
**FACTOR ANALYSIS OF FACTORS CAUSING DELAYS IN EPC PROJECTS USING
DMAIC AND ALTERNATIVE SOLUTIONS**

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ABSTRACT

The development of the construction world today, especially in EPC (Engineering, Procurement and Construction) project work is very rapid and complex. So the level of difficulty and the potential for delays is quite large. From data taken at one of the EPC divisions of construction companies in Jakarta in March 2023, there are 9 projects that experience delays from 10 existing projects. So the purpose of this study is to identify and analyze the main factors causing delays in completing EPC projects as well as alternative completion. In achieving good project time performance, it requires the support of resources (Man, Material, Machine, Money, Method) that are owned efficiently from the input process to the output. The method used in this study is DMAIC (Define, Measure, Analyze, Improve & Control) where analysis is carried out using Fishbone, 5W + 1H Brainstorming and Pareto Diagram. The main factors causing delays in EPC project work are lack of material supply, lack of manpower, late material arrival schedule, damage or loss of materials, lack of experts and design errors during planning. Alternatives to solving EPC project delays are first submitting an EOT (Extention of Time), adding man power, evaluating schedules, monitoring the implementation of engineering designs, and collaborating with consultants who are more experienced in the EPC field so that there are no planning design errors and implementation methods.

INTRODUCTION

The development of the construction business in Indonesia is currently quite significant, especially for large-scale and high-complexity project projects. In general, large-scale projects are owned by the government such as the construction of toll roads, dams, flats, airports, docks, bridges, as well as public facilities and other large infrastructure. In addition to these projects, there are also large-scale projects owned by private companies and SOEs with other high complexity such as power plant projects, oil, and gas, or industrial or mining projects. Typical for the project project is an EPC (*Engineering, Procurement, and Construction*) project which is a term for a project that includes the planning or design stage, the procurement stage, then the construction stage in addition to these three stages there is usually another stage, namely *Commissioning* or trial stage where this is an important stage as a determinant of the success of the EPC project function. In this *commissioning* stage, it will be ensured that all systems/components/utilities run properly according to the standards set and achieve *he output* or function of the entire project.

EPC projects have a very high challenge because they have dependencies between work activities, *overlaps* between each activity and require detailing and timeliness between jobs. In addition, the organizational structure in EPC projects is more complex because it requires a

managerial-level person in each section. The arrangement per section in the EPC Project under the Head of Project generally includes the manager of the Finance and Administration section, *Construction section*, *Procurement section*, *Engineering section*, *Commissioning section*, *Quality section* (V. C. Putri, 2020), *HSSE section*, *Risk management contract management section*, *Cost Control section* and *Project Control section*. Uncertainty in initial design and engineering detailing, Implementation Schedule Plan (Putri, 2019), uncertainty in the price of construction needs, accuracy in budgeting and the risk of failure make EPC type projects potentially experience losses or delays in the specified target time (Sabila, 2022).

According to (Dewanto, 2020). The results of regression analysis show the Linear Method (Y. Putri, 2020) plays a significant role in the performance of time on road work so that an effort needs to be made to always make an effort to make improvements (Sujatmiko, 2021). The causes of delays that had the greatest influence in this study were the engineering stages and the coordination ability of project managers (Yurianto & Kadri, 2020).

EPC project delays for contractors are something that is avoided, because the impact of delays will affect the contractor's planned profit margin, and even cause the project to experience losses. In addition, delays will have contractual impacts, such as late fees (Rahman, 2020), The potential for *blacklisting* and making *the* company's company profile bad and affecting the acquisition of the next contract. If the EPC project is on time or faster than the initial planning, it will benefit both the project owner and the contractor. From the project owner's side, timely or faster project completion will make the project quickly produce and generate profits as planned. Meanwhile, from the contractor side, it will avoid fines, *over costs* due to more time, maintaining the company's good name, and the potential to get similar projects in the future is greater. Therefore, EPC construction companies will always try to carry out project projects according to the time specified in the contract or minimize delays, and will even try to accelerate so as to make benefits for both parties, both project owners and contractors. From the contractor side, the contractor will try to take the necessary corrective actions and make the right decision based on the analysis of various delay factors.

