European Journal of Business and Management Research
Vol 9 | Issue 4 | August 2024
ISSN 2507-1076

RESEARCH ARTICLE

Using The Kepner-Tregoe and Analytical Hierarchy Process for Strategic Project Execution to RDMP RU V Balikpapan Project

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ABSTRACT

PT. PERTAMINA (Persero) has initiated Refinery Development Master Plan (RDMP), which was pioneered by RDMP Refinery Unit V Balikpapan. Through RDMP RU V Balikpapan, PERTAMINA RU V Balikpapan aims to increase the capacity of 100,000 BOPD to the existing Refinery Unit V Balikpapan, increasing Refinery Product (Fuel & Petrochemical) such as an increase in diesel fuel of 30,000 BOPD and new propylene product of 230,000 tons per year, increasing the quality of fuel product from Euro II to Euro V standard, increasing the Nelson Complexity Index (NCI) from 3, 7 to 8, 0 by additional conversion unit to product much more higher yield value product from 75% to 96%, increasing the flexibility on Crude Processing which having higher sulfur contamination. The total project cost is estimated at around USD 6.5 Billion, which is funded by PT. PERTAMINA (Persero) and project financing through lenders. The Contract for RDMP RU V Balikpapan Project was signed on December 10th, 2018. The Kickoff Meeting has established an effective date of February 28th, 2019, with a duration of 53 months. Until October 25th, 2022, the overall project has achieved 61.99% (actual) vs. 95.81%. The project has suffered mainly because of the COVID-19 pandemic, which has affected the progress of the project. So, the author would like to approach the mitigation plan in terms of finding a solution to the project delay that has to be accelerated from various sectors based on the root cause analysis by using a theoretical approach through two methods, which are Kepner-Tregoe Problem Analysis and Fault Tree Analysis. At the end of the thesis, based on the available alternative business solution items for each root cause factor, the author establishes an implementation as one of the objectives of this thesis that is deemed as a strategy and plan from the best-selected solution through The Analytic Hierarchy Process (AHP) to accelerate the project completion and also to achieve economical margin value including all parameter and variables as it has been defined as per investment decision.

Keywords: Analytical Hierarchy Process, Fault Tree Analysis, Kepner-Tregoe Problem Analysis, RDMP RU V Balikpapan.

Submitted: January 16, 2024

Published: August 16, 2024

10.24018/ejbmr.2024.9.4.2292

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1. Introduction

In order to realize national energy security and, ensure the availability of national fuel oil & reduce dependence on imported fuel oil (BBM), which was recorded in 2015 as 323,331 (thousand Barrel Oil Equivalent (BOE) as per data in Table I from Handbook of Energy & Economic Statistics of Indonesia 2021, where the Refinery Production for Total Fuel in 2015 is 329,536 (thousand Barrel Oil Equivalent (BOE) as shown in Table II.

On December 22nd, 2015, The President of the Republic of Indonesia established President Decree No. 146 in 2015 regarding the implementation of oil refinery development in the country. The president's decree has assigned PT. PERTAMINA (Persero) is a National Oil State Owned Company with the government for the construction of oil refineries which PERTAMINA (Persero) acts as PJK (Penanggung Jawab Kegiatan) (CDI-EMR, 2021). Table I

TABLE I: Final Energy Consumption

Year	Biomass	Coal[1)]	Natural gas	Fuel	Biogasoil[2)]		Biogasoil[2)]	Biogas	Briquette	LPG	Electricity	Total
					Gasoil	Biodiesel	Blending product					
2011	105241	144502	94190	334727	43476	2329	45804	n.a	121	37060	97998	859645
2012	99238	123022	97512	389030	54888	4340	59227	n.a	130	42883	106656	917699
2013	95286	42729	98546	378049	60226	6798	67025	n.a	130	47801	114962	844527
2014	92748	55064	97417	363713	60901	11967	72868	n.a	58	51942	121743	855552
2015	84643	70228	95354	323331	85895	5939	91834	120	50	54361	124344	844266
2016	79704	63504	77434	329094	59244	19516	78760	145	107	56626	132411	817784
2017	74723	58800	89029	331454	77200	16682	93882	157	107	61299	136781	846232
2018[3)]	67522	100506	95587	320730	105949	24327	130276	163	36	64471	154052	933342
2019[3)]	61784	167412	94622	261971	150395	41494	191889	167	28	66198	160621	1004693
2020[3)]	65209	113416	97476	222339	124806	54494	179300	177	188	68372	159121	905597
2021	60392	87820	89557	235941	133767	60292	194059	180	0	72921	168375	909245

Source: Handbook of economic statistics of Indonesia 2021 (Thousand BOE).

TABLE II: Refinery Production

Year	Secondary fuel				Non fuel	Lubricant	LPG	HOMC	Total production
	Naptha	LOMC	LSWR	Total					
2011	28613	0	24021	52634	25768	3065	9143	11908	342823
2012	23180	0	26308	49488	18999	2988	7288	10405	328115
2013	23793	0	23743	47536	21726	2697	6635	6564	322664
2014	21985	243	26946	49174	30460	2529	6362	8544	342577
2015	13089	3131	24713	40933	27175	0	8084	4498	329536
2016	13641	107	24798	38546	15770	2019	10297	6904	340289
2017	18165	1223	26565	45953	22470	2457	10062	8254	356755
2018	19334	349	22815	42498	22656	2787	10289	6763	365576
2019	18782	0	26162	44944	23093	2332	9936	6269	366779
2020	16006	0	21497	37504	27032	2339	10183	6311	334844
2021	231	0	4905	5137	23666	2160	10145	79	296235

Source: Handbook of economic statistics of Indonesia 2021 (Thousand BOE).

shows the final energy consumption by type and Table II shows the refinery production by type.

The current condition of an oil refinery in Indonesia (Ministry of Energy and Mineral Resources Republic of Indonesia, 2021) as shown in Table III.

TABLE III: Refinery Capacity in 2014

Refinery	Refinery capacity
Tri Wahana Universal (TWU)	6.00
Dumai	127.00
Sungai Pakning	50.00
Musi	127.30
Cilacap	348.00
Balikpapan	260.00
Balongan	125.00
Cepu	3.80
Kasim	10.00
Tuban (TPPI)	100.00
Total	1157.10

Source: Handbook of economic statistics of Indonesia 2021 (Thousand BOE).

As the pilot project for this assignment, PT. PERTAMINA (Persero) has initiated the Refinery Development Master Plan (RDMP), which was pioneered by RDMP RUV Balikpapan. PERTAMINA Refinery Unit V (RU V), located in Balikpapan City, East Kalimantan, having an existing capacity of around 260,000 BOPD (Barrel Oil Per Day), which has been divided into Primary Process (Crude Distillation Unit & High Vacuum Unit) and Secondary Process (Hydro Catalytic Cracking Unit) including other Process Units such as Platforming Hydrogen Manufacturing Unit, Treating Unit, Oil Movement, Offsites & Jetty, and so on. The overview of the Refinery Development Master Plan RU V Balikpapan is shown in Fig. 1.

The Contract for RDMP RU V Balikpapan Project was awarded to the Consortium of SK E&C-Hyundai Engineering-PT. Rekayasa Industri–PT. PP (Persero). The Contract was signed on December 10th, 2018. The Kickoff Meeting has established effective date from February 28th, 2019, with the duration 53 months. The total Capital Expenditure (CapEx) investment is estimated at around USD 6.5 billion, which was started with the funding from PT. PERTAMINA (Persero). The scheme for project funding has been considered to go through a Project Financing mechanism, with the projection for the funding expected to be around USD 3.1 billion. To execute RDMP RU V Balikpapan Project, PT. PERTAMINA (Persero) has established an affiliate company named PT. Kilang Pertamina Balikpapan as Special Purpose Vehicle (SPV). Therefore, PT. Kilang Pertamina Balikpapan is set to run and afford the Project Financing for earning a loan of around USD 3.1 billion from the lender to completely cover the Capital Expenditure Investment requirement.

