Refinery Project Database Automation through Standardized Multidimensional WBS: A Bidding Template Approach for EPC Project [1] [2]

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ABSTRACT

This study explores ways to strengthen project management practices in Amine Regeneration Unit (ARU) projects at a National Oil and Gas Company, particularly in addressing recurring cost and schedule overruns. The research centers on creating a standardized format for a multidimensional Work Breakdown Structure (WBS) and bidding template, designed to capture the essential project information needed for accurate and project-specific bids. A comparative method was applied, benchmarking the company's existing practices against the U.S. National Park Service's Construction Class A Cost Estimate Template. The approach involved formulating a structured WBS and examining the bidding process to design a more uniform and efficient framework. Findings indicate that adopting a standardized bidding template integrated with a detailed WBS can enhance project execution, reduce the risk of cost overruns, improve resource allocation, and foster clearer alignment of project requirements between Contractors and the Company. In addition, this framework is expected to serve as a foundation for database automation, strengthening front-end loading. Sustained improvements through performance monitoring and the establishment of KPIs will be essential to ensure long-term success.

Keywords: Standardized, Multidimensional WBS, OmniClass Table, Refinery Expansion, Amine Regeneration Unit, hydrogen sulfide (H2S), Database Automation, Artificial Intelligence, National Oil and Gas Company

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[2] This paper was originally prepared during a 6-month long Graduate-Level Competency Development/Capacity Building Program developed by PT Mitrata Citragraha and led by Dr. Paul D. Giammalvo to prepare candidates for AACE CCP or other Certifications. https://build-project-management-competency.com/our-faqs/

INTRODUCTION

A. Amine Regeneration Unit for Refinery Expansion and Grassroots Refinery Development in Indonesia

Indonesia has played an essential role in the global oil and gas sector for decades. In the past, the country was not only a major producer but also a significant exporter of crude oil and natural gas, with the industry serving as one of the key drivers of national economic growth. However, in recent years, Indonesia's oil and gas sector has faced the Energy Trilemma[3] challenges, three pillars associated with the country's macroeconomic situation in terms of economic development: energy security, energy equity, and sustainability[4]. Indonesia is carefully managing the energy trilemma to maintain economic development, with the current decline of oil production to approximately 650,000 barrels of oil per day (BOPD) and an increase in domestic consumption up to approximately 1,5 million BOPD. This shift has altered Indonesia's position in the global energy market, shifting the country from being a net oil exporter to a net importer. To address this challenge while aligning with its net-zero emission commitments, Indonesia is now prioritizing investments in green refinery expansion and the development of new grassroots refineries.

One of the primary challenges in refinery project design and development is managing Hydrogen Sulfide (H_2S). This gas is colorless, flammable, and highly toxic, and it commonly occurs in refinery operations. During the conversion of crude oil into products such as gasoline, diesel, and lubricants, impurities like H_2S are often generated. In addition, H_2S is typically present in off-gases from various process units. If released into the atmosphere, these sour gases can emit significant amounts of H_2S, creating serious risks for worker safety, equipment integrity, and the surrounding environment. Effective management of H_2S is therefore critical to maintaining safe and sustainable refinery operations.

Developing an Amine Regeneration Unit capable of absorbing and eliminating the risk of these off-gases is a mandatory requirement. The Amine Regeneration Unit will be required to strip H2S and CO2 from the Rich Amine with a Stripper. Sour Gas will be routed to the Sulphur Plant, while product amines (Lean Amine) will be recirculated to each process unit. Topsoe, as one of the technology providers, describes the process of ARU as follows:

[3] World Energy Council. (2024). *World Energy Trilemma 2024: Evolving with resilience and justice.* Retrieved from https://www.worldenergy.org/publications/entry/world-energy-trilemma-report-2024
[4] Marti, L. & Puertes, R. (2022). *Sustainable energy development analysis: Energy Trilemma.* Retrieved from https://www.sciencedirect.com/science/article/pii/S2773032822000074

When hydroprocessing units convert organic sulfur compounds into H2S, the H2S ends up in the sour off-gas for removal by absorption in an amine scrubber. The result is H2S-enriched amine pumped to the top of the amine regenerator column. Here, it is counter-currently contacted with hot vapor from the amine regenerator reboiler at the bottom of the column. The H2S is then stripped off and recovered from the top of the column, while lean amine with equilibrium amounts of H2S is recovered from the bottom. Reflux water is fed into the top of the column to absorb any amine carry-over in the rectification section (Topsoe, n.d.)[5]