As is done in the EPC division that handles EPC-type project projects. Corrective and monitoring actions continue to be carried out by conducting monthly coordination meetings that show the progress of the plan compared to monthly realization. From January to December 2022, we saw the achievement of the number of projects that experienced delays. The largest GAP occurs in the evaluation period (Kurniawan, 2021).

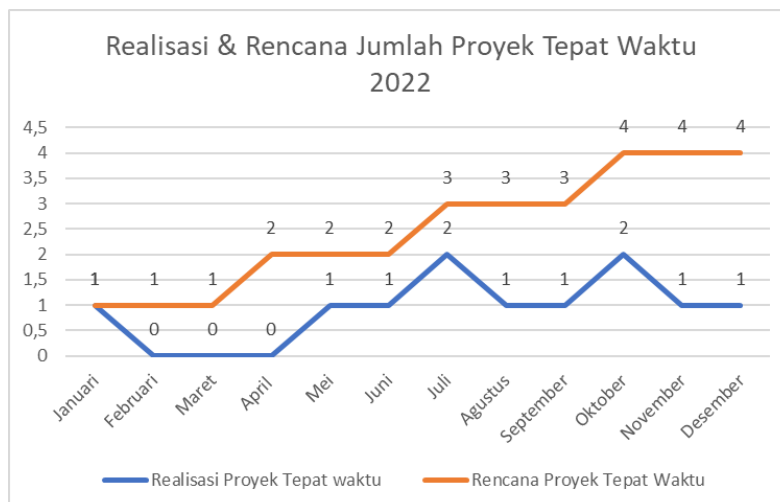


Figure 1

Target Number of projects on time vs Realization of achievements Source: EPC Division, 2022

From the picture above, it shows that there is a stagnant phenomenon, namely the number of projects on time each month only ranges from 1 to 2 projects, and a maximum of 2 projects on time occurs in October 2022. From the targeted increase in the number of projects on time in each quarter, it increases by 1 project, but in fact the number of projects that experience delays tends to stagnate. The largest GAP occurs in the year-end period, which is only 1 project on time from the plan, 4 projects should be on time.

In getting a further picture of the percentage of delay, a project delay ranking was compiled based on the classification of epc projects as follows:

Table 1
Late Projects and their classification

No	Project Name	(HB) Exc Id PP N million Rp	Execution time	Presentation (%)			RPC project classification
				MS. (Ra)	EXT. (Ri)	DEV.	
1	Oil Refineries & Jetties	684,349	22 Jan 2021-13 of 2022	100,00	54,40	(45,60)	oil & gas
2	Development of TBBM pipes	245,543	13 of 2018-3 Oct 2022	100,00	79,51	(20,49)	oil & gas
3	TBBM Pier	301,400	22 apr 2020-30 sept 2023	61,99	43,32	(18,67)	oil & gas
4	PLTU	4.372.010	16 oct 2020-22 mar 2025	80,14	68,96	(11,18)	Power plant
5	PLTM 2X4MW	246.442	21 Sep 2016-10 May 2023	94,02	87,01	(7,01)	Power plant
6	Upgrade of cement processing plant & jetty	1.118.500	17 jan 2022-8 nov 2023	29,89	23,34	(6,55)	Industrial
7	RDMP	1.418.560	15 oct 2019-8	53,03	47,98	(5,05)	oil & gas

Facilities		mar 2024					
8	PLT GU 650 MW	2.041.152	21 Dec 2017-18 Jun-2020	100,00	97.84	(2,16)	Power plant
9	PLT GU 600-850 MW	776.713	24 Jul 2017-26 Jun 2023	98,58	98,58	(0,37)	Power plant
10	PLTM 9,9 MW	18.1933	Oct 20, 2015- May 24, 2022	100.00	100.00	-	Power plant

Based on the table above, it can be seen that out of 10 projects, 9 of them experienced delays. While the type of EPC project type of power plant is the dominant project numbering 5 Projects out of 10 and the type of Oil & gas project there are 4 Projects and 1 Industrial type Project in 2022 in the EPC division. The project experienced delays with a delay range between 40% to 0.37%.