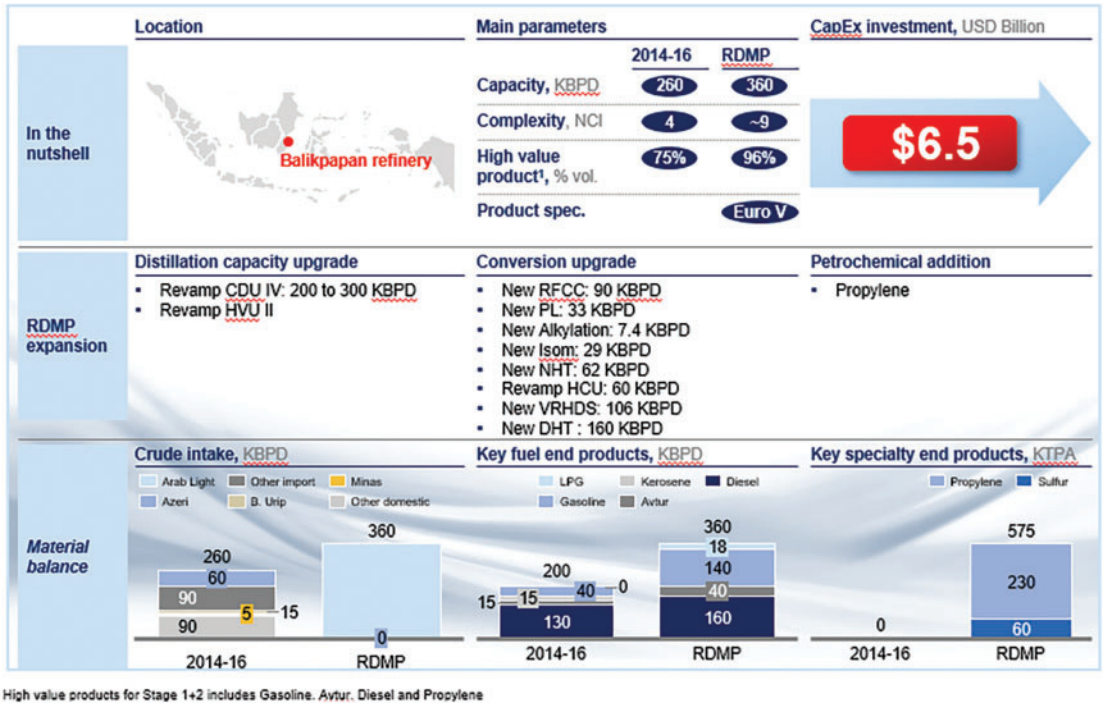

Fig. 1. The overview of RDMP plan RU V Balikpapan.

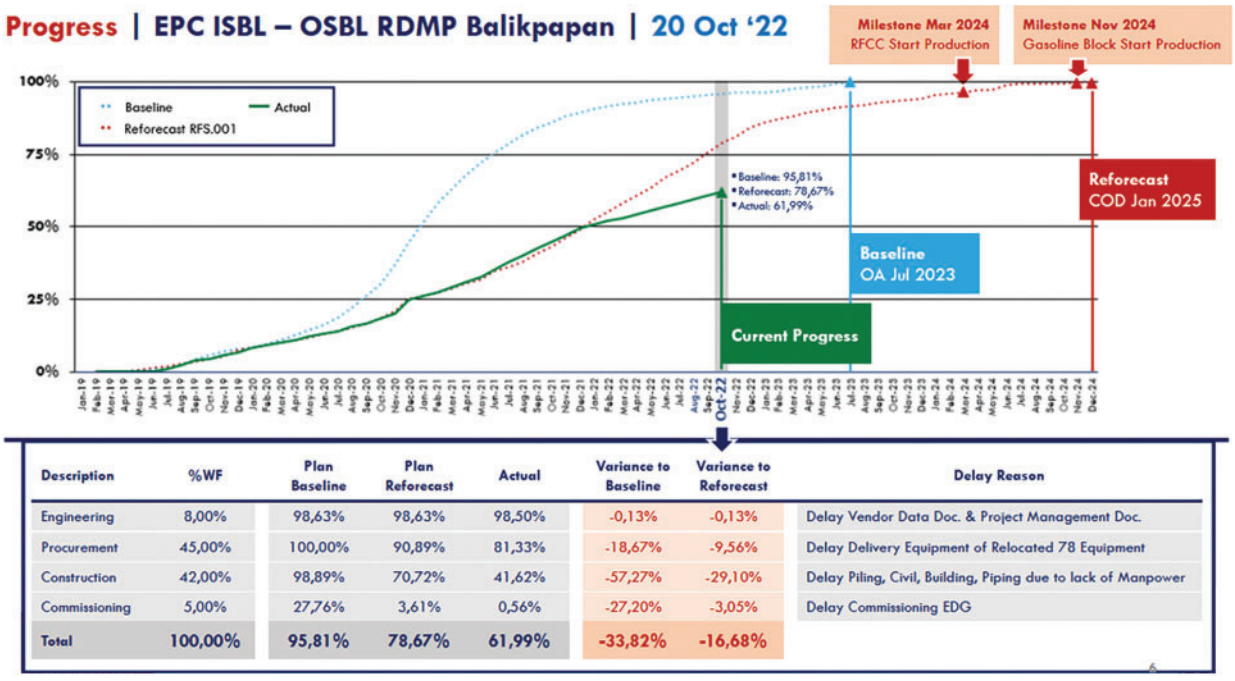

Fig. 2. Overall progress S-curve EPC ISBL OSBL RDMP RU V Balikpapan project.

In the meantime, the RDMP RU V Balikpapan project execution, the project has been facing many challenges in delivering the project successfully. Not only the EPC Work but also affording the project financing to earn the loan from the lender. The EPC Works was facing the COVID-19 pandemic, which was spreading and suffering globally in almost the entire world. With various challenges which have been faced, RDMP RU V Balikpapan Project was insisted to be able to identify the issues and define root cause analysis comprehensively and then resolve those issues and problems with available alternative business solution items. Those alternatives will result in an implementation plan to be realized into a strategy and plan from the best-selected solution.

2. Business Issue

2.1. Symptoms and Gaps

The current project phase of EPC Work is under construction phase. For EPC ISBL OSBL RDMP RU V Balikpapan Project, if it is counted from February 2019 until October 20th, 2022, as shown in Fig. 2, then the

project has entered M-44 (ED + 44 Months) where the progress is around −33.82% (delayed comparison between Actual Progress vs. Plan Baseline), or the comparison progress is around −16.68% (delayed comparison between Actual Progress vs. Plan Reforecast). The update progress for EPC ISBL OSBL RDMP RU V Balikpapan Project is shown in Fig. 2.

As identified, those delays are affected by various sectors, such as:

- Engineering Progress Delay;
- Material Procurement Delay;
- Pre-Construction Preparation which covering manpower loading, sub-contractor management, heavy equipment & tools for construction, and so on;
- Construction Progress Delay.

Those above preliminary root causes have been influenced mainly due to Covid-19 Pandemic and also Negative Cash Flow from Main Contractor.

2.2. *Business Situation Analysis*

For the conditional of project terms, which have been declared and agreed during the Project Kick Off Meeting as seen in Table IV.

In October 2022, due to impact especially Covid-19 pandemic that affecting to the delay progress of the project then CONTRACTOR has been suffering to the financial condition Meanwhile, based on payment mechanism above then CONTRACTOR also are not able to earn payment terms since the conditional has not been met by CONTRACTOR.

In PERTAMINA side, through PT. Kilang Pertamina Balikpapan also has not successfully earned the funding from project financing while the process still undergoing to approached multiple lenders with all conditional and terms requested by each lender. PT. Kilang Pertamina Balikpapan has interest to resolve this progress delay due to delaying project then it means delaying the operational of New Refinery Unit RDMP RU V Balikpapan. At the same time, the evaluation to the investment decision based on some variables/parameters such as IRR, Hurdle Rate, NPV, and so on need to be put into concern for any contingency shall not be failed.

TABLE IV: General Information EPC ISBL OSBL RDMP RU V Balikpapan Project

Project name	EPC ISBL OSBL RDMP RU V Balikpapan project
Site location	Balikpapan, East kalimantan
Company	PT. PERTAMINA (Persero)
Contract type	Lump sum Turnkey
Scope of work	Engineering, Procurement, Construction and commisioning (EPCC)
Contract period	Effective date: 28th February 2019 Mechanical completion: ED + 48 months Operational acceptance: ED + 53 Months
Contract price	Approx. USD 3.97 billion (Multi currencies in USD/IDR)
Payment condition	Milestone payment: 40% Progress payment: 60% Provisional sum: Reimbursable (note)
Warranty period	12 months after operational acceptance (Max. 24 months)

Notes: Training, Operation Spare Parts, HAZOP/LOPA Changes, Piling, Stone Column.

From point of view Stakeholder Analysis as shown in Fig. 3, EPC ISBL OSBL RDMP RU V Balikpapan having some stakeholder as following:

- Government (Ministry of State Owner Enterprises, Ministry of Energy and Mineral Resources (ESDM), and all Indonesians Parliaments
- National/Indonesians Citizens
- Board of Commissioners (Holding & Sub-Holding)
- Board of Directors (Holding & Sub-Holding)
- Sponsor (Lender, Holding)
- Project Manager

Based on the stakeholder analysis above, it is concluded that the sponsor and government shall be managed closely, while the Board of Commissioners and Board of Directors shall be kept satisfied.

