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Evaluating The Scheduling of The Development Projects of Rural Electricity Network Distribution Using Critical Path Method

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ABSTRACT. Delay in the completion of a project is a problem that is often faced, it certainly has an impact on the entire project. CPM is one of the control tools to get a working picture of the project. In 2015, PT PLN South Banten Area made a Development Project of Rural Electricity Network Distribution in Banten. This project is held by an electrical installation services company, PT. Z, in June 2015.This project is due 150 days, PT. Z had defined time completion on 143 days, but the completion took 154 days. The type of research used in this research is quantitative research with analytical technique CPM approach. This research identified the least project schedule planning. There are three activities in this project schedule which are unlisted yet, therefore it affected the timeline of the project. Based on the CPM calculation, PT. Z could have shortened the work time down to 3 days with the cost of Rp 1.802.386.000.

Keyword: Scheduling; Project; CPM
JEL Classification: M11; M19

INTRODUCTION

A project has purpose to produce a product with explicitly specified criteria with the allocation of limited resources and took place within a certain period, which the cost required to complete the project consists of direct and indirect cost (Yulianto, 2013:35). According to Gray & Larson, a project is a complex endeavor, not routine, always constrained by time, budget, resources, and performance specifications that are designed to meet the needs of customers (Mansyur, 2012:6, Yulianto 2013:36). Resource and time limitations, requires a project to be planned and controlled well. In supporting the development of a project, engagement planning both in terms of time, cost, and scope of the project are important (Widiasanti, 2013). However, the result of a planning document is not free of revision as a reference for the stages of implementation and control (Husen, 2011).

The demands and the nature of the project activities are varied, so differences of the managements of each activity are bound to happen, the environment and the atmosphere is relatively stable as a routine operation activity. The management is then called project management. PMI (Project Management Institute) defines project management as a form of science and art related to leading and coordinating the resources that consist of human and material with the use of modern management techniques to achieve the objectives that have been determined, i.e., the scope, quality, schedule, and cost as well as fulfilling the demands of the stakeholders.

According to Turner's (1996) definition of project as "the art and science of turning vision into reality" (Levin, et al, 2018:274). His research on Levin, et al (2018) posited, the Project management process and project outcomes help to develop social ties between the two organizations – client and its agency. Hersanto (2011) argues that project management is a whole activity that uses the principles of management starting from the planning, implementation, and control of the resources to be used in one or more projects with the expectation of benefit (return) on a specific period. In addition, project management is the activity of planning, organizing, directing, and controlling the company's organizational resources to achieve specific objectives within a specific time with specific resources (Santosa, 2003).

Based on the notion of that sense, it can be concluded that project management is an art and science in conducting planning, organizing, direction and control over the resources that belong to the companies to achieve the goal in a particular time and resources are limited. In project management it needs to be considered so that the output of the project is in accordance with the goals and objectives of the planned, the various problems that may arise when the project was implemented need to be identified. Cost, time, quality, and safety should be in project performance milestones in the process of achieving goals and objectives of the project management (Husen, 2011). (1) The cost, the entire sequence of project activities needs to have a standard cost-performance project created with accurate periodic reports made with intent so that overtime can be evaluated and controlled and become a reference in making decisions related to actions of correction in case of irregularities. (2) Quality, quality assurance can be obtained by performing a process based on the criteria of material or work which has been determined to come by the

standards of the final product. For project work in the future, all the documents of the previous project are re-evaluated to get a better level of efficiency. (3) Time, time standard performance is determined by referring to the whole stages of project activities and their duration and use of sources. The results of monitoring reports need to be evaluated and corrected, the trick with the updating of data and information to make the performance time achieved according to plan. (4) Safety and health work, it is the most important factor in the achievement of the goals of the project. The HSE management system is a structure of complex composition with personnel, resources, programs, along with the policies and procedures that will be integrated in the Organization, container company, or agencies.

Scheduling is step to interpret a plan into a diagram according to the time scale from the start of the project to be implemented, postpones, and completed, so that financing and resources can be adjusted according to needs (D, Irwan, & Purabasari, 2016). Project plan scheduling describes the activities required for the project to achieve the specified target effectively and efficiently. Precision in scheduling will affect the project implementation seriously in order to avoid great loss, such as swelling costs, delays in delivery, and disputes or claims (Widiasanti, 2013).