In terms of costs, with delays, there will be losses in the form of over costs from operational costs, and also work costs will increase during several months of delay. So that the EPC division experiences a loss or minus profit that continues to grow from year to year as shown in the following graph:

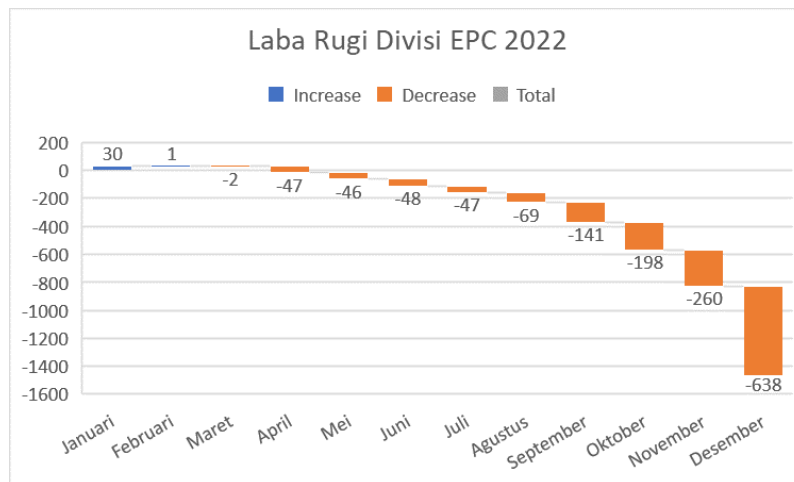


Figure 2
Profit and Loss Achievement 2022
Source: EPC Division, 2022

According to the chart above, it can be seen that losses in 2022 occurred month by month, where in the second month it still experienced profits and the third month experienced losses and continued to grow year by year and the peak began at the end of 2022, which was a loss of 638 billion. This happened one of them due to project delays which resulted in increased implementation costs from project implementation and also related effects due to some late work items. In addition, the effect of losses is obtained from fines given by the Owner to EPC contractors due to delays that occur.

Meanwhile, the progress of revenue in 2022 is still in line with the plan, judging from the following table.

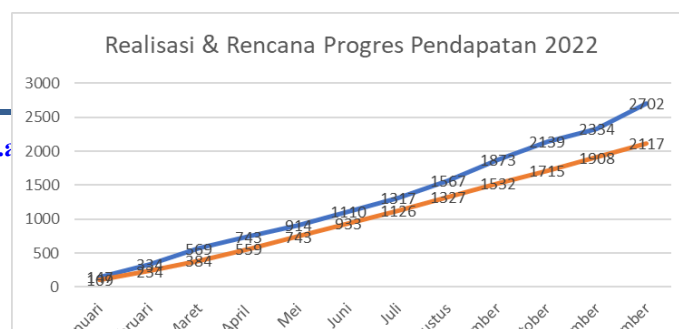


Figure 3
Progress vs Plan Achievements 2022
Source: EPC Division, 2022

From table 3, it shows that the project progress is still according to plan, but when viewed from Figure 1 EPC projects that are on time are only stagnant ranging from 1 to 2 projects from the final target of 2022, the projects that are on time are 4 projects. And in table 2 it can be seen that the deviation range of the master schedule plan with its reality is the highest at 45.6% and the lowest at 0.37%. And the dominant project in the EPC division in one of the Construction Companies in Jakarta is the power plant project then Oil & Gas.

Without good problem management, this delay event will continue to repeat from year to year and will even potentially occur again when the EPC Division acquires a new project of the same kind. Evaluation needs to be done to determine the extent to which the factors related to the implementation of this project affect the time of project implementation. The project is said to be on time if the realization of progress is greater than the progress plan. The comparison can be seen in the Master schedule chart which displays realization compared to plans that are usually broken down per month. Or it can also be seen with the help of MS Project Tools or Primavera, it can be prepared improvement plans and effects on project completion time. And to get the right improvement process for solving the delay problem above, the author uses the DMAIC method (Define, Measure, Analyze, Improve & Control) to define the problem, measure the level of the problem, analyze and make improvements as needed.