With reference to Overall Progress EPC ISBL OSBL RDMP RU V Balikpapan cut off October, 20th 2022, both Integrated Timeline RDMP RU V Balikpapan Project and Overall Progress S-Curve EPC ISBL OSBL RDMP RU V Balikpapan Project which are regularly updated in each week and each month then it can be inferred that EPC ISBL OSBL RDMP RU V Balikpapan Project is under delayed progress as per current EPC Works ongoing execution process including there is financial condition issues both in PT. Kilang Pertamina Balikpapan, as OWNER, has not earned the project financing and is in Joint Operation SHRP (SKEC, Hyundai Engineering, PT). Rekayasa Industri, and PT. PP (Persero). EPC ISBL OSBL RDMP RU V Balikpapan Project requires prompt recovery of the project and financial situation to overcome all issues; thus, the project can be accelerated back on track as targeted.

From the problems that have been explained in the business issue, especially problem identification, in the EPC ISBL OSBL RDMP RU V Balikpapan project, it is understood that there was a delay in the EPC Works execution process, so the authors set some research questions, which are:

- What are the main and critical factors that actively contribute to the delay in progress?
- What are the alternative solutions to resolve the project delay?
- What strategic planning and decisions shall the top management take in this project delay condition?

2.3. *Conceptual Framework*

Referring to Fig. 2, overall project progress EPC ISBL OSBL RDMP RU V Balikpapan has quite significant delay progress in percentage (−16.68%) and as it has been described in Business Situation Analysis in section 2.2 that has been undergone in the current EPC Works execution process which could be the main factor in determining the continuation of the project and can cause a larger delay in contribution if improper management and problem-solving in the days ahead. Several potential problem items

Fig. 3. Stakeholder analysis EPC ISBL RDMP RU V Balikpapan project.

will be evaluated using a number of tools to determine the main root cause of the delayed progress issue.

The conceptual framework approach used for this research is shown in Fig. 4. The author will identify starting from items that contribute to the progress delay, using the tool to determine the main item that has the largest percentage and parallel collect data from site activity for alignment data and facts. In the end, mitigation measures and strategies are taken to improve the delayed progress that occurred in the Balikpapan RDMP project, and best practices are looked for as lessons learned to be implemented in Project PT. PERTAMINA in the future.

Based on the conceptual framework above, the author would like to connect and emphasize that the process started with analyzing the data, root cause analysis, and continued to solution and mitigation using a theoretical foundation, which are SWOT analysis, Kepner-Tregoe Problem Analysis, Fault Tree Analysis, and Analytical Hierarchy Process (AHP).

3. Methodology

3.1. Research Design

This research employs a mixed-methods approach, which integrates both qualitative and quantitative methods. A mixed-methods approach provides comprehensive and widely descriptive thinking, considering validity, reliability & ethical considerations (John & Creswell, 2017).

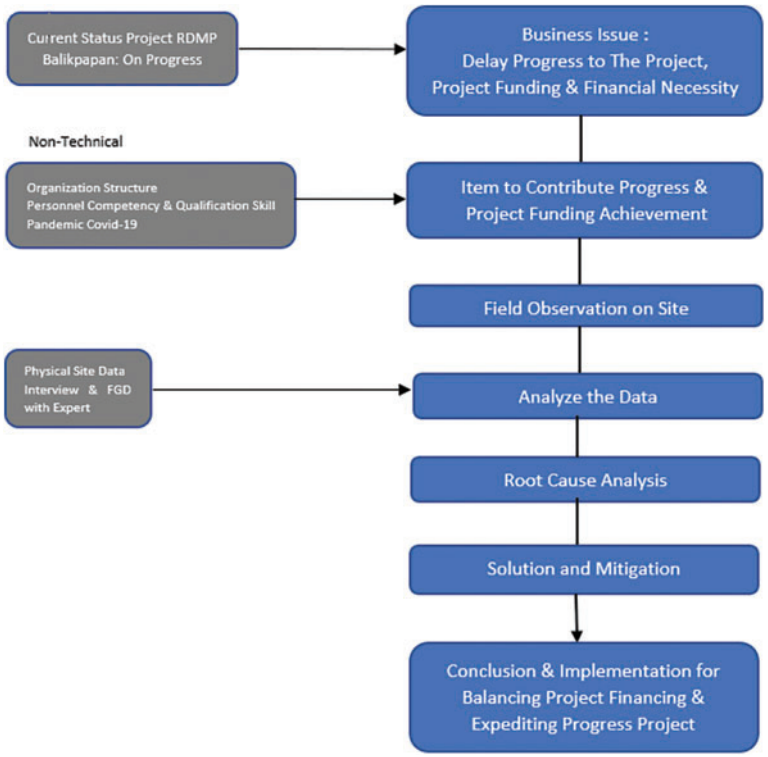

Fig. 4. Conceptual framework.

The qualitative aspect involves conducting interviews and focus group discussions with three main areas as sources of information from expertise on the Construction Aspect, Financial & Funding Aspect, and System Completion (Simultaneous Operation). This interview and FGD will deliver widely understanding picture related to the research subject in terms of balancing project financing and strategic project execution for Megaproject.

The quantitative approaches will use the Analytical Hierarchy Process (AHP) method to rank the identified improvement areas in terms of importance. AHP is a structured technique used to solve complex decision-making problems by breaking them down into a hierarchical structure and evaluating the criteria and alternatives in a pairwise comparison manner (Saaty, 2008).

The sequence of research will be approached into five stages, as shown in Fig. 5.

3.2. *Data Collection Method*

The method of data collection will be approached to satisfy the research comprehensively and will be elaborated on both primary sources and secondary sources.

The Primary Sources will play key roles in the data collection which could be obtained through methods below:

3.2.1. *Interview*

Interviews will be conducted in semi-structured interviews with the key persons in three main areas, which are Construction Expert, Financial Team (Project Financing), and System Completion (Simultaneous Operation Department).

3.2.2. *Focus Group Discussion*

Focus Group Discussion will be used in terms of defining Cashflow Improvement, Construction Improvement, also Commissioning & Start Up Improvement from three Main Expertise Areas. Those improvement alternative solutions will be approaches based on appraisal values from the expertise, with the pairwise comparison method also enhanced in the research.

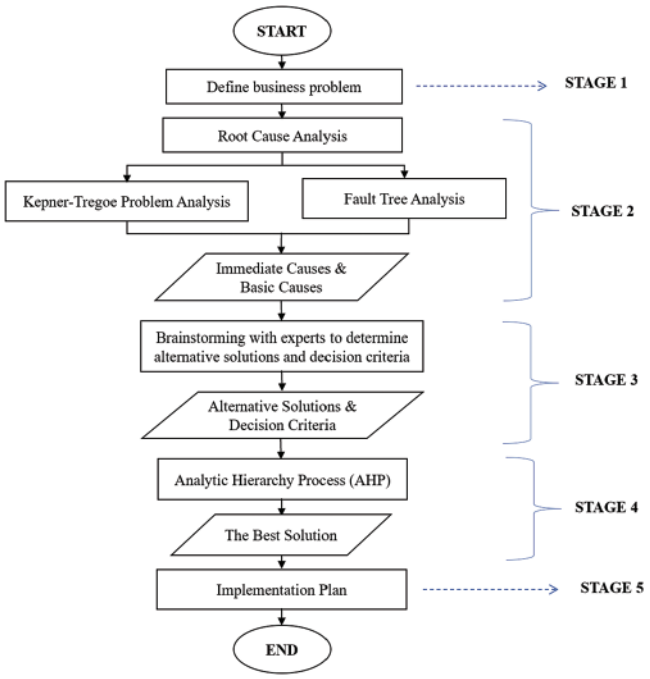

Fig. 5. Research sequence.

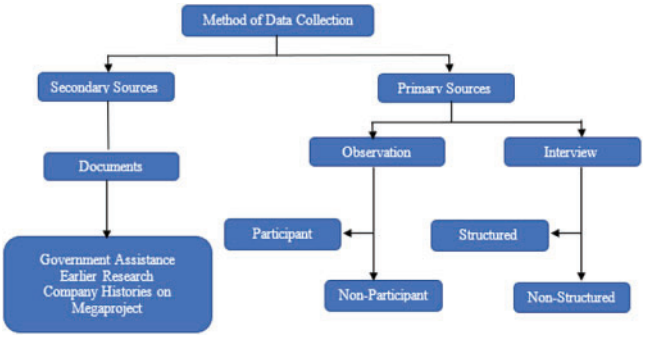

Fig. 6. Data collection method structure to the research.

3.2.3. *Observation*

Conducting observation is a substantial research framework in terms of obtaining actual data from the project site to measure the variable from both qualitative and quantitative with the association relationship with the objective improvement which will be approached in this research.

Particular approaches are identified using the marked-up data collection method (Fig. 6).

The secondary sources will complete the data collection through documents which are taken from:

- Government Assistance
- Earlier Research
- Company Histories on Refinery Megaproject

3.3. *Data Analysis Method*

The research will be analyzed by using Kepner-Tregoe (KT) Problem Analysis to define Problem Analysis, Situation Analysis, and Decision Analysis, which will be further evaluated also to define the problem through Fault Tree Analysis as reinstatement root cause analysis to the business issue/problem.