The critical path method is a time-oriented network planning method that is in charge of determining the scheduling and estimation of project completion time which is deterministic (Qomariyah & Hamzah, 2013). The Critical Path Method is carried out in order to get an idea of how the project control process is carried out according to schedule (Caesaron & Thio, 2015). The application of CPM is an effective method in anticipating the problem of excess or lack of time on a project (Yenika Purhariani, 2017). Using CPM can also anticipate the occurrence of cost over run in a project (Siregar & Iffiginia, 2019). Using the Critical Path Method, a project can determine the optimal time and the estimated total cost required (Ulfa & Suhendar, 2021). In line with the research of Utomo & Mulyono (2021), CPM is used to find the most optimal time for rescheduling a construction. Delay in the completion of a project is a problem that is often faced, it certainly has an impact on the entire project. CPM is one of the control tools to get a working picture of the project. (Caesaron & Thio, 2015; Siregar & Iffiginia, 2019; Astari, Subagyo, & Kusnadi, 2021).

Critical Path Method (CPM) scheduling method is one that assumes that the timing activity was uncertain, and it requires only one factor for each of its activity (Purhariani, et. al. 2017:5). CPM is one type of network schedule work plan or so-called Network Planning is most widely used among all other systems using the principle of the network formation. Drafting the CPM network in the identification of activities as well as using the single time estimate already identified as implementation time. CPM is the first engineering activity network in which diagrams are introduced and developed in 1957 by J.E. Kelly of Remington Rand and M.R. Walker of DuPont Company to assist in the development and the maintenance of the chemical plant in DuPont De Numours & Co. In the CPM system, it determined two estimates of time and cost for each of the activities contained in the work. Both estimates are the normal (Normal Estimate) and quick estimations (Crash Estimate) (Hersanto, 2011). The use of the CPM method in scheduling a project can help determine the optimal time and cost, as well as the critical path that requires special supervision, so that the project can be completed on time (Raharja, 2014; Ilwaru, Rahakbauw, & Tetimelay, 2018; Utomo & Mulyono, 2021).; Saputra, Handayani, & Dwiretnani,

2021). The CPM method makes job times faster than ever. This is because the work in a project is organized into a network that should not experience delays that have an impact on project delays (Permana & Kholil, 20016; Angelin & Ariyanti, 2019). The CPM method is very suitable in developing empirical construction projects. (Maulidi, Arifin, & Suyoso, 2021).

With the deadline for the project and the limited resources, often the question of whether the project can be carried out more optimally and economically arises. To minimize the possibilities of delay, yet the implementation did not go in accordance with the plan set out.

As it happened to PT. Z for construction project of Rural Electricity distribution network, Banten 2015, there is still a gap both in terms of time or cost planning and the implementation of the project by the deadline for completion in of the project-based contracts for 150 business days (table 1). The delay in completion of the project can be detrimental to the owner or the company establishing the contract. So, oftentimes, the project period and costs are set a lot more than what had been planned previously.

Table 1. A Comparison Between Planning and Realization

Company	Due date	Planing		Realization	
		Period (day)	Cost (Rp)	Period (day)	Cost (Rp)
PT. Z	150 days	143 days	1.803.421.000	154 days	1.803.421.000

Source: data processed by the author

Based on description, then the identified problem of the delay in completing the project will result in the addition of machining time. The occurrence of schedule mismatch made consciously in project planning company in the field resulted with the delayed completion of the project which will have an impact on overtime settlement. As in the project with PT. Z, the original settlement in contract is only 150 working days and it needed to be changed to 154 working days. This means that the project experienced a delay of up to 4 days.

The subject of this research is to examine problems in optimizing machining project time using the CPM AON method on the construction project of Rural Electricity network distribution of 2015 in Banten by PT. Z.