The objectives and benefits of the Research are To identify and analyze the main factors causing delays in EPC project completion and To identify and analyze alternatives to solving EPC project delays (Anggraeni et al., 2022). The benefits of this research are: For companies engaged in construction services, especially EPC projects, it can be used as a basis for decision making and anticipation of delays in the timing of EPC projects (Alaydrus & Hardjomuljadi, 2019). And for the companies mentioned in this study in order to be able to implement alternative solutions to the impact of EPC Project delays In general, the benefits of this study are to obtain the main factors and according to the ranking of the causes of delays so that it is hoped that the data can be used by EPC construction companies as evaluation material and help minimize delays and as guidelines in the implementation of EPC project projects.

RESEARCH METHODS

Research Design

This research based on its character and nature can be classified as qualitative descriptive research, which is a *research* that is carried out focusing on solving a problem that exists and develops today by using fact-based existing data and carried out systematically. Research methods are ways and procedures to obtain data used for proof, discovery, development based on the rules of science According to (Creswell, 2012), deep (Sugiyono, 2018), Qualitative research methods are divided into five types, namely *phenomenological research*, *grounded theory*, *ethnography*, *case study* and *narrative research*. Research is included in *the type of Phenomenological research*, which is one type of qualitative research, where researchers collect data with participant observation to find out the essential phenomena of participants in their life experiences.

Done *cross-sectionally* because data is collected all at once at one particular time and only once (Cooper, n.d.) That is by distributing questionnaires to respondents. This research is located in a National Construction company engaged in EPC Projects in Jakarta.

Population and Sample

Population is the total set of elements that are expected to be studied and then expected to draw conclusions, where elements in the population are the participation of individuals or an object taken to know (Cooper, n.d.). The population in this study is all individuals working on EPC projects spread throughout Indonesia totaling 10 EPC Projects in Table 2 The Project Sample used in this study is a 650MW Steam Gas Power Plant Project located in Bekasi, West Java. This Project selection is based on KLPP internal data (collection of Project Performance Rate) Table 1 which shows that the Project should have been completed by June 18, 2020, meaning that the project has been pushed back about 2 years and 9 months and is the highest delay rate of the other 10 Projects. While the sample project is as follows:

Table 2
Daftar Proyek EPC

No	Project	Project type	Location
1	PLTU 2X1000 MW	Power plant	Cilegon, banten
2	PLTGU 640 MW	Power plant	Bekasi jawa barat
3	PLTGU 850 MW	Power plant	Semarang jawa tengah
4	PLTM 9,9 MW	Power plant	Pekalongan jawa tengah
5	PLTM 2X4 MW	Power plant	Pekalongan jawa tengah
6	TBBM Pier	Oil & Gas	Balikpapan Kalimantan timur
7	Development of TBBM pipes	Oil & Gas	Cilacap jawa tengah
8	Fuel Oil Refinery &; Jetty	Oil & Gas	Sorong papua
9	RDMP Facilities	Oil & Gas	Penajam Kalimantan timur
10	Upgrade of cement processing plant and jetty	Industry	Tuban jawa timur

Sample

Project samples based on the table above are determined (purposive sampling) the 650MW Steam Gas Power Plant Project located in Bekasi, West Java. The reason for choosing the project is because the project experienced the highest delay compared to other projects.

While the respondents or respondents of this project are determined as many as 20 people consisting of core project personnel. consisting of *Project Manager, Deputy Project manager, Site Engineer Manager, Site Administration Manager Project Control Manager, Site Operation manager, Construction manager, Quality Control Manager, Professional Staff, Scheduler, Engineer and Supervisor.* All data was taken from July 2022 to April 2023.

Variable Definition and Operationalization

The research was conducted at one of the national construction companies engaged in EPC Projects by carrying out preliminary observations of data from the results of delay evaluations in the period July 2022 to April 2023.