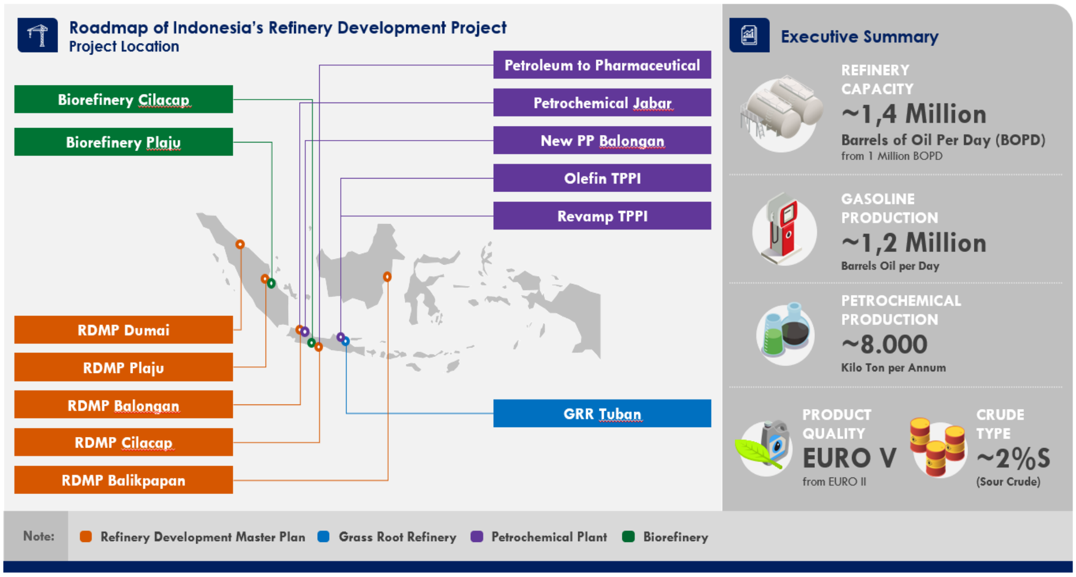

Figure 1 Roadmap of Indonesia's Refinery Development Project[6]

[5] Amine regeneration | Process licensing | Products | Topsoe. (n.d.). Topsoe. Retrieved from https://www.topsoe.com/our-resources/knowledge/our-products/process-licensing/amine-regeneration
[6] Pertamina. (2022). *Roadmap of Pertamina's refinery development project*.

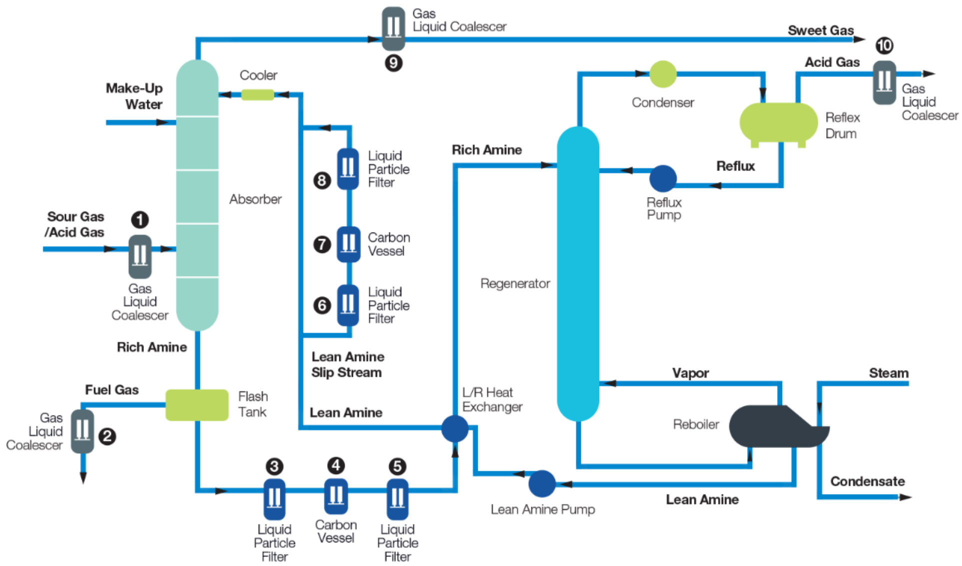

Figure 2 Illustration of how the Amine Regeneration Unit works[7].