For the AHP, the priorities will be determined by pairwise comparisons, which will be processed using an AHP software tool. The consistency ratio (CR) will be calculated to ensure the consistency of the judgments. A consistency ratio of less than 0.1 is generally considered acceptable (Ishizaka & Labib, 2009). This mixed-methods approach will provide a robust methodology for assessing and prioritizing enhancements for finding out the best alternative solutions to expedite delayed progress and project funding and finance necessity.

4. Business Issue Exploration and Results

PT. PERTAMINA (Persero) through PT. Kilang PERTAMINA Internasional has established PT. Kilang Pertamina Balikpapan as Special Purpose Vehicle (SPV) to be responsible for the execution of RDMP RU V Balikpapan Project with reference to the EPC ISBL OSBL RDMP RU V Balikpapan Contract, which the contract novation from PT. PERTAMINA (Persero) to PT. Kilang Pertamina Balikpapan will directly own the new asset unit

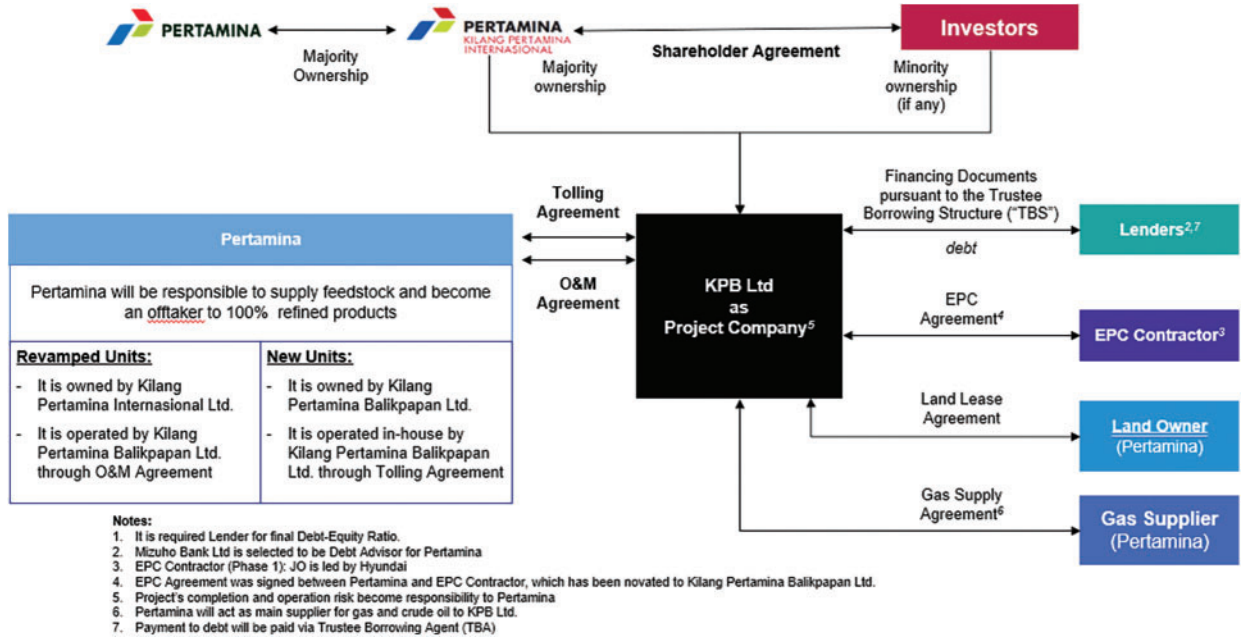

Fig. 7. Business scheme for new RDMP RU V Balikpapan refinery.

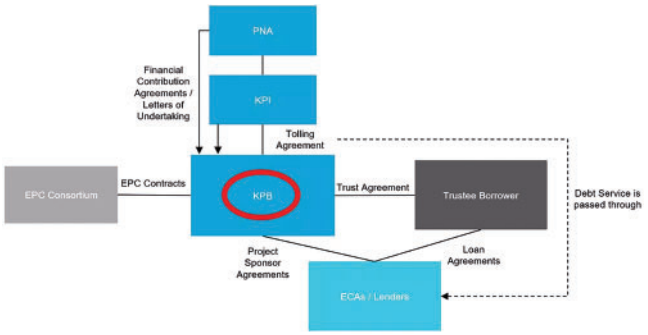

Fig. 8. Project financing structure for RDMP RU V Balikpapan project.

and further will be assigned to operate Refinery Unit V Balikpapan for a whole existing and new unit. For the operating services, which have been run by PT. Kilang Pertamina Balikpapan then PT. Kilang PERTAMINA Internasional will pay the cost and compensation through Tolling and Operation & Maintenance (O&M) fee. Fig. 7 presents the business scheme by PT. Kilang PERTAMINA Internasional.

4.1. Project Funding

Project Funding is the way PT. PERTAMINA (Persero), especially PT. Kilang Pertamina Balikpapan to provide funding or financial support for Refinery Development Master Plan (RDMP) RU V Balikpapan Project. There are several options for project funding scheme which comprise:

- *Corporate Loan:* The definition is a kind of loan which is given to a company and not given to a government organization or an individual person. A company is able to issue a corporate bond or obtain money from a bank through a corporate loan.
- *Global Bonds:* A Global Bonds is an investment in debt which is issued by a foreign entity. For example, US based Global Bond might fund to invest in Australia Government Bonds, Chinese Corporate Bonds and other government and corporate bonds which is issued in foreign countries. Commonly, Global Bonds are deemed as Eurobonds, but Global Bonds can also be traded and issued in the country whose currency is used to value the bond.
- *Project Financing:* The definition is the long-term financing of infrastructure and industrial projects where the RDMP RU V Balikpapan project to fund the Refinery & Petrochemical industry based upon the projected cash flows of the project rather than the balance sheets of its sponsor.

Fig. 8 shows the Project Financing Structure Scheme for RDMP RU V Balikpapan Project.

Between Lender and PT. Kilang Pertamina Balikpapan, the drawdown for the financing is facilitated for its reimbursement through the Trustee Borrowing Scheme (TBS). The TBS will take part as the facilitator entity, which is appointed to manage assets on behalf of the lenders. TBS will play a crucial role in a trust or sponsorship agreement between Lenders and PT. Kilang Pertamina Balikpapan, which is legally arranged and allows The TBS to hold and manage assets for lenders' protection as per the sponsorship agreement.

In the middle between the lender and PT. Kilang Pertamina Balikpapan, there is a Facility Agent who is interfacing and facilitating some queries from the lenders. There are two Facility Agent as following:

- *HSBC HK:* As the Agent for Korean ECA and its Global Facility
- *HSBC London:* As the Agent for SACE (Italy).

Meanwhile, the Trustee Borrowing Scheme is appointed to Trustee HSBC New York. To execute the project

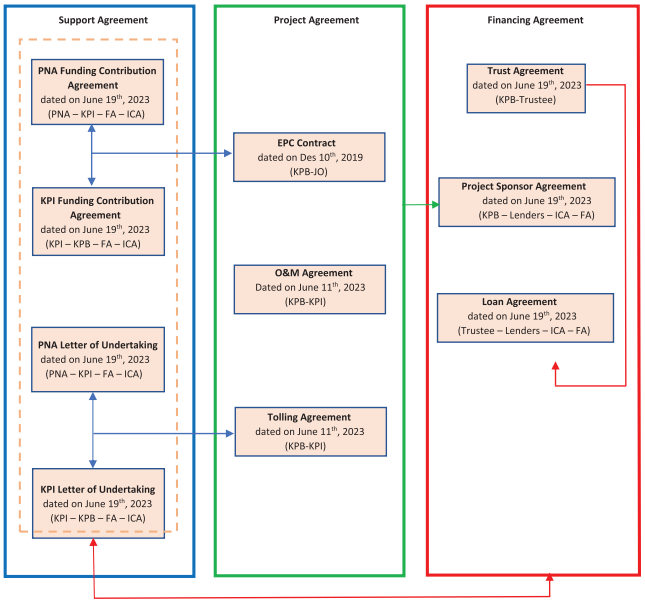

Fig. 9. Project financing RDMP RU V Balikpapan project document scheme.

financing, there are three parts of agreements that shall be fulfilled, which are the support agreement, project agreement, and financing agreement based on the Project Financing RDMP Balikpapan Document Scheme, as shown in Fig. 9.

4.2. *SWOT Analysis*

Based on an analysis of the company's internal and external environment, Table V shows the SWOT analysis results of the Refinery & Petrochemical Businesses in Indonesia.