Table 3
Variable Penelitian

Research Variables	Dimensi	Definisi	Indikator
EPC Project System Effectiveness	DMAIC	Troubleshooting methods used in quality improvement and process improvement	- Define
			- Measure
			- Analyze
			- Improvement
	Fishbone	Diagrams used to identify problems and their causes and consequences	- Control
			- Man
			- Machine
			- Methode
			- Material
	5W +1 H	Methods used to help identify problems and their solutions	- Money
			- What
			- Who
- When			
Performance Results of Implementation Time	Ahead of Plan Schedule	Progress of Realization > of Plan Progress	- Where
			- Why
			- How
	Same as Schedule plan	Realization Progress = from Plan Progress	- Master Schedule
			- Kurva S
			- MS Project
Deviasai Minus of the Plan	Realization Progress < from Plan Progress	- Master Schedule	
		- Kurva S	

Research Variables	Dimensi	Definisi	Indikator
	Schedule		- MS Project

Data Collection Methods

Data collection is carried out to obtain the information needed in order to achieve research objectives, where the objectives expressed in the form of survey questions require research to answer them, so data collection is needed. There are two types of data used in this study:

1. Primary data, is data collected and processed by researchers themselves directly through the results of questionnaires distributed to respondents who are mostly directly involved in Project Projects in the EPC division. From the results of the questionnaire then processed using statistical analysis so that the dominant factors that become obstacles in the completion of the EPC Project are obtained (Prastyo & Cholis, 2015). In addition, FGD was conducted to brainstorm with personnel regarding delays in EPC project projects.
2. Secondary data, is data obtained in finished form obtained from literature. In addition, secondary data is obtained from internal and external company data. After obtaining the dominant factors that become obstacles in project completion, conclusions can be drawn and determine solutions and strategies for the completion of the EPC project project.

Data Analysis Methods

Data analysis is an effort or way to process data into information so that the characteristics of the data can be understood and useful for problem solutions, especially problems related to research. Or another definition of data analysis is an activity carried out to convert data from research into information that can later be used in drawing conclusions. The purpose of data analysis is to describe the data so that it can be understood, then to make conclusions or draw conclusions about population characteristics based on data obtained from the sample.

1. Describe ranking results into a Pareto chart
A pareto chart is an illustration that sorts data classification from left to right according to the highest to lowest ranking order. This can help determine problems that are a top priority to be solved (highest rank) to those that do not need to be resolved immediately (lowest rank).
2. Identify the source of the delay
In this step, the source of the EPC project delay is identified. Therefore, a cause and effect diagram or Ishikawa (*Fish Bone*) diagram is used, which is often called a fish bone diagram. In this study the cause of delay was only observed from 5 M *Man, Material, Machine, Method, Money*
3. Alternative improvement Design at the improve stage is done by going through the stages of designing the 5W-1H method (*Who-who, What-what, Where-where, When-when, Why-why, How-how*).
 - a. *Improve on the Man factor*: it is determined whether the goal is to improve on the Man factor, the reason for its usefulness, location, and how.
 - b. *Improve on Machine factors*: *determine whether the purpose of improving on Machine factors*, the reason for its usefulness, location and how.
 - c. *Improve on Material factors* : it is determined whether the purpose of improving on Material factors, reasons for their use, location and how.

- d. *Improve* factor Method: determine whether the purpose of *improve* on the Factor Method is the reason for its usefulness, location and how.
- e. *Improve Money* factor: it is determined whether the purpose of improving the *Money Factor* is the reason for its usefulness, location and how to Improve (improvement) is done after the source source and root cause of the problem are identified, it is necessary to establish an action plan to Improve The Quality Of Six Sigma (Panjaitan, 2022). The Method Used Is 5w+1h As The Method Used In The Improvement Plan Based On The Root Cause That Has Been Defined (Setyoko, 2022).

RESULTS AND DISCUSSION

Research Data

Data This study was conducted by distributing questionnaires directly to respondents who were on EPC Projects in the company environment. In the sample, the collection was carried out by the core project personnel in charge of the Steam Gas Power Plant project in Bekasi, West Java. The collection was carried out by distributing questionnaires with predetermined variables to individuals directly involved in the EPC Project of the Steam Gas Power Plant in Bekasi, West Java. The data obtained will then be analyzed and made a ranking and pareto diagram. The questionnaire was conducted online using Microsoft Form with a link in the <https://forms.office.com/r/09CAKnuGNY> which was carried out in February-March 2023

Define

The first stage in the DMAIC method is *Define*. The *Define* phase establishes what the problem is and what is needed to derive the Solution. In this stage will be clearly defined the problem, objectives and finally the scope needed to achieve it. Identification of the causes of delays in project implementation is carried out by distributing questionnaires to personnel directly involved in the EPC Project of a Steam Gas Power plant in Bekasi, West Java. So that data on the factors causing delay are obtained as follows.