Furthermore, incorporating this unit into the refinery development project is crucial, given that the quantity of H2S present in the refinery process will increase directly with the expansion of the refinery's capacity. From the perspective of health, safety, and the environment, the new refinery would not have been operational without the completion of this unit. It is, therefore, essential to manage the construction planning and methodology effectively to ensure smooth construction execution to result in the OTOBOSOR (On Time, On Budget, On Specification, On Regulation) target.

B. Challenges in Project Management

Oil and gas refinery projects and mega projects face significant challenges in project management before and during execution, according to a study from McKinsey & Company in 2015[8], 98% of projects incur cost overruns or delays, with the average cost increase being 80% of the original value. The average slippage is 20 months behind the original schedule.

According to AT Kearney, in 2017[9] 6 out of 10 projects experienced over-budget and behind schedule, including 100 major global companies in the oil and gas, chemicals,

[7] Amine sweetening | Gas sweetening | Jonell systems. (2020, July 27). Jonell Systems. https://www.jonellsystems.com/industries/oil-gas/amine-sweetening/
[8] Changali, S., Mohammad, A., & van Nieuwland, M. (2015). *The construction productivity imperative*. McKinsey & Company. Retrieved from https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-construction-productivity-imperative
[9] ATKearney. (2017). *Excellence in capital projects: a goal yet to be achieved.* Retrieved from https://kearney.com/energy/article/-/insights/excellence-in-capital-projects-a-goal-yet-to-be-achieved

metals, mining, and utility industries. Leading companies have adopted measures to address underperformance. Subsequently, there is an obligation to identify the optimal forms and methodologies for embedded best practices and disciplined execution, with the objective of ensuring the project's success. In addition, it also shows that 60% of capital projects experience a 10% cost and schedule overrun, and around 30% experience cost and schedule overruns of up to 25%.

Indonesian National Oil Company is also experiencing the same, where from 45 sample projects, at least about 56% of projects incur 10% cost and schedule overrun, and 36% of projects incur cost and schedule overrun up to 25%[10]. In addition, according to Zain[11], of 95 pier projects in the National Oil Company, 97.9% are over budget and behind schedule. Only two projects are on budget but still behind schedule.

A survey conducted by PwC in 2014 identified the three primary causes of project failure or overrun since 2004. These were found to be changes in project scope during the course of the project (41%), inaccurate estimates made during the planning phase (39%), and insufficient resources (30%). These results show that poor scope management, cost estimation, schedule, and construction execution plan lead the project to fail or overrun.

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[10] Wisnugroho, J. (2020). *Indonesia Oil & Gas Cost Estimating vs International "Best-Tested and Proven" Practices – A Benchmarking Study*; *PM World Journal*, Vol. IX, Issue II, February.
[11] Zain, R. A. (2024). *Developing Parametric Modelling for Class 4 Estimate of Pier and Jetty Construction by Analyzing Historical Databases using AI Tools & EVM Techniques*; *PM World Journal*, Vol. XIII, Issue IV, April.