4.3. *Kepner Tregoe Problem Analysis*

In this research, the Kepner-Tregoe Problem Analy- sis method is used without taking "situation analysis" into account considering the business issue as described as problems which are faced by PT. Kilang Pertamina Balikpapan are true and apparent as written in the "Business Issue" chapter, The business issue related to project delay which is comparison between Actual Progress vs. Plan Baseline. By using Kepner-Tregoe Problem Analysis, possible causes that contribute to delayed progress of RDMP RU V Balikpapan Project are:

- Pandemic Covid-19
- Inadequate Sub-Cont. Plan & Scheduling
- Lack of Competence and Experience to handle project issues both technical & non-technical
- Parallel Project, especially delay on the predecessor of Early Works Project
- Financial Condition of CONTRACTOR

And the most possible causes are:

- Pandemic Covid-19
- Parallel Project, especially delay on the predecessor of Early Works Project
- Financial Condition of CONTRACTOR

4.4. *Fault Tree Analysis*

The results of the root cause analysis from the Fault Tree Analysis will complete each other with the results from the Kepner-Tregoe Problem Analysis. Detail of Fault Tree Analysis (FTA) can be seen in Fig. 10. The methods through brain storming to determine several possible causes from Board of Management and Technical Experts such as ice Presidents and Managers as Subject Matter Expert (SMEs), who have comprehensive knowledge and extensive experience, with the capabilities and management view including authorization for running the project in creating Fault Tree Analysis. There are seven Subject Matter Experts as shown in Table VI that were involved in determining root cause analysis in RDMP RU V Balikpapan Project related to delayed progress, which is currently occurring.

Fault tree analysis on the delayed progress of RDMP RU V Balikpapan Project is shown in Fig. 10.

Based on the result of FTA in Fig. 10, the root cause of problems is divided into two categories, consisting of immediate causes and basic causes. Table VII. SME's recommendation for the root cause of the problem is shown in Table VII.

TABLE V: SWOT Analysis Result to the Refinery and Petrochemical Businesses in Indonesia

Strength	Weakness
Existing RU V has been operating with complete facilities and infrastructures which is integrated from upstream to downstream for oil and gas industry.	Existing RU V produces an excess of LSWR (Low Sulphur Waxy Residue) which is low valuable intermediate product of around 1200 MB/month.
The financial condition is still supported by Holding PT. PERTAMINA (Persero) at minimum 50%.	Limitation to produce fuel with quality standard Euro 2 which has a relatively high sulfur content.
PT. PERTAMINA has a strong brand image both nationally and internationally.	Refinery Unit which having mainly Crude Storage Tanks and Product Storage Tanks are only sufficient to accommodate the existing production capacity, hence, to increase the capacity of the existing refinery it is necessary to increase the number of storage tanks.
Existing RU-V has a monopoly on the production of several fuel and non-fuel products for eastern Indonesia region, both for retail customers and corporate customers.	Most Process Units of the Existing RU V have been operating with old technology so that the complexity is lower than international competitors and consequently the conversion rate is also low. This causes the profit of RU V is not optimal. The quality product is Euro 2 standard (high emission).

TABLE V: CONTINUED

Opportunities	Threats
At this current condition, Indonesia is the largest fuel importer in Asia, 40% imported Fuel Products (BBM) & 40% imported Petrochemical products. Meanwhile for fuel demand and Petrochemical products in Indonesia continues to increase, and the production capacity of the existing PERTAMINA refinery is still insufficient. so, there is a market opportunity that can be utilized by Existing RU V. The market share of Fuel Products (BBM) in Indonesia is controlled by PERTAMINA. The community and industry still depend on PERTAMINA to buy fuel products due to competitive prices and large volumes. Through Law No. 8 of 1971, the government regulates the role of PERTAMINA to produce and process oil and gas from oil fields as well as to provide fuel and gas needs in Indonesia. PERTAMINA was given the mandate by the Government to manage and to cultivate the energy for national energy resilient by carrying out National Strategic Projects in the form of New Grass Root Refinery (NGRR) and Existing Refinery Development (RDMP). The supporting regulations are Presidential Regulation No. 146 of 2015, Presidential Regulation No. 56 of 2018, Ministry of Energy and Mineral Resources Decree No. 1001 2016. Other Government supports are various benefits and legal basis & privileges such as relevant regulations, Expedited Licensing, Tax Incentives. Sour crude (high %S) has a lower price than sweet crude (low %S). By processing 100% imported sour crude, it will increase the profitability of the Existing RU V. PT. Kilang Pertamina Balikpapan will be able to generate profit since the tolling and O&M Fees have been established for the business scheme between PT. Kilang Pertamina Internasional and PT. Kilang Pertamina Balikpapan.	Crude Supply (feedstock); Domestic crude production (upstream) will fall 40% in the next 10 years. Most of the crude (imported & domestic) will be sour crude (high %S), while the RU V existing refinery is designed to process sweet crude (low %S). As a result, the Existing RU V cannot cultivate the process of sour crude (high %S) with high volume. The Existing RU V margin will continue to decline if it only relies on sweet crude because sweet crude is rare and expensive. Crude prices are very dynamic and change easily according to the global & geopolitics situation. The government instruct PERTAMINA to produce Fuel Oil Products (BBM) with a minimum standard of Euro 4 (more environmentally friendly) meanwhile, current existing RU-V can only produce fuel with quality standard Euro 2 (relatively high sulfur content). If it is not complied with regulation, PERTAMINA might have consequences from the Government. Upgrading the existing RU V will require large investment funds so that it has the potential to disrupt PERTAMINA's finances if it only relies on financial sources from PERTAMINA. Fuel Product (BBM) has been becoming livelihood of many Indonesians, thus the establishment of the selling price of BBM products is determined by the Government.

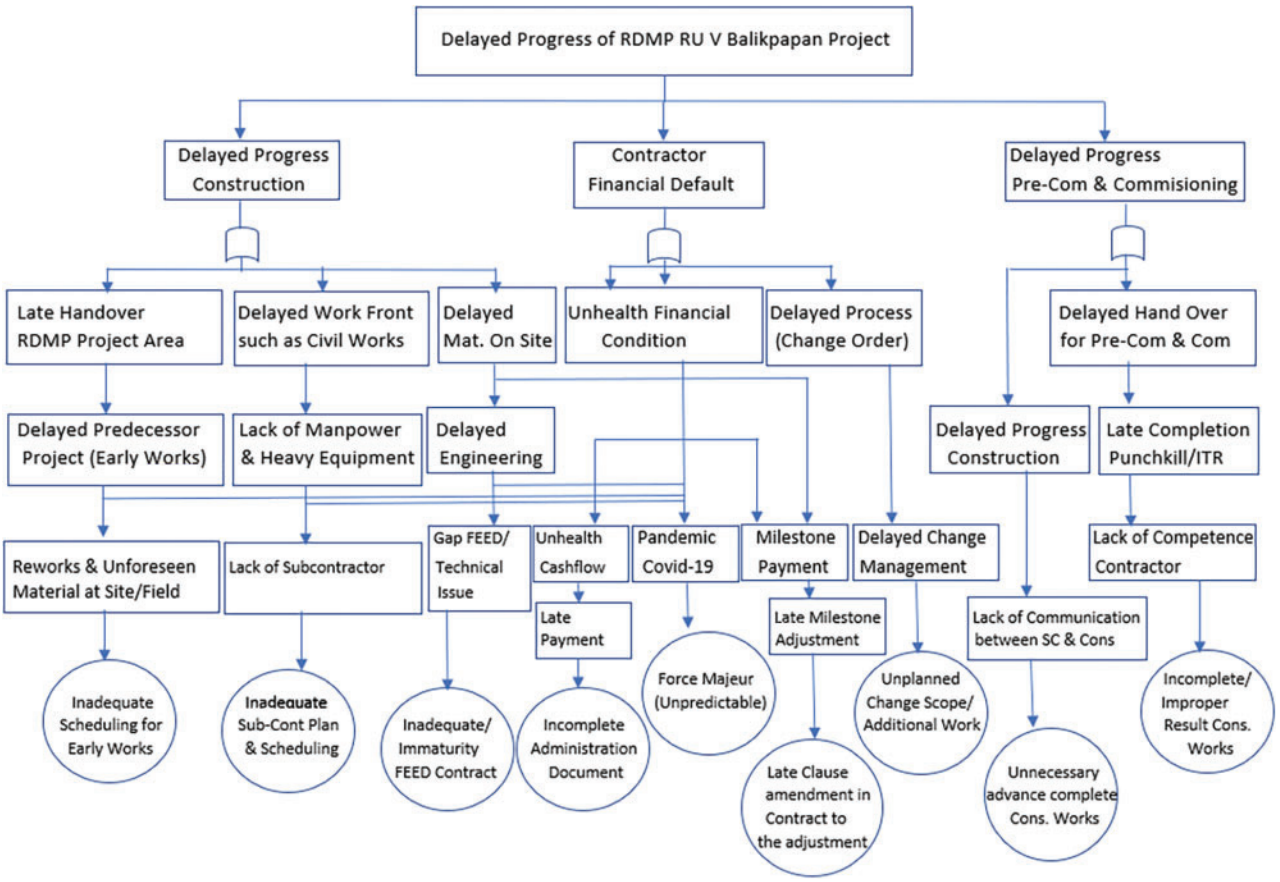

Fig. 10. Fault tree analysis on delayed progress of RDMP RU V Balikpapan project.

