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PERFORMANCE ANALYSIS SYSTEM USING EARNED VALUE METHOD FOR ELECTRICAL GREENHOUSE WORK PROJECT IN BATAM CITY

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ABSTRACT

Infrastructure projects, such as greenhouse construction, are necessary for economic growth. Effective project control is essential, especially in managing budgets and ensuring timely completion. The Earned Value (EVM) method is used in construction project control because it integrates costs, time, and work progress. This allows for the identification of potential cost and time overruns. Data on expenditures and project-related documentation are gathered for analysis. Work plans and project schedules determine the value of work yet to be completed. The research findings up to the 10th month indicate that the projected total cost for completing the project is IDR 10,773,835,000. This leaves 8% of the total budgeted value as the remaining project budget. According to the data reported in the 11th month, the projected project completion time is 334 days. This is approximately 304 days ahead of the planned schedule. In summary, the EVM method is a valuable tool for project control in the construction industry. It can help to identify potential cost and time overruns and ensure that projects are completed on time and within budget.

Introduction

The growth of construction projects has gone hand in hand with technological advancements, both in physical and cost aspects. Every project has limited resources, so it needs management from start to finish. Every construction project must achieve targets regarding price, quality, and time (Ginting, 2020). Therefore, efforts are needed to complete this target through construction management activities involving the planning, implementation, and supervision stages (Rahmanto & Janizar, 2022). These stages are part of the project implementation process to produce quality and reliable construction products (Indriani, Utomo, & Rizqy, 2022).

Project management refers to managing and controlling a project within the company to realize the project according to a predetermined plan, including cost, scope of work, and quality (Prasetya, 2018). Infrastructure projects have a significant impact on the national economy and regional development. Effective management, good planning, and investment in infrastructure play a vital role in a country's economic growth (Ibrahim, Thorpe, & Mahmood, 2019). However, large construction projects such as greenhouses require reasonable control because they involve many interrelated work.

A critical aspect of control is the effective allocation of project budgets to ensure timely and efficient use of financial resources (Hadi & Mariana, 2022). Each project has unique characteristics so that the arising problems can vary due to internal and external

factors. Internal factors such as planning and construction errors, labor shortages, and material delays can increase the risk of project delays (Rahmanto & Janizar, 2022). Meanwhile, external factors such as environmental, weather, and geographical conditions can also contribute to delays.

In the construction world, estimating the work schedule is one crucial aspect that affects the project. Schedule estimation is a vital part of project management because it affects the continuity and success of the project (Sugiyanto & Gondokusumo, 2020). For this reason, the Earned Value (EVM) method is one of the control methods commonly used in construction companies (Ariana & Lestari, 2023). The Earned Value method allows for measuring and communicating the progress of project performance by paying attention to key variables such as schedule, cost, and work (Kartikasari & Inayaturrochmah, 2018). This method combines aspects of cost, time, and progress of work and helps estimate the cost and time of project completion and identify potential initial costs or delays that need to be addressed (Nufah, Yanti, & Lubis, 2019).

The Earned Value method helps in cost-effectiveness analysis that measures the efficient use of project budgets, whether the project is below or above the predetermined budget, and whether the project is running according to the planned schedule (Priyo, 2021). With a better understanding of cost-effectiveness, project managers can take the necessary steps to address issues or make changes as needed to keep the project running smoothly. This research is expected to provide valuable insights for project stakeholders to make better decisions in managing projects effectively and successfully (Rahmanto & Janizar, 2022).

This study aims to analyze the cost-effectiveness of the Batam Electrical Work Greenhouse project using the Earned Value (EVM) method. Regular cost monitoring will be critical in this project to keep the budget under control and effective.

Research Methods

This analytical and descriptive research method describes certain project conditions using analysis of existing data. The purpose of the study was to monitor the effectiveness of using the project budget, determine whether the project cost was below or above budget, and assess whether the electrical work was completed on schedule. The data collection methods used in writing this study are:

Research design

1. This type of research uses a quantitative analysis approach to analyze the cost-effectiveness of the Batam Greenhouse Electrical Work project data.
2. The information comes from financial statements, cost accounts, project progress reports, and project-related documents.
3. The time the study is conducted over some time, such as during a specific period of the project or the entire project.