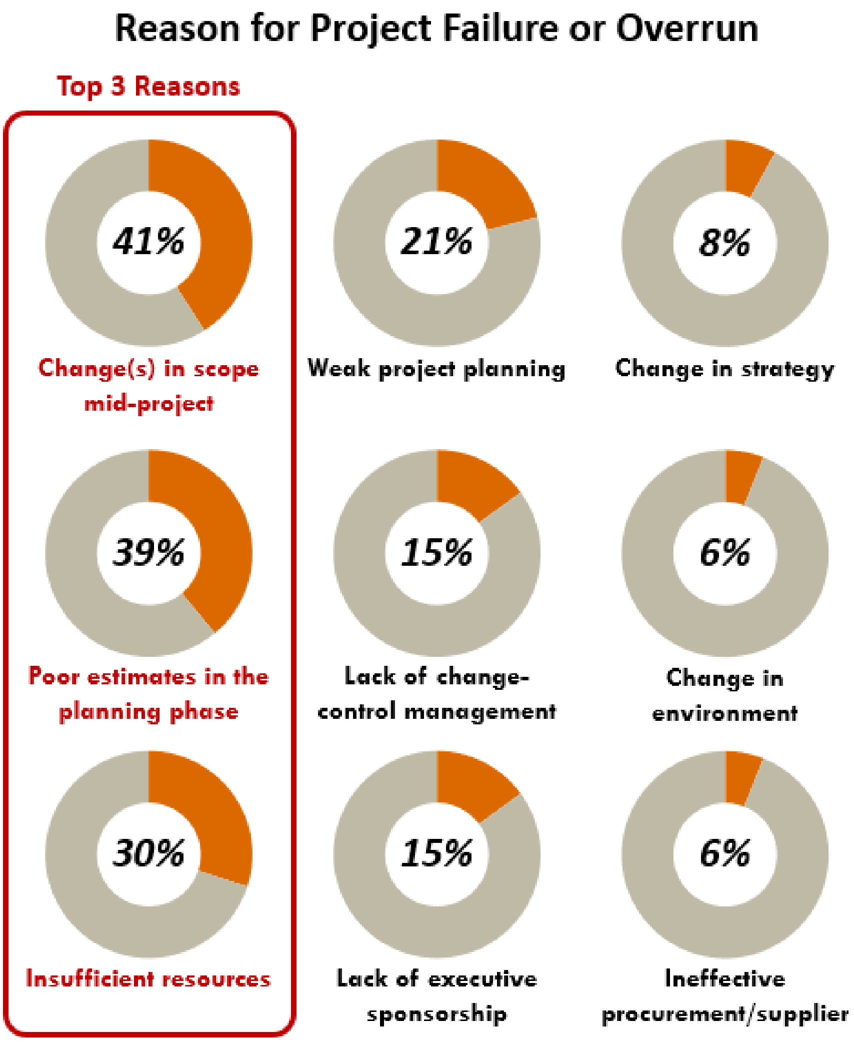

Figure 3 Reasons for project failure or overrun[12]

C. Standardized WBS & Bidding Template in Refinery's Amine Regeneration Unit (ARU) Project

The overall project management execution, whether in oil and gas, utilities, chemical, or metals and mining, companies face similar performance challenges. To optimize their project concept and design, cross-functional collaboration, standardization of design, and

[12] PricewaterhouseCoopers. (2014). *Project management: improving performance reducing risk*. Retrieved from https://www.pwc.com/jg/en/publications/ned-presentation-project-management.pdf

modularization shall be the main focus.[13] Standardization can save costs, time, and scope variations, and can be used across functions or similar projects.[14]

The implementation of scope management enables project managers to respond effectively when a project encounters difficulties in meeting its schedule, budgetary constraints, or quality standards during the execution phase. Scope management can also minimize project changes and budget omissions and improve the accuracy of project cost estimates and risk responses. For scope management to be effective, it must rely on a robust work breakdown structure (WBS)[15].

WBS is a structure that separates the project into manageable work packages, components, or WBS elements to provide a standard mechanism for scheduling scope, costs, distribution of responsibilities, communication, risk assessment, monitoring, and control. The standardized WBS could help to build a reliable database that people can refer to when a product occurs repeatedly. This could help erase one of the significant causes of cost overrun, which is to omit probable scope from the estimate and omit probable risk from the analysis.[16]

A standardized and proper Bidding Template could also help the companies in such ways as follows:

a) Project costs can be better managed to stay within previously authorized and appropriate limits.
b) Project costs and scope changes will be easier to manage and track through the planning, design, and construction process.
c) Increasing the reliability of early cost estimates can reduce the redesign activities necessary to bring projects within budget.
d) Rely on project planning to control and manage performance. Integrating the planning process is essential to managing the relationship between cost, time, and scope. Coordinating cost, time, and scope requirements is the path to achieving project success.

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[13] ATKearney. (2017). *Excellence in capital projects: a goal yet to be achieved.* Retrieved from https://kearney.com/energy/article/-/insights/excellence-in-capital-projects-a-goal-yet-to-be-achieved
[14] Changali, S., Mohammad, A., & van Nieuwland, M. (2015). *The construction productivity imperative*. McKinsey & Company. Retrieved from https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-construction-productivity-imperative
[15] Cerezo-Narváez, A., Pastor-Fernández, A., Otero-Mateo, M., & Ballesteros-Pérez, P. (2020). Integration of cost and work breakdown structures in the management of construction projects. *Applied Sciences*, *10*(4), 1386. https://doi.org/10.3390/app10041386
[16] 1.4.1.10 unit 10-Managing cost estimating and budgeting. (2022, October 24). PTMC. Retrieved from https://build-project-management-competency.com/1-4-1-10-unit-10/

e) Improved estimate documentation will improve review efficiencies and shorter review cycle times.
f) Facilitate the development and maintenance of The Company's cost database. We can use this to establish a baseline and assist in planning and estimating future projects.[17]

In this paper, the author will develop a standardized WBS & Bidding Template for the refinery's Amine Regeneration Unit (ARU) project in the National Oil Company that can fulfill these plans:

1) Develop a suitable Work Breakdown Structure (WBS) / Cost Breakdown Structure (CBS) for the refinery's Amine Regeneration Unit (ARU) project that covers all aspects and phases of the project, allowing various stakeholders to utilize it for cost estimation and scheduling.