METHODS

The type of research used in this research is quantitative research. Bryman (2005) defines the quantitative research process starting from theory, hypothesis, research design, choosing the subject, collecting data, processing data, analyze data, and writing the conclusions (Sujarweni, 2015:39). Based on the level of explanation, the research is classified in descriptive research. Descriptive research is research conducted to find out the value of the independent variables, whether one or more, without making comparison or connecting with one another (Sugiyono, 2009). The aim of the research was to make a descriptive description, picture or painting systematically factual and accurate regarding the facts, properties and relationships between the phenomenon examined. In this approach, research is applied in this, so the purpose of this research

is to solve the problems faced by companies implementing the projects in carrying out its activities. Problems encountered is the occurrence of the delay in completing the project.

Operational Definitions of Variables

Sugiyono (2009) suggests that research is a variable attribute or the nature or value of the persons, objects, or activities which have a certain variation specified by the author to be studied and drawn to the conclusion. Variables are generally divided into two, namely the independent variable and the dependent variable. The variables used in this study i.e., the dependent variable as the optimal time and duration of the project, the dependent relationships between project activities, and budget plan costs as its independent variables.

To simplify the analyzing process then each variable will be defined operationally. The operational definition is elaborating one variable research into the detailed indicators. The operational definitions of variables in this research are as follows:

a. **Time optimal project**
   Time, in this case, is the length of a series when the process takes place, which is a project planning elaboration into a sequence of steps to achieve the target. Optimal project time is the amount of time to complete the project, the best or a relatively short time.
b. **The duration of the project**
   The project duration is the amount of time needed to complete the whole project work.
c. **Dependent relationships between project activities**
   Dependent relationships between project activities related to which of the activities must take precedence or worked on and an activity cannot be started if the previous activities not done yet.

These studies use a non-probability sampling, a sampling in which not all samples were given the opportunity to be selected as the samples to be in use. Samples taken for this research is the development of the Rural Electricity network distribution, a package of 22, by PT. Z.

Data Analysis

The issues facing this project was the time of the completion of the project that is not as planned. Optimization does speed up the duration of the project. The accelerated duration can be done on activities undertaken by the critical path. There are several ways to speed up an activity so that the best alternative was obtained in accordance with the conditions in the field. The analytical technique used in this research is to use CPM approach.

According to Heizer and Render (2011), CPM assumed that time is known for sure, so it only takes one time factor for each activity. On the CPM, the "deterministic" way is used i.e., using a numeric estimate. So, it's time to finish the job that is considered unknown, then in the next phase, further studies were held to shorten the period, for example by adding to the cost or time cost trade-offs or crash the program. The systematics of the process in preparing the network is as follows (Suharto, 1999): (a) Reviewing and identifying the scope of the project, outlining, breaking it into an activity or a group of activities is a component of the project. (b) Rearranging the components into a chain of the order of the corresponding logic dependency. (c) Providing an

estimated timeframe for each activity that is produced from the decomposition of the sphere project. (d) Identifying the critical path and float on the networks.

The line is a series of activities that relate to one another, starting from the initial node to the end. To complete the project, all paths must be bypassed. The longest path to determine the total time needed to complete the project. If there is a delay on the longest line, then it will happen late in the project. The longest line of activity is the activity of the critical path, and the longest line is called the critical path. After critical path is known, the next step is to do the acceleration of the project. The steps are as follows: (a) To determine the acceleration of time and calculate the acceleration of the surcharge for each activity. (b) Speed up the completion of projects with an emphasis on the critical activities that have the lowest cost slope. If the acceleration of the efforts made on activities that are not on the critical path, then the projected overall will not be reduced. (c) Stacking back the network that works. (d) Repeat steps a second time and stop doing the acceleration efforts in case of a critical path for the increase. Try to avoid going on the addition or removal of critical path if the duration of the acceleration was held at one of the events. (e) The acceleration Attempts stopped in activities on the critical path has been completely saturated (not likely pressed again). (f) Calculate the acceleration due to the overall cost to find out the total cost of the project is issued

RESULT AND DISCUSSION

Analysis of Project Scheduling

The following data obtained for the analysis of project scheduling are as follows:

Planning of the company

Project planning of the development of the rural electricity network distribution Banten 2015 is designed by the company started from the predecessor scheduling (table 2) the Gantt chart shows how long the project is carried out by the company. The predecessor scheduling is a table describing each activity that preceded and activities that precede or known as relationship activities. Predecessor is useful for planning the project so that the project can run appropriate planning nicely.