Table 4
Classification of Factors Causing EPC Project Delays

No	Classification	Delay Factor	Score	Bobot
1	Workforce	(Labor) Lack of Manpower	89	3,21%
2		(Labor) Lack of Experts	82	2,96%
3		(Labor) Lacking Ability/Skill	79	2,85%
4		(Labor) Lack of Worker Attendance/Absence	78	2,81%
5	Bahan Material	(Material Material) Disadvantages of Material Suplly	90	3,25%

No	Classification	Delay Factor	Score	Bobot
6		(Material Material) Damage & Loss of Construction Materials	83	2,99%
7		(Material Material) Material Changes by the Owner	70	2,53%
8		(Material Material) Material Quality Not according to specifications	75	2,71%
9	Equipment	(Equipment) Equipment availability	77	2,78%
10		(Equipment) Equipment malfunction	71	2,56%
11		(Equipment) Poor quality of equipment	66	2,38%
12		(Equipment) Do not understand the procedure for using equipment	66	2,38%
13		(Equipment) Equipment misplacement	63	2,27%
14		Characteristics of the place	(Characteristics of the place) Surface condition and under tanah	62
15	(Characteristics of the place) Physical characteristics of existing buildings / around the project		55	1,98%
16	(Characteristics of the place) Social Responses from the Project Environment		50	1,80%
17	Managerial	(Managerial) Field Manager Experience	80	2,89%
18		(Managerial) Material and Equipment Management Errors	80	2,89%
19		(Managerial) Project Supervision	78	2,81%

No	Classification	Delay Factor	Score	Bobot
20	Keuangan	(Finance) the price of expensive materials/materials/wages	73	2,63%
21		(Finance) Not paying attention to unexpected / other costs	71	2,56%
22		(Finance) Additional equipment rental costs	65	2,34%
23		(Finance) Increased working costs	62	2,24%
24		(Finance) Additional costs due to environmental/social safeguarding costs	56	2,02%
25	Design/Engineering	(Design/Engineering) design errors during initial planning	82	2,96%
26		(Design/Engineering) Incomplete data and detailed images	75	2,71%
27		(Design/Engineering) Design changes by owner	74	2,67%
28		(Design/Engineering) Image detail creation delay/ACC	73	2,63%
29	Weather	(Weather) High rainfall intensity	65	2,34%
30		(Weather) Changing weather	58	2,09%
31		(Weather) High Hot Weather	48	1,73%
32	Time and Control	(Time and Control) Late material schedule	84	3,03%
33		(Time and Control) Improper execution methods	80	2,89%

No	Classification	Delay Factor	Score	Bobot
34		(Time and Control) Planning schedule is not as planned	75	2,71%
35		(Time and Control) Poor preparation of work schedules	72	2,60%
36		(Time and Control) Schedule Revision by Consultant or Owner	68	2,45%
37	External factors	(External Factors) Difficult licensing	67	2,42%
38		(External Factors) Response of the surrounding community that does not support the project &; Theft	66	2,38%
39		(External Factors) Response of the surrounding community that does not support the project &; Theft	64	2,31%

Source: Data processing (2023)

CONCLUSION

Based on the results of the analysis and discussion carried out, several things can be concluded as follows:

1. The main factors causing delays in EPC project work are Lack of Material supply, Lack of manpower, Late material arrival schedule, damage or loss of materials, lack of experts and design errors during planning.
2. An alternative to solving the delay of the EPC project is to first submit an EOT (Extention of Time) so that a Baseline is formed which is then used as the latest reference, besides that it has the potential to avoid LD (Liquidated Damages). The second is monitoring the allocation and planning of adding manpower so that it is more effective and optimal. The third is the routine schedule evaluation meeting so that the implementation schedule is easier to monitor and evaluate together. The fourth is to routinely monitor and update the implementation of engineering designs so that it is easier to control and produce positive progress. As well as collaborating with consultants who are more experienced in the field of EPC so that there are no planning design errors.

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