2) Create the bidding templates for the refinery's Amine Regeneration Unit (ARU) project to obtain the "best tested and proven practices" and develop specific recommendations to improve the National Oil Company's bidding template.

METHODOLOGY

The author will develop a methodology referring to the procedure described by Sullivan[18] in Figure 4.

As shown in Figure 4, every research that follows the methodology of scientific work must have 4 points as follows:

1. **Problem recognition** is the step to provide a clear description of the fundamental problem; this step is followed by refining the Research Paper Question to break it down into more specific issues.

2. **Development of the Feasible Alternatives** is a verification process using other researchers to review results by replicating the experiment and assessing its soundness to develop a range of alternative possibilities.

[17] National Park Services. (2023). *Construction Cost Estimating Requirements Handbook*. National Park Service (NPS) - Denver Service Center (DSC).
[18] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2019). Chapter 2 Cost Concepts and Design Economics. In *Engineering Economy Global Edition* (17th ed.). Pearson UK.

3. **Development of the Outcomes** and Cash Flows for each alternative accurately describes the methods and tools utilized for data gathering.

4. **The selection of a Criterion** explains how the raw data is compiled and analysed.

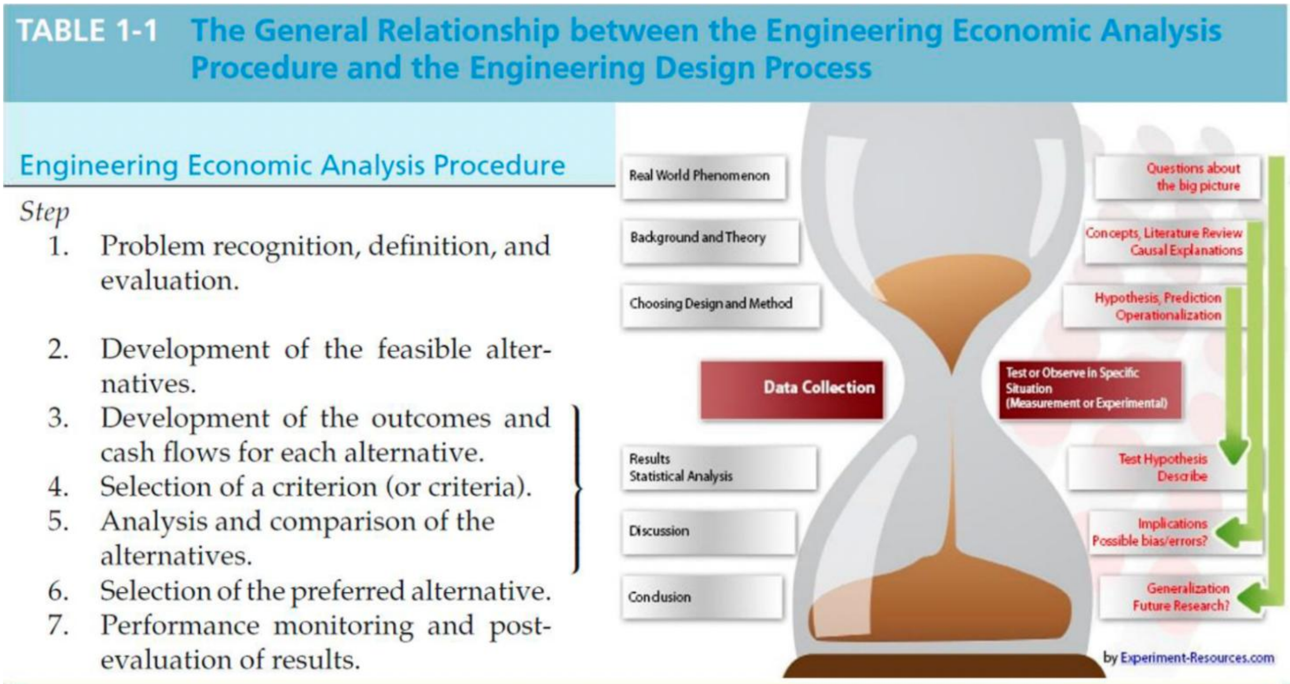

Figure 4 Engineering Economic Analysis Procedure & Step of the Scientific Process[20]

5. **Analysis and Comparison of the Alternatives** is a thorough analysis and comparison of the feasible alternatives performed using the established criteria.

