Project Financial Sustainability

Schedule delay and cost overrun directly affect the project's financial sustainability. Delays cause project expenditures for labor, equipment, vendors, subcontractors, field operations, administration, and financing to continue, while progress-billing revenue depends on progress achievement, milestone completion, billing-document readiness, project-owner approval, and claim settlement. This creates an imbalance between cash-out and cash-in that puts pressure on project liquidity. Cost overrun also increases cost-to-complete, funding requirements, financing costs, and pressure on project margin. Not all additional costs resulting from delays, design changes, or additional work can be claimed to the project owner, so unclaimable additional costs become a direct burden on the project that erodes margin.

Interpretively, financial sustainability is determined not only by the availability of funds at the project initiation stage, but by the project's ability to maintain financial stability throughout execution. This is consistent with the project finance concept (Yescombe, 2018), which emphasizes cash flow stability, cost control, and revenue certainty as determinants of a project's financial feasibility. Evaluation of a project's financial sustainability therefore needs to be conducted continuously throughout execution, not only at the planning stage. A financial early warning system linking physical progress, schedule, actual cost, progress billing, claims, payment obligations, and funding requirements is essential for detecting financial risk early, before it escalates into a condition that threatens project continuity. This integrative finding extends prior research by Cantarelli et al. (2010, 2012) and Bocken et al. (2014) by showing that financial sustainability in infrastructure projects is an emergent property of multiple interacting performance dimensions, rather than the result of static planning.

Improvement Strategy

The improvement strategies identified from the synthesis of this study emphasize five main directions. First, implementing an integrated project control system that links schedule, physical progress, actual cost, procurement status, claims, variation orders, cost-to-complete, progress billing, and cash flow, supported by an early warning system for early detection of deviation. Second, strengthening procurement and vendor management through systematic vendor evaluation, shipment monitoring, document readiness, and disciplined coordination among the engineering, procurement, commercial, and construction functions. Third, a design-freeze policy and strict change management that requires design lock-in before major work begins, together with formal documentation, cost-time impact calculations, and contractual processing for all work changes. Fourth, early involvement of the cost control and finance functions from project initiation, not limited to cost reporting but actively engaged in reviewing cost estimates, cash flow, progress billing, cost-to-complete forecasting, claim evaluation, and financial risk identification. Fifth, realistic risk identification from the planning stage, with periodic updates throughout execution, combined with continuous project evaluation linking work progress, schedule, actual cost, risk, claims, cash flow, and funding requirements.

CONCLUSION

This study concludes that the 2×31 MW coal-fired power plant project experienced significant deviations in both schedule and cost - a delay of 53.85% (21 months) from the planned duration of 39 months, and a cost overrun of 55.50% - formed through the cumulative interaction of procurement delays, design changes, field technical constraints, coordination shortfalls, rework, and suboptimal project control. Project risk, encompassing procurement, technical, managerial, and financial dimensions, played a central role both as a trigger and as a reinforcer of deviation, with each risk category dynamically influencing schedule performance, cost performance, and ultimately financial sustainability through chain effects. Financial sustainability came under pressure through cash flow imbalance, delayed progress billing, increased cost-to-complete, unclaimable additional costs, rising financing costs, and margin erosion, confirming that financial stability is an emergent outcome of multiple interacting dimensions of project performance rather than solely a function of the adequacy of initial planning. Project control was carried out through monitoring and reporting activities but had not yet functioned as a fully integrated early warning system linking schedule, cost, procurement, claims, cost-to-complete, and cash flow data for proactive corrective decision-making. For similar future projects, this study recommends the implementation of an integrated project control system supported by an early warning mechanism, strengthened cross-functional coordination among engineering, procurement, construction, cost control, and finance, a design-freeze policy with strict change management, early involvement of the cost control and finance functions, disciplined vendor management, and continuous, risk-based project evaluation - all directed toward the proactive management of financial sustainability throughout the project life cycle, not only at the planning stage.

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