Table 2. The Relationship of Project Activity of PT Z

No	Code	Activities	Time (day)	Predecessor	Followers
1		Preparation			
	A	Survey On Job Sites	7	-	B
	B	Procurement Of Materials: MDU dan Non MDU Goods	30	A	C
	C	Mobilization of personnel, equipment, Material, Labour and equipment K3	3	B	K
2		Job Network SUTM			
	D	Installation Of Traves	11	K	E
	E	Installation Of Tupang Drag/Stack Between Taris	7	D	F
	F	Wire Withdrawal AAACS 70 mm2	7	E	G
3		Job Network SUTR			

No	Code	Activities	Time (day)	Predecessor	Followers
	G	Accessories Installation TR	12	F	H
	H	Skur Installation TR	3	G	I
	I	Wire withdrawal TIC 3 x 35 + N/3 x 50 + N	9	H	J
4	J	Substation jobs Cantol 50 kVA	45	I	L
5	K	Work of the pillars LBS 630 A	6	C	D
6	L	Finishing and administration	3	J	-
Time of finishing the project			**143 days**		

Source: Document of PT. Z

Not only to do the scheduling, but the company also plans the cost budget (table 3). Budget plan costs is the cost of the large number of calculations needed for materials, wages, and other costs related to the implementation of the project. Creating a cost budget means estimating the value of the project early on to adjust to the existing budget.

Table 3. Budget Planning PT. Z

No	Jobs	Volume	Cost (Rp)
1	**Transmission**		**1.029.412.050**
	A. SUTM		
	1. Construction SUTM	5,540	246.557.715
	2. Wire Materials AAACS 150 mm2	9,360	259.767.750
	3. Wire Materials AAACS 70 mm2	7,660	120.597.750
	4. Pin Post Insulator	422	105.922.000
	5. Complete Accessories of Isolator Afspan	69	25.185.000
	B. SUTR		
	1. Construction SUTR	6,050	103.254.235
	2. Twisted Cable Materials TIC 3 x 35 + N	1,580	161.300.000
	3. Twisted Cable Materials TIC 3 x 50 + N	4,590	150.590.000
2	**Distribution substation**		**610.061.600**
	A. Construction of Distribution subtation 50 kVA	5	298.171.800
	B. Supply Errect Substation Materials	5	161.300.000
	C. Trafo 3 phasa 50kVA	5	150.590.000
	Transmission and substation amount		**1.639.473.850**
	PPN 10%		**163.947.385**
	Total		**1.803.421.235**
	Rounding		**1.803.421.000**

Source: document of PT. Z

The realization of the Project

The data consists of project realization (table 4 and table 5), Gantt Chart (Figure 9) as well as the realization of project implementation costs (table 5). In the predecessor project realization, there are some jobs that are not listed on the corporate planning it. Such activities are deforestation work, testing, and refinement, and Booths, SUTM SUTR. Following the project realization: predecessor

Table 4. Predecessor Project Realization PT. Z

No	Code	Activities	Time (day)	Predecessor	Followers
1		Preparation			
	A	Survey On Job Sites	8	-	B
	B	Procurement Of Materials: MDU dan Non MDU Goods	30	A	C
	C	Mobilization of personnel, equipment, Material, Labour and equipment K3	3	B	D
2	D	Felling trees	3	C	L
3		Job Network SUTM			
	E	Installation Of Traves	11	L	F
	F	Installation Of Tupang Drag/Stack Between Taris	7	E	G
	G	Job Network SUTM	7	F	H
4		Installation Of Traves			
	H	Accessories Installation TR	12	G	I
	I	Skur Installation TR	3	H	J
	J	Wire withdrawal TIC 3 x 35 + N/3 x 50 + N	9	I	K
5	K	Substation jobs Cantol 50 kVA	40	J	M
6	L	Work of the pillars LBS 630 A	6	D	E
7		Finishing and administration			
	M	Checking SUTM, Substation, and SUTR	10	K	N
	N	Finishing SUTM, Substation, and SUTR	5	M	-
Time of finishing the project			**143 days**		