6. **Selection of the preferred alternative** is where a decision is made to choose the most suitable or preferred alternative that aligns with the project's goals and criteria.

7. **Performance monitoring and post-evaluation** results will be carried out after implementation to determine the performance and understand the effectiveness of the selected alternative.

[20] Martyn Shuttleworth (2008). What is Research? Retrieved from: https://explorable.com/what-is-research

Step 1 - Problem Definition

According to Zilikram,[19] "Out of 48 projects in the Company, only 21% did not experience project overrun, 73% experienced up to 25% project overrun, and 6% experienced above 25% project overrun. The Company experienced more schedule overruns than cost overruns."

National Oil & Gas Company's present project management strategies could run across challenges compromising its effectiveness and efficiency. One of these challenges could be insufficient knowledge of the project's scope, responsibilities, deadlines, and expenses, which could cause possible delays, budget overruns, and poor resource use. Integrating Cost Breakdown Structure (CBS) and Work Breakdown Structure (WBS) approaches into the National Oil & Gas Company project management systems could help to solve these problems and raise project management effectiveness. [20]

WBS is a Decision Support Package (DSP) component that must be prepared before entering the gate after the defining phase (phase 4), as shown in **Figure 5**. Referring to this minimum requirement in phase 4, making a standardized format for the Amine Regeneration Unit (ARU) Project Bidding Template, which stemmed from the standardized WBS for said assets, is urgent.

[19] Zilikram, M. F. (2023). Benchmarking Indonesia's Downstream Oil & Gas Construction: Evaluating Project Scheduling and Cost Estimating Processes Against Global "Best-Tested and Proven" Practices. PM World Journal, 12(10).

[20] Sukmono, C. (2023). Enhancing Project Management Efficiency in PERTAMINA through Work Breakdown Structure (WBS) and Cost Breakdown Structure (CBS) Integration. In *PM World Journal* (pp. 2330–4480).