TABLE VI: The List of Subject Matter Experts (SMEs) to Determine Root Cause Analysis

No.	Subject matter expert (SMEs)	Division	Job description
1.	VP construction Balikpapan	Construction	Responsible to direct and coordinate for construction Balikpapan and keeping the progress not be delayed
2.	Manager construction OSBL	Construction	Responsible to manage construction activity and its progress in OSBL area
3.	Act. manager construction ISBL area-1	Construction	Responsible to manage construction activity and its progress in ISBL area
4.	VP system completion	System completion	Responsible to direct and coordinate for pre-com and commissioning to ISBL, OSBL, Offsite and Lawe-Lawe area
5.	Manager OSBL–Offsite & Lawe-Lawe	System completion	Responsible to manage for pre-com and commissioning to OSBL-Offsite & Lawe-Lawe area
6.	VP finance	Finance	Responsible to direct and coordinate for finance of PT. Kilang pertamina Balikpapan
7.	Manager corporate finance	Finance	Responsible to manage for corporate finance matter, such as project financing

TABLE VII: SME's Recommendation for Root Cause of Problem

Root cause of problem	Recommendation
Immediate causes Delayed progress of RDMP RU V Balikpapan Project due to: 1. Inadequate Sub-Cont. Plan & Scheduling 2. Unplanned Change Scope/Additional Works 3. Late Clause Amendment in Contract to the adjustment 4. Unnecessary advance complete construction works	Recommendations could be taken: 1. Instructing CONTRACTOR to add sub-contractor so that manpower and required equipment for executing works at site are supporting the target schedule 2. Expediting Change Management Procedure to proceed the change order to be paid and limiting Change Order to CONTRACTOR to prevent scope creeping 3. Starting to proceed clause amendment for milestone payment to the Contract EPC ISBL OSBL RDMP RU V Balikpapan from original portion 60% Progress 40% milestone become 80% Progress 20% milestone. 4. Starting to proceed clause amendment for percentage construction vs commissioning from 45% construction 5% commissioning become 49% construction 1% commissioning. 5. System Completion to implement Flawless Sub System Method for Pre-Commissioning & Commissioning. 6. System Completion to implement Skyline/Backward Method from downstream to upstream
Basic causes: 1. Inadequate scheduling for early works 2. Inadequate/Immaturity FEED Contract 3. Incomplete Administration Document 4. Force Majeur (unpredictable) Covid-19 5. Incomplete/Improper Result Const. Works	Recommendation could be taken: 1. Managing Interface & Integration Plan between Early Works Project and Main EPC ISBL OSBL RDMP RU V Balikpapan Project through dashboard system include the timeline and actual progress 2. Applying Cold Eye to re-verification and re-validation FEED Contract and Workshop Joint Review FEED Contract to address the gaps FEED shall be further taken during EPC Execution Stage. 3. Establishing agreed procedure and providing dashboard system to monitor compleness of administration document for payment purpose. 4. Proposing Covid-19 as considerations to Force Majeur events to the stakeholders and sponsor, so that the rebaseline schedule as the final consolidation can be agreed with CONTRACTOR

TABLE VIII: Alternative Solutions for Root Cause Problem

Root cause problem	Alternative solutions
The delayed progress of RDMP RU V Balikpapan project	1. Terminate the current EPC contractor joint operation (JO) SHRP and appoint new EPC contractor to continue and to accomplish remaining works until operational acceptance & final acceptance for the project can be achieved 2. Takeover scope of CONTRACT which under-performed, or CONTRACTOR has delivered officially through a letter that CONTRACTOR are not able to execute a particular scope of work and asking descoping works from CONTRACT to PT. Kilang Pertamina Balikpapan, so that OWNER is requested to do the works 3. Appoint new contractor to work together with EPC ISBL OSBL RDMP RU V Balikpapan without any deduction to the existing contract EPC ISBL OSBL RDMP RU V Balikpapan

4.5. Alternative Solution for Business Issue

The brainstorming method is conducted to determine several alternative solutions by involving Subject Matter Experts as decision maker in RDMP RU V Balikpapan Project, where there are alternatives solutions from the root cause problem and considering to recommendation which have been determining on previous chapter. Table V presents the alternative solutions for root cause problem as shown in Table VIII.

TABLE IX: The Project Cost of Three Alternative Solutions for Root Cause Problem

Alternative solutions	Project cost	Reference	Remarks
Terminate the current EPC contractor joint operation (JO) SHRP and award new EPC contractor	USD 954 million	Cost estimation from project cost has been realized and with the basis cost estimation which is used during bidding EPC ISBL OSBL RDMP RU V Balikpapan contract with the inflation estimation augmented	Contract termination cost and award new EPC contractor for remaining works
Takeover scope of CONTRACT for remaining works under performed or descoping from CONTRACTOR	USD 3.3 million	Cost estimation from remaining works shall be completed with rough estimation from project control team (Cost estimator)	Takeover cost for remaining works. Total spent cost will be deducted to EPC main contractor
Appoint new contractor to work together with EPC ISBL OSBL RDMP RU V Balikpapan without any deduction to the existing contract EPC ISBL OSBL RDMP RU V Balikpapan	USD 1.1 million	Cost estimation from remaining works shall be completed with rough estimation from project control team (Cost estimator) with notes only to Service (Man hours and equipment/tools)	Appoint new contractor cost which is being extra cost for supporting remaining works along with the main contractor. Total spent cost will not be deducted to EPC main contractor

TABLE X: SME's Criteria Selection for Alternative Solutions

Criteria	Description
Schedule	All schedule required for implementation of the selected best alternative solution shall not more than 2025 as the last operational of gasoline block process units
Cost	All cost required for implementation of the selected best alternative solution such as project cost, and other cost such as overhead cost
Complexity	The complexity for the works to implement the selected best alternative solution
Bureaucracy	Procedure and official administration for approval to authorized person
Regulation	Regulation for the CONTRACT EPC ISBL OSBL RDMP RU V Balikpapan and sponsorship agreement with lenders, also PERTAMINA regulation and procedure

The project cost of three alternative solutions above can be seen in Table IX, where the reference of the project cost is estimation from remaining works shall be completed, the project cost has been realized and with the basis cost estimation which is used during Bidding, EPC ISBL OSBL RDMP RU V Balikpapan Contract.

In decision-making, the most critical and relevant criteria that influence the decision analysis must be selected to determine the best alternative solutions. Using brainstorming methods with several Subject Matter Experts (SMEs) to define the criteria for decision-making to select the best alternative solutions. SMEs decided to use (5) five criteria in selecting the best solution, which comprises Schedule, Cost, Complexity, Bureaucracy, and Regulation, as shown in Table X. Criteria of Schedule are the main criteria and mandatory requirements for each alternative solution. Acceptable schedule with the impact to Target Operational Schedule of RDMP RU V Balikpapan Project more than 2025 will be rejected because it will totally change the last project charter, and Economic Calculation for the last Final Investment Decision has been made.

4.6. Analytical Hierarchy Process (AHP)

Pairwise comparisons between the above criteria and sub-criteria were delivered through a questionnaire dedicated to the selected respondents to be filled with assessment on each comparison. Pairwise questionnaire of criteria is shown in Table VI.

Meanwhile, pairwise questionnaire of alternative solutions is shown in Fig. 12. Consistency Ratio in this research, there are two categories of consistency ratio calculation consisting of pairwise comparison Level-1 (criteria) as shown on Table XI and Level-2 (alternative solution) as shown on Table XII.

4.6.1 Modelling of Analytical Hierarchy Process

Synthesize the result to determine the best alternative solutions:

- Matrix of Criteria (Fig. 12)
- Matrix of Alternative Solution (Fig. 13)

4.6.2 Development Priority Ranking

By using the priority vector of solution criteria (Level-1) in Fig. 12, and the priority vector of alternative solution (Level-2) in Fig. 13, the next step is to make priority ranking in the structure a hierarchy based on the weight of all alternatives and criteria, that shown in Fig. 11.

Based on the weights of all alternatives and criteria in Fig. 14, Regulation gets the highest score in the priority ranking of criteria (final score 31%) because regulation related to the CONTRACT about termination and sponsorship agreement which are not allowing PT. Kilang Pertamina Balikpapan assigns or novate any right or obligation under, nor amend, vary, or terminate any term of the EPC Contract except with the prior consent of the Lenders.