Source: Document of PT. Z

Table 5. Project Cost Realization PT. Z

No	Jobs	Volume	Cost (IDR)
1	**Transmission**		
	B. SUTM		
	6. Construction SUTM	5,540	246.557.715
	7. Wire Materials AAACS 150 mm2	9,360	259.767.750
	8. Wire Materials AAACS 70 mm2	7,660	120.597.750
	9. Pin Post Insulator	422	105.922.000
	10. Complete Accessories of Isolator Afspan	69	25.185.000
	C. SUTR		
	4. Construction SUTR	6,050	103.254.235
	5. Twisted Cable Materials TIC 3 x 35 + N	1,580	115.769.500
	6. Twisted Cable Materials TIC 3 x 50 + N	4,590	52.331.100
2	**Distribution substation**		
	D. Construction of Distribution subtation 50 kVA	5	298.171.800
	E. Supply Errect Substation Materials	5	161.300.000
	F. Trafo 3 phasa 50kVA	5	150.590.000
	Transmission and substation amount		**1.639.473.850**

No	Jobs	Volume	Cost (IDR)
	PPN 10%		**163.947.385**
	Total		**1.803.421.235**
	Rounding		**1.803.421.000**

Source: Document of PT. Z

The necessary data in this study i.e., schedule and cost planning construction project of Rural Electricity Network Distribution Banten 2015 are obtained from interviews and an examination of the documents of the company. Data obtained processed with CPM using the AON method. After the planning is made by the company and the project is realized in the analysis, the results obtained by processing the data in the form of planning proposals are aimed for the evaluation of the project. Planning the proposal consists of a predecessor proposed scheduling, network diagram by using the method of calculation proposed, as well as AON costs using CPM.

1. Proposal of Predecessor Scheduling

Predecessor is a table describing each activity that preceded and activities that precede or known as the relationship activities. Predecessor is useful for planning the project so that the project can be executed according to good planning. The proposed predecessor scheduling is made by different authors with the predecessor planning company. This is because the work of deforestation can be carried out simultaneously with the procurement of materials and goods a non MDU without interrupting the critical path of the project. The predecessor proposal can be seen in table 6 below.

Table 6. Predecessor Proposal PT. Z

No	Code	Activities	Time (day)	Predecessor	Followers
1		Preparation			
	A	Survey On Job Sites	8	-	B
	B	Procurement Of Materials: MDU dan Non MDU Goods	30	A	C
	C	Mobilization of personnel, equipment, Material, Labor and equipment K3	3	B	L
2	D	Felling trees	3	A	L
3		Job Network SUTM			
	E	Installation Of Traves	11	L	F
	F	Installation Of Tupang Drag/Stack Between Taris	7	E	G
	G	Job Network SUTM	7	F	H
4		Installation Of Traves			
	H	Accessories Installation TR	12	G	I
	I	Skur Installation TR	3	H	J
	J	Wire withdrawal TIC 3 x 35 + N/3 x 50 + N	9	I	K
5	K	Substation jobs Cantol 50 kVA	40	J	M
6	L	Work of the pillars LBS 630 A	6	C, D	E
7		Finishing and administration			
	M	Checking SUTM, Substation, and SUTR	10	K	N

No	Code	Activities	Time (day)	Predecessor	Followers
	N	Finishing SUTM, Substation, and SUTR	5	M	-

2. Planning a proposal using the Network Diagram AON

After the predecessor proposal is made, then the next stage is planning a proposal to use the AON network diagram. AON is a network scheduling that is represented by a node (box). The dependency between the activity depicted with arrows between the squares on the AON network. Arrows mark on how associated activities and the order in which some matters to be resolved. The planning is proposed by using the image-based predecessor AON network proposal can be seen in Figure 10.