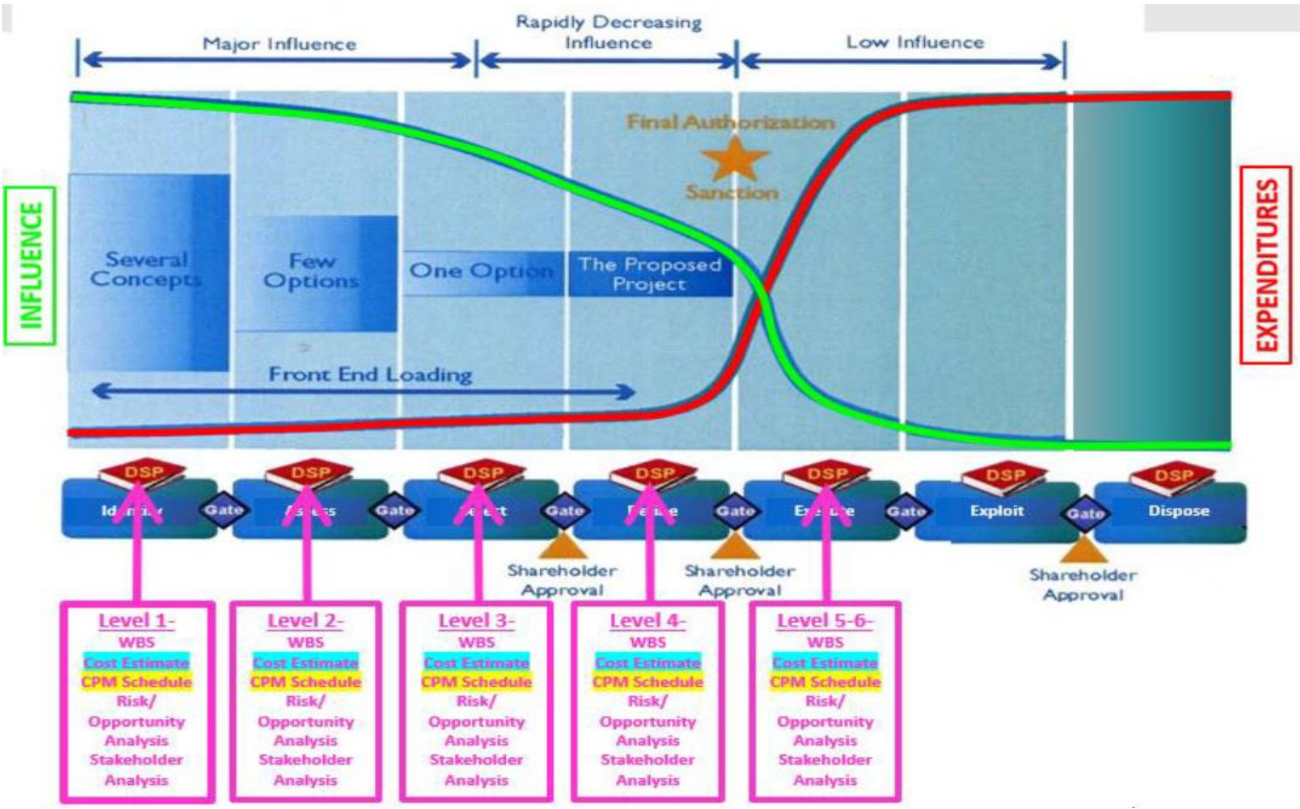

Figure 5 Decision Support Package (DSP) Information (MacLeamy, Paulson, or Boehm Curve) [21]

Before developing a standardized WBS, it's essential to understand the type of databases to be used and the differences between flat files, relational databases, and object-oriented databases. "Flat files, also known as a text database, store data in plain text format and are organized as a single table with no relationships between tables. Meanwhile, a Relational Database is a type of database that stores and organizes data in a collection of tables; these tables are related to each other using a common field known as a primary key. Relational databases are used to store, organize, and retrieve data quickly and efficiently, so they are now the most common database used in business applications". [22]

While the relational database is robust, performance may become challenging with extensive databases or complex queries involving multiple table joins. However, due to

[21] Giammalvo, P. D. (2021). The Bigger Picture: Project Life Cycles from a Broader, Real-World Perspective. PM World Journal, 10(6). https://pmworldlibrary.net/wp-content/uploads/2021/06/pmwj106-Jun2021-Giammalvo-the-bigger-picture-commentary.pdf
[22] *Relational database vs flat file (Differences & similarities)*. (2023, January 24). DatabaseTown. https://databasetown.com/relational-database-vs-flat-file-differences-similarities/

their rigid schema, highly structured relational databases have limited scalability and flexibility.[23]

Therefore, an object-oriented Database is preferable and could perform better for more extensive and complex data. Object-oriented Databases store data in objects rather than tables. An object in an Object-oriented Database signifies a real-world entity encompassing data (attributes) and operations (methods) that can interact with that data.[24] For those benefits, an Object-oriented by Multidimensional WBS will be developed.

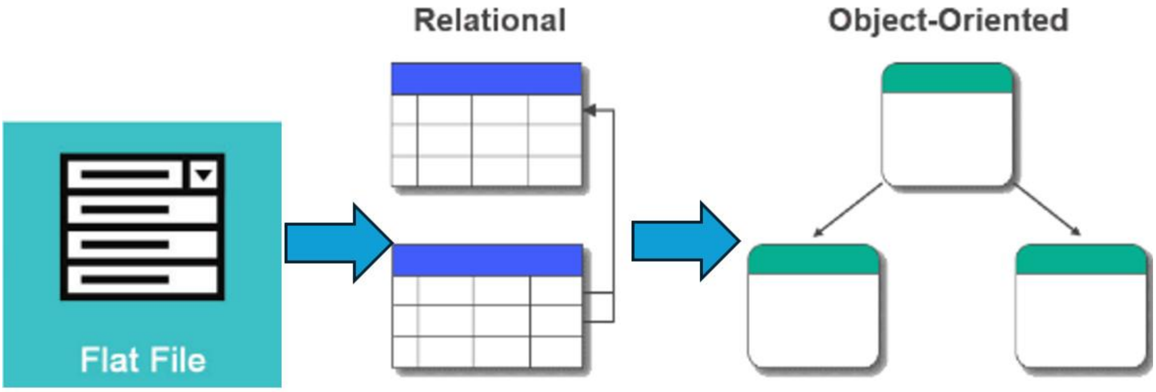

Figure 6 The Difference between Flat File, Relational Database, and Object-Oriented Database [25]

The WBS is not limited to only three dimensions. It can be shown in 4, 5, 6, or more dimensions. Using multiple dimensions lets us perform sorts that show each stakeholder what information is essential to them. When we develop the WBS in any project, particularly in construction, the WBS must respond to eight potential questions from our stakeholders (**Figure 7**). One possible solution to this issue is to use Tesseract.