Data Collection

Collection of information about actual costs incurred in each phase or specific phase of the project. This information can be gathered from financial statements, expense

reports, and related project documentation. The work plan used by the work plan and project schedule can calculate the work value to be completed in each phase or period of the project.

Analyzes Data

1. Calculate the costs incurred at a certain point in the project based on a predetermined work schedule, such as cumulative plans and cumulative realized in the form of Actual Cost, Planned Value, and Earned Value of project work.
2. Using obtained value method formulas such as cost variability (CV), cost-effectiveness index (CPI), schedule variability (SV), and schedule performance index (SPI). By calculating the performance index, the speed or delay of work on a project and the difference in budgeted costs can be seen directly.

Data Analysis Results

1. Calculates the Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS) costs incurred at a given point in the project based on a predetermined work schedule.
2. Calculates the Actual Cost (AC) or Actual Cost of Work Performed (ACWP) associated with electrical work up to a certain point in the project.
3. Obtain the Earned Value (EV) or Cost Budget of Work Done (BCWP) and calculate the value of electrical work performed at a given time in the project.
4. Using obtained value method formulas such as cost variability (CV), cost-effectiveness index (CPI), schedule variability (SV), and schedule performance index (SPI) to analyze the cost-effectiveness of electrical work on the project.

Results and Discussion

Research data: In this study, the Microsoft Excel application was used to apply the yield value (Earned Value Concept) method. The data used as the basis of the research came from the City Electrical Work Greenhouse Development project report. Analysis of work is carried out for 11 months.

Data Analyzes

Budget Value of Work Cost = Rp 10.773.835.000,-
Time required in the project = 11 moon
Project finish time = ten months (earlier)

Actual Cost (AC) Calculation

Actual Cost (AC) is the real cost incurred to complete the work during a specific period. Direct costs are obtained from the weekly report cost data that the author gets. A recapitulation of direct costs can be seen in Table 1.

Table 1
Project Work Plan and Actual Progress Table

Moon	% Plan Progress	% Progress Aktual	Actual Cost / Month
1	10%	15%	IDR 1,616,075,250
2	22%	30%	IDR 3,232,150,500

Moon	% Plan Progress	% Progress Aktual	Actual Cost / Month
3	30%	40%	IDR 4,309,534,000
4	40%	46%	IDR 4,955,964,100
5	50%	50%	IDR 5,386,917,500
6	65%	68%	IDR 7,326,207,800
7	74%	80%	IDR 8,619,068,000
8	80%	86%	IDR 9,265,498,100
9	85%	93%	IDR 10,062,761,890
10	92%	100%	IDR 10,773,835,000
11	100%		

Source: Research Data, 2023

The conclusion that can be given is that the work progress time in Table 1 above is faster than the progress of the planned work plan. Thus, the project occurred at the speed of one month and had an advantage between actual cost and budget. In the last 11 months of project work, the project still has 8% of the weight of completed work left.

BCWS, BCWP, and ACWP Data Analysis

The results will be collected after analyzing the BCWS, BCWP, and ACWP data. Then, the three indicators will be added cumulatively, and the comparison results will be presented in Table 2 as follows:

Table 2
BCWS, BCWP, and ACWP Data Processing Results

Moon	Cumulative BCWS	Cumulative BCWP	Cumulative ACWP
1	IDR 1,077,383,500	IDR 1,616,075,250	IDR 1,616,075,250
2	IDR 2,370,243,700	IDR 3,232,150,500	IDR 3,232,150,500
3	IDR 3,232,150,500	IDR 4,309,534,000	IDR 4,309,534,000
4	IDR 4,309,534,000	IDR 4,955,964,100	IDR 4,955,964,100
5	IDR 5,386,917,500	IDR 5,386,917,500	IDR 5,386,917,500
6	IDR 7,002,992,750	IDR 7,326,207,800	IDR 7,326,207,800
7	IDR 7,972,637,900	IDR 8,619,068,000	IDR 8,619,068,000
8	IDR 8,619,068,000	IDR 9,265,498,100	IDR 9,265,498,100
9	IDR 9,157,759,750	IDR 10,062,761,890	IDR 10,062,761,890
10	IDR 9,911,928,200	IDR 10,773,835,000	IDR 10,773,835,000
11	IDR 10,773,835,000		