The next step of the AHP method is to calculate the ranking of alternative solutions to select the best

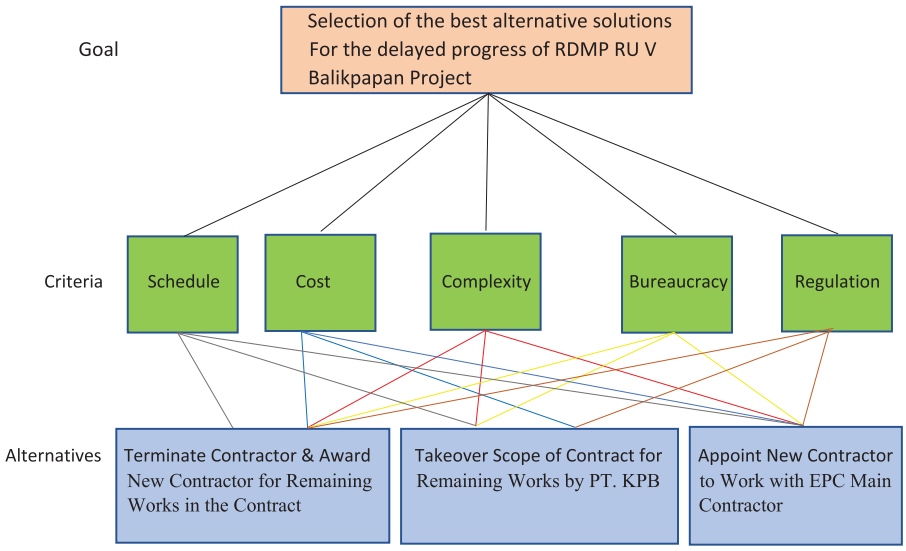

Fig. 11. The structure and hierarchy of the AHP model.

Solution Criteria	Priority Vector
Schedule	0.26
Cost	0.24
Complexity	0.1
Bureaucracy	0.09
Regulation	0.31

Fig. 12. Priority vector for solution criteria (Level-1).

alternative solution. The ranking of alternative is calculated by multiplying the priority vector matrix of the alternative solution (Level-2) in Fig. 13. with the priority vector matrix of the solution criteria (Level-1) in Fig. 12. Calculation details of alternative ranking is shown in Fig. 15.

$$Ranking\ alternative = \begin{bmatrix} 0.07 & 0.080.07 & 0.090.08 \\ 0.7 & 0.690.69 & 0.680.69 \\ 0.23 & 0.230.24 & 0.230.23 \end{bmatrix} \times \begin{bmatrix} 0.26 \\ 0.24 \\ 0.1 \\ 0.09 \\ 0.31 \end{bmatrix}$$

$$Ranking\ alternative = \begin{bmatrix} 0.0773 \\ 0.6917 \\ 0.231 \end{bmatrix}$$

TABLE XI: Pairwise Comparison

Question: Which of the following criteria do you think is more critical for selecting best alternative solutions to resolve delayed progress of RDMP RU V Balikpapan Project

Criteria	←Pairwise Numerical Rating→																			Criteria
Schedule	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Cost
Schedule	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Complexity
Schedule	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Bureaucracy
Schedule	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Regulation
Cost	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Complexity
Cost	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Bureaucracy
Cost	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Regulation
Complexity	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Bureaucracy
Complexity	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Regulation
Bureaucracy	←	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	→	Regulation

TABLE XII: Pairwise Quest. of Alt.

Question: Based on Criteria "Schedule, Cost, Complexity, Bureaucracy, and Regulation", Which one of the following alternative solutions do you think is the most preferable to recover delayed progress of RDMP RU V Balikpapan Project

Alternative Solutions	← Pairwise Numerical Rating Alternative Solutions →
Terminate Contractor and Award New Contractor	← 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 Takeover Scope by PT. KPB
Terminate Contractor and Award New Contractor	← 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 Appoint New Contractor to Workwith EPC Main Cont
Takeover Scope by PT. KPB	← 9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9 Appoint New Contractor to Workwith EPC Main Cont

Alternatives Solutions	Schedule	Cost	Complexity	Bureaucracy	Regulation
Terminate Contractor & Award New Contractor Takeover Scope by PT. KPB	0.07 0.7 0.23	0.08 0.69 0.23	0.07 0.69 0.24	0.09 0.68 0.23	0.08 0.69 0.23

Fig. 13. Priority vector for alternative solutions (Level-2).

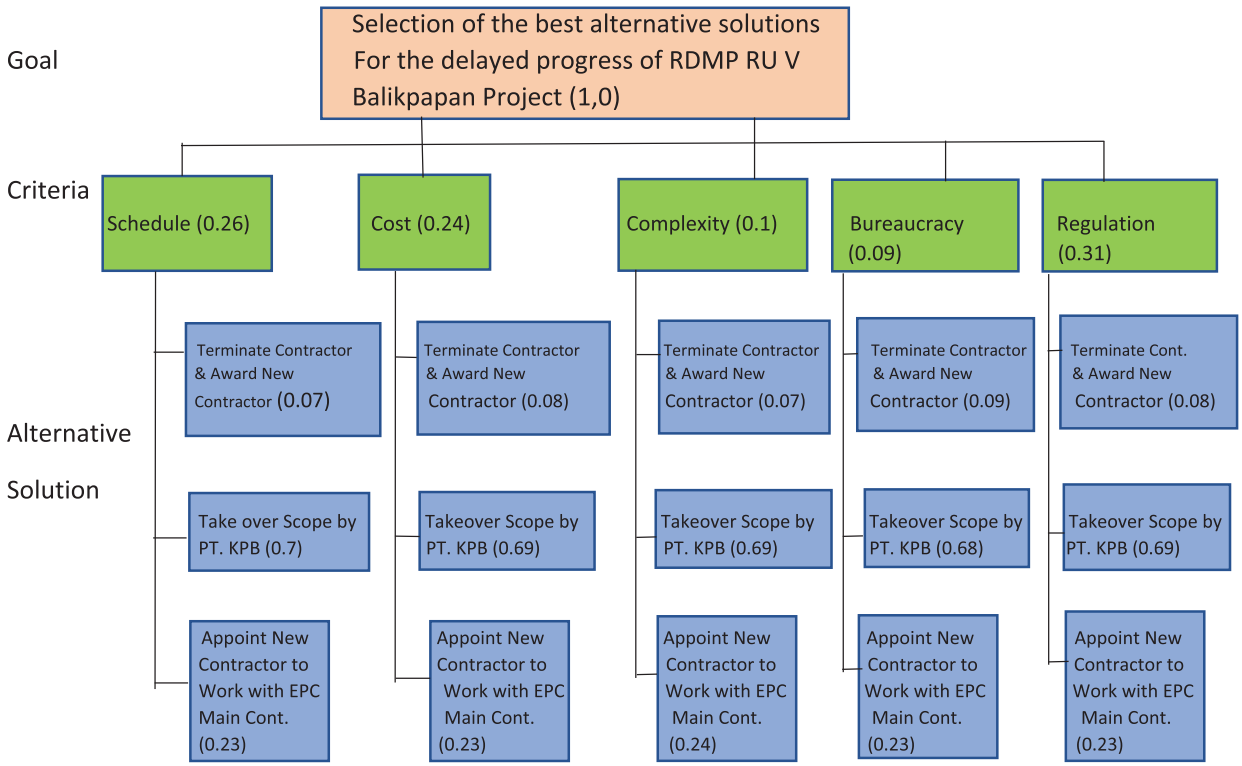

Fig. 14. The weight of all alternative and criteria.

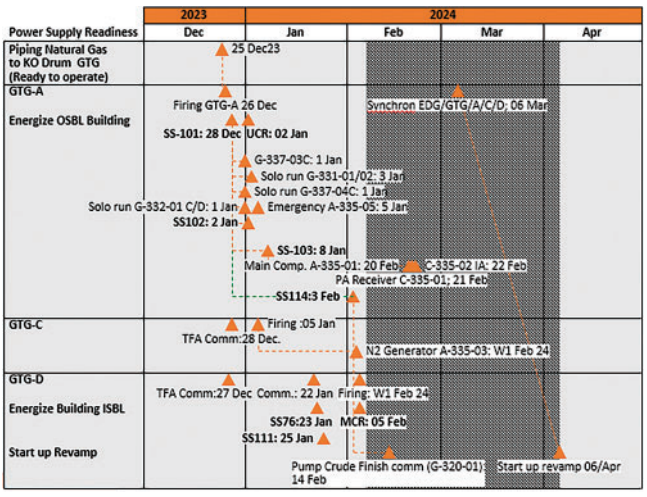

Fig. 15. Power supply readiness plan schedule.

From the results of the calculations above, an alternative ranking matrix is obtained, where the highest score from the matrix indicates the best alternative solution. Fig. 13. shows the selection of the best alternative solution from the result of alternative ranking.