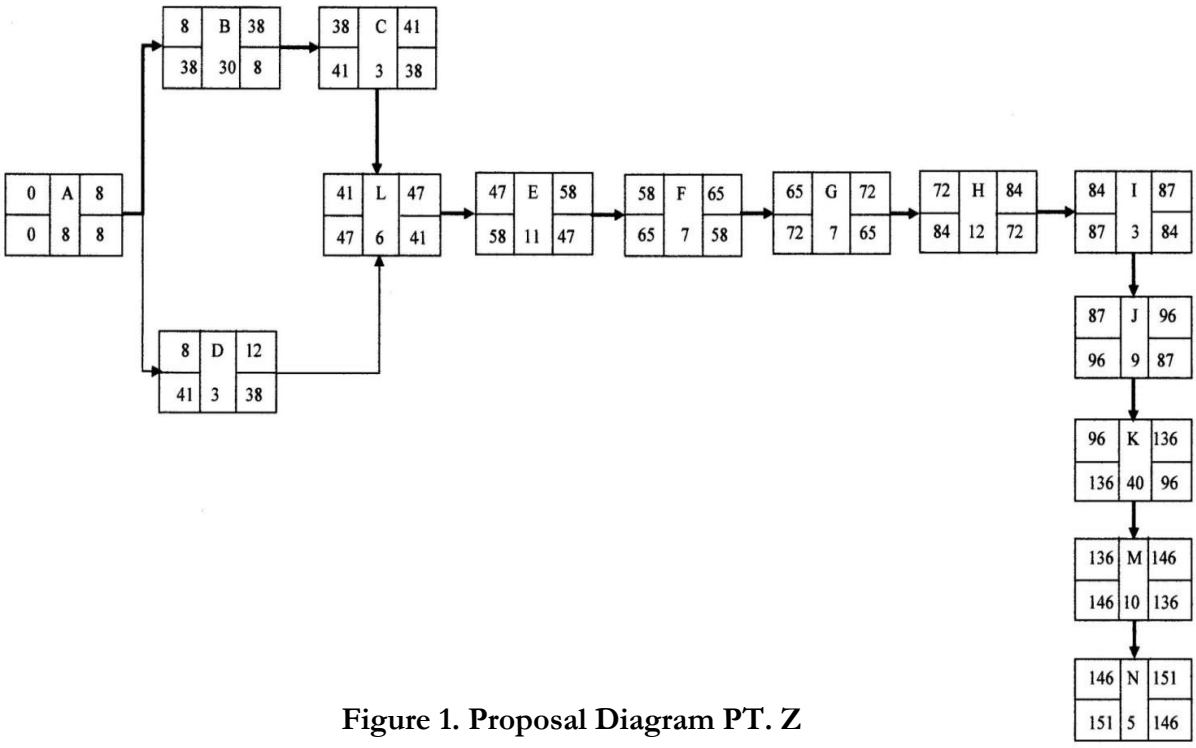

Figure 1. Proposal Diagram PT. Z

The final condition for the development of Rural Electricity network distribution Banten 2015 with AON to CPM method as follows: (1) Based on the table of the relationships between the activities of planning, then the result of the subsequent data processing done by using the method of AON is on time with the critical path, namely the series of activities of a project that has huge effects on the project undertaken. If one of the activities of the project on the critical path is delayed it may impact other activities. (2) Other results obtained by using the method of AON is that the work that could be done in conjunction with other work, namely deforestation, may reduce the working time of the project. The difference of scheduling PT. Z of 154 days – 151 days = 3 days. From the results (rescheduling), then it can be described as follows: (a) Every activity undertaken can be seen in detail when it is implemented. (b) To minimize the activities that take time can extend the time of execution of the project.

CONCLUSION

Conclusion the results of the analysis using the method of CPM in construction project of Rural Electricity Network Distribution Banten 2015. The delay in completing of the project is due to the lack of a critical path that is applied on the planning made by their respective companies. In addition, the delay is also caused due to the increase of project work not previously noted in schedule planning. There is an actual work that can be done in conjunction with other works without interfering with the critical path. It is deforestation that could be carried out simultaneously with the work of the procurement of materials. And for the future research is needed about the evaluation of the project costs.

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