Source: Research Data, 2023

In the 11th month, the cumulative value of BCWS reached Rp10,773,835,000, while the cumulative value of BCWP reached Rp10,773,835,000. In addition, the cumulative value of ACWP in the 10th month was Rp10,773,835,000. After obtaining cumulative value data from the three indicators, a combined graph was compiled using the "S" curve shown in Figure 1 as follows:

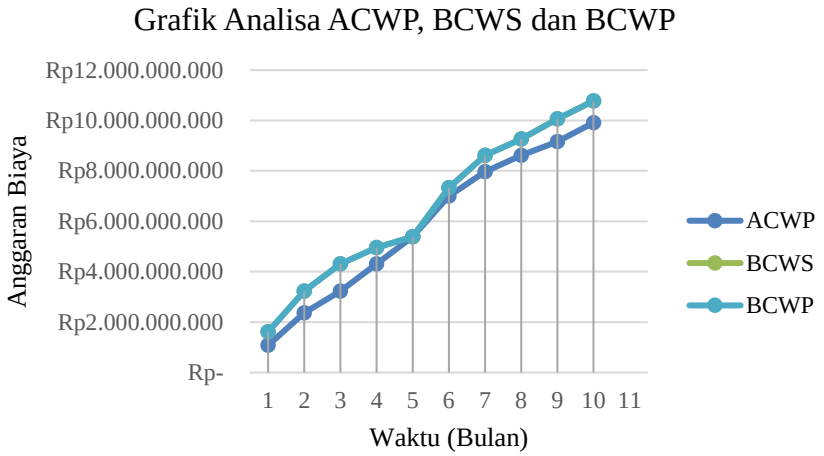

Figure 1. ACWP, BCWS, and BCWP Analysis Charts

Cost and time analysis chart based on the results of the graph in the period 1st to 11th month, there is a condition where the value of BCWS (Budgeted Cost of Work Scheduled) is equal to the value of BCWP (Budgeted Cost of Work Performed). In months 1 to 11, the ACWP (Actual Cost of Work Performed) value is lower than the BCWP value.

Cost Variant (CV) and Schedule Variant (SV) Analysis

In CV (Cost Variance) and SV (Schedule Variance) analysis, a negative calculation value (-) indicates that the cost of work exceeds the plan and there is a delay in work (cost/schedule overrun). If the calculation value is zero (0), the result goes according to plan and on time (scheduled on time). Meanwhile, if the calculation value is positive (+), the work cost is lower than planned, and there is work progress (cost/schedule underrun). All CV and SV calculation results are presented in the recapitulation in Table 3 as follows:

Table 3
Hasil Pengolahan Data Cost Variance & Schedule Variance

Moon	CV	SV
1	Rp-	-IDR 538,691,750
2	Rp-	-IDR 861,906,800
3	Rp-	-IDR 1,077,383,500
4	Rp-	-IDR 646,430,100
5	Rp-	Rp-
6	Rp-	-IDR 323,215,050
7	Rp-	-IDR 646,430,100
8	Rp-	-IDR 646,430,100
9	Rp-	-IDR 905,002,140
10	Rp-	-IDR 861,906,800

Source: Research Data, 2023

From the 1st to the 10th month, the CV (Cost Variance) value has a zero number. Meanwhile, the SV (Schedule Variance) value during the first month to the seventh month is positive (+), the SV value in the fifth month is zero, and the rest of the month has a negative number (-). The cumulative value of CV in the 10th month reaches Rp -, while the cumulative value of SV in the 10th month is -Rp861,906,800.

Analysis Cost Performance Index (CPI) and Schedule Performance Index (SPI)

In evaluating CPI (Cost et al.) and SPI (Schedule et al.), if the calculation result is less than 1, project expenses exceed planned, and work performance is not by the target time. Conversely, if the calculation result is more than 1, project expenditure is lower than planned, and work performance is faster than the scheduled time. Meanwhile, if the calculation result equals 1, the version of time and work cost is by the plan. All analysis results from CPI and SPI calculations are compiled in Table 4 as follows:

Table 4
Results of CPI and SPI Data Processing

Moon	CPI	SLEEP
1	1.00	0.67
2	1.00	0.73
3	1.00	0.75
4	1.00	0.87
5	1.00	1.00
6	1.00	0.96
7	1.00	0.93
8	1.00	0.93
9	1.00	0.91
10	1.00	0.92