Based on the weights of all alternatives and criteria in Table VII, the alternative solution of "Takeover scope of CONTRACT for remaining works by PT. Kilang Pertamina Balikpapan" acquired the highest score for 5 (five) of 5 (five) selected criteria that consist of schedule (score 70%), cost (score 69%), complexity (score 69%), bureaucracy (score 68%), and complexity (score 69%). From alternatives priority ranking calculation, "Takeover scope of CONTRACT for remaining works by PT. Kilang Pertamina Balikpapan" is the best solution.

4.7. Consistency Ratio

In this research, there are two categories of consistency ratio calculation consisting of pairwise comparison Level-1 (criteria) as shown on Table XIII and Level-2 (alternative solution) as shown on Table XIV. Table XVI shows Consistency Ratio of Pairwise Comparison "Criteria" (Level-1) meanwhile Table XVII shows Consistency Ratio of Pairwise Comparison "Alternative Solution" (Level-2).

TABLE XIII: Pairwise Comparison of Criteria Solutions

Solution criteria	Average point	Solution criteria	Average point
Schedule	5.86	Cost	0.17
Schedule	5.57	Complexity	0.18
Schedule	5.43	Bureaucracy	0.18
Schedule	0.19	Regulation	5.29
Cost	0.21	Complexity	4.7
Cost	5.0	Bureaucracy	0.2
Cost	5.71	Regulation	0.17
Complexity	0.15	Bureaucracy	6.43
Complexity	0.16	Regulation	6.14
Bureaucracy	0.17	Regulation	5.71

TABLE XIV: Pairwise Comparison of Alternative Solutions

Criteria	Solutions	Average points	Solutions	Average points
Schedule	Terminate contractor & award new contractor	0.15	Takeover scope by PT. KPB	6.43
Schedule	Terminate contractor & award new contractor	0.18	Appoint new contractor to work with EPC main cont.	5.43
Schedule	Takeover scope by PT. KPB	5.86	Appoint new contractor to work with EPC main cont.	0.17
Cost	Terminate contractor & award new contractor	0.17	Takeover scope by PT. KPB	6.0
Cost	Terminate contractor & award new contractor	0.19	Appoint new contractor to work with EPC main cont.	5.14
Cost	Takeover scope by PT. KPB	5.7	Appoint new contractor to work with EPC main cont.	0.18
Complexity	Terminate contractor & award new contractor	0.14	Takeover scope by PT. KPB	7.0
Complexity	Terminate contractor & award new contractor	0.17	Appoint new contractor to work with EPC main cont.	5.86
Complexity	Takeover scope by PT. KPB	5.43	Appoint new contractor to work with EPC main cont.	0.18
Bureaucracy	Terminate contractor & award new contractor	0.17	Takeover scope by PT. KPB	5.86
Bureaucracy	Terminate contractor & award new contractor	0.2	Appoint New Contractor to work with EPC Main Cont.	5.0
Bureaucracy	Takeover scope by PT. KPB	5.43	Appoint new contractor to workwith EPC main cont	0.18
Regulation	Terminate contractor & award new contractor	0.17	Takeover scope by PT. KPB	5.86
Regulation	Terminate contractor & award new contractor	0.18	Appoint new contractor to workwith EPC main cont	5.71
Regulation	Takeover scope by PT. KPB	6.28	Appoint new contractor to workwith EPC main cont	0.16

TABLE XV: The Selection of the Best Alternative Solution

Alternative solution	Final score	Rangking
Terminate contractor & award new contractor	7.73%	Third
Takeover scope by PT. KPB	69.17%	First
Appoint new contractor	23.1%	Second

TABLE XVI: Consistency Ratio of Pairwise Comparison Criteria (Level-1)

Criteria (Level-1)	Row avrg.	Weight sum	Average value	λ_{max}	CI	CR
		Step-1	Step-2	Step-3	Step-4	Step-5
Schedule	0.26	2.77	10.65	5.4	0.1	0.09
Cost	0.24	1.26	5.25			
Complexity	0.1	0.32	3.2			
Bureaucracy	0.09	0.28	3.11			
Regulation	0.31	1.49	4.8			

TABLE XVII: CONSISTENCY RATIO OF PAIRWISE COMPARISON ALTERNATIVE SOLUTION (LEVEL-2)

Criteria (Level-2)	Alternative solution	Row average	Weight sum	Average value	λ_{max}	CI	CR
			Step-1	Step-2	Step-3	Step-4	Step-5
Schedule	Alt-1	0.07	0.21	3.0	3.05	0.025	0.048
	Alt-2	0.7	2.08	2.97			
	Alt-3	0.23	0.73	3.17			
Cost	Alt-1	0.08	0.24	3.0	3.09	0.045	0.086
	Alt-2	0.69	2.06	2.98			
	Alt-3	0.23	0.76	3.3			
Complexity	Alt-1	0.08	0.21	3.0	3.047	0.023	0.044
	Alt-2	0.69	2.02	2.93			
	Alt-3	0.23	0.77	3.21			
Bureaucracy	Alt-1	0.08	0.25	3.1	3.08	0.04	0.077
	Alt-2	0.69	1.97	2.85			
	Alt-3	0.23	0.8	3.3			
Regulation	Alt-1	0.08	0.24	3.0	3.1	0.05	0.096
	Alt-2	0.69	2.05	2.97			
	Alt-3	0.23	0.77	3.34			

Note: All consistency ratio <0.10, which represents that the judgement is consistent and generally acceptable.

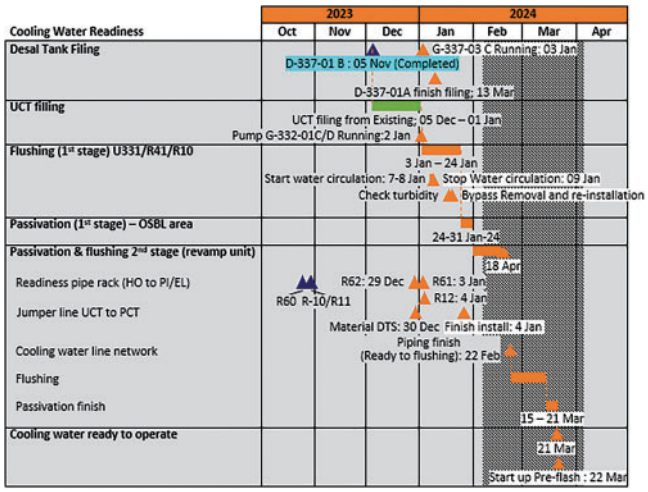

Fig. 16. Cooling water readiness plan schedule.

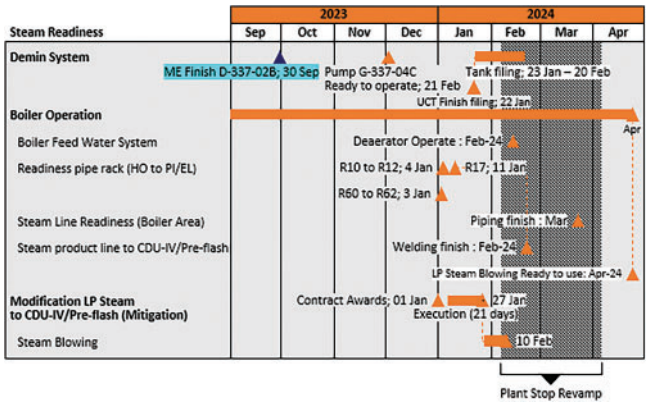

Fig. 17. Steam readiness plan schedule.

5. CONCLUSION AND RECOMMENDATION

5.1. *Conclusion*

Based on AHP Method, which has been conducted, take over scope of CONTRACT for remaining works by PT. Kilang Pertamina Balikpapan is the best alternative solution on how to recover the delayed progress of RDMP RU V Balikpapan Project whose score is 69.17% as shown on Table XV which considers Regulation as the most important criterion and it requires around USD 3.3 Million for the required remaining works to start-up Revamp Unit in terms of increasing capacity of RU V Balikpapan from 260 MBOPD to 360 MBOPD which covering:

a) Power Supply Readiness
b) Cooling Water Readiness
c) Steam Readiness
d) IA/PA/N2 Supply Readiness

5.2. *Recommendation*

For required works as mentioned in the conclusion, here are the following main readiness including its timeline which are required:

a) Power Supply Readiness, Fig. 15 shows the readiness timeline for the power supply.
b) Cooling Water Readiness, Fig. 16 shows the readiness timeline for the cooling water.
c) Steam Readiness, Fig. 17 shows the readiness timeline for the steam.

ACKNOWLEDGMENT

I dedicate this final assignment to my wife Kartini Rolitta Sibarani, my sons Shalom Mikhael Gamaliel Purba and Shiloh Gavriel Immanuel Purba, also all my family and my best friends and friends, which I cannot mention one by one because they are my loyal supporters in completing this journal paper.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

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