After doing the calculation, it is known that the cumulative CPI in the 10th month is 1.00, while the cumulative SPI in the 10th month is 0.92. Based on these results, a combined graph of CPI and SPI can be compiled, which can be found in Figure 2 as follows:

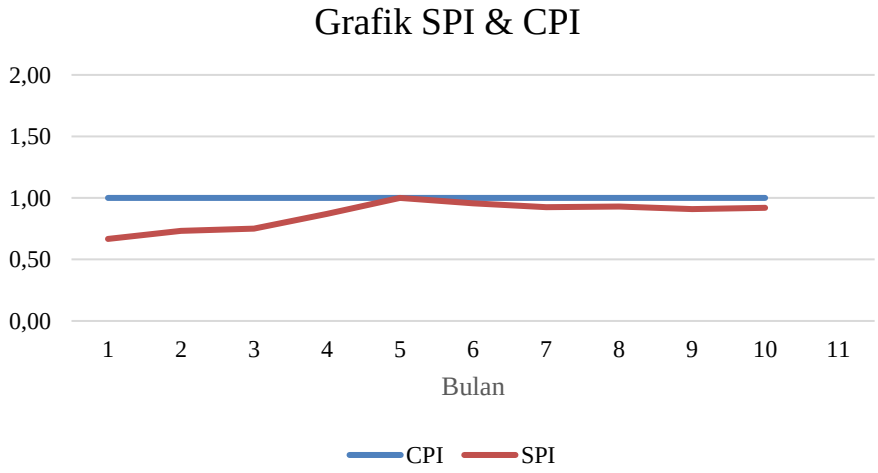

Figure 2. SPI and CPI charts

During months 1 to 10, the value of CPI (Cost et al.) is at value 1, indicating that the cost of work is stable with the budget during the period, and there are times when the cost of labor is equal to the budget during the work. Meanwhile, the SPI (Schedule et al.) calculation throughout the 1st to 10th months shows an average value above 1, indicating that the project experienced speed in its implementation throughout the period.

Project Cost and Time Calculation Analysis

The results of the analysis of the calculation of costs and project schedules for the Construction of Greenhouse Electrical Work work in Batam City using the Earned Value Method for the period from the 1st month to the 11th month have been compiled and documented in detail in Table 5 below:

Table 5
Project Cost and Time Calculation Analysis

Analysis	Result
Estimate to Completion (ETC)	Rp-
Estimate at Completion (EAC)	IDR 10,773,835,000
Remaining Cost	IDR 861,906,800
Actual Time Estimate	334 day
Original Duration	304 day
Time Estimate (TE)	307 day
Speed	27 day
Speed Progress	8%

Source: Research Data, 2023

Based on the analysis up to the 10th month, the estimated total cost to complete the job is Rp 10,773,835,000. The remaining project budget is Rp 861,906,800, 8% of the total cost budget value. The rest of this budget occurs because the progress of the work is completed faster than the planned work.

Based on analysis up to the 10th month, the estimated time to complete the remaining work will take 304 days. Meanwhile, the estimated total time to complete the job is 334 days. From these results, it can be estimated that the project implementation experienced a time speed of 27 days from the initial planned implementation plan schedule for 11 months.

Conclusion

The performance of the project implementation from the results of the study "Performance Analysis System Using the Earned Value Method for the Electrical Greenhouse Work Project in Batam City" in the 10th month in terms of costs shows that the project expenditure is lower than the planned cost, or the project has achieved profitability. This is evidenced by the positive (+) Cost Variance (CV) indicator of Rp - or Cost Performance Index (CPI), which is equal to 1. However, from the aspect of schedule, the project shows speed, indicated by the Schedule Variance (SV) indicator, which is negative (-) of -Rp 861,906,800 or the Schedule Performance Index (SPI), which is below number 1, which is 0.92<1. If the project implementation performance in the 10th month of reporting is completed before the end of the project, then the estimated total project implementation cost (EAC) is Rp -. In this condition, the project will profit Rp 861,906,800 or experience a percentage yield of 8% because this figure is still below the planned cost. Based on reporting data in the 11th month, the estimated project completion time (EAS) is 334 days. The project experienced speed in completing completed work during 304 days from the schedule of the project execution plan.

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