This Tesseract analogy will enhance BIM to "develop accurate project requirements, provide an improved understanding of building projects and the process of linking additional data dimensions to building models, and give real-time and centralized information to project stakeholders."[26] In practice, it is feasible to model every aspect of

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[23] Bansal, M. (2024, September 04). *Difference between RDBMS and OODBMS*. GeeksforGeeks. https://www.geeksforgeeks.org/difference-between-rdbms-and-oodbms/
[24] Obregon, A. (2024, February 26). *Object-Oriented Database vs. Relational Database — A Beginner's Guide*. Medium. https://medium.com/@AlexanderObregon/database-vs-relational-database-a-beginners-guide-86cc4e8357ad
[25] EDUCBA. (2023, March 13). *Relational database vs. flat file*. https://www.educba.com/relational-database-vs-flat-file/
[26] News Desk. (2024, May 21). *What are bim dimensions? 2d, 3d, 4d, 5d, 6d, 7d and even 8d*. SurveyingGroup. https://www.surveyinggroup.com/what-are-bim-dimensions-2d-3d-4d-5d-6d-7d-and-even-8d/

a construction site and visualize it realistically, aided by advanced technologies like virtual reality (VR), augmented reality (AR), or mixed reality (MR).[27] AR, VR, and MR can virtually bring key personnel to any job site, enabling more people to be present without needing travel or physical interaction, reducing risks and logistical challenges.

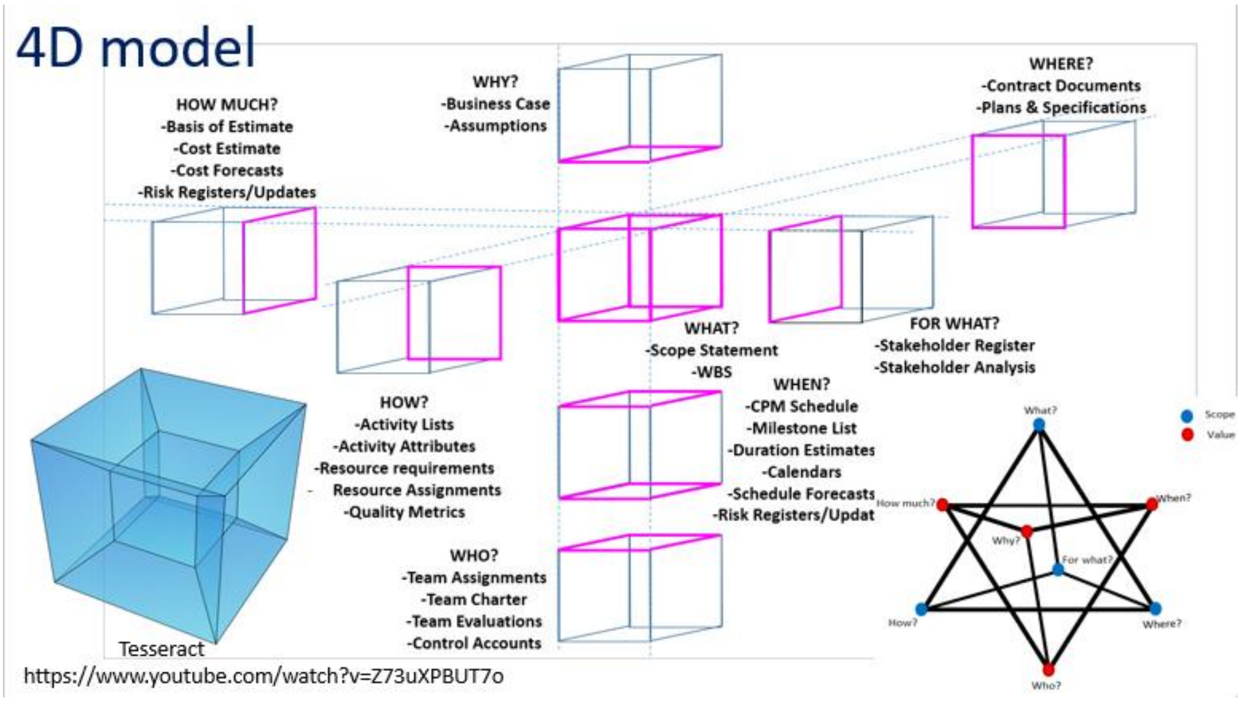

Figure 7 The Tesseract and the Eight Questions to be answered if asked by our stakeholders [28] [29]

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[27] Editorial Team. (2021, November 26). *8D BIM: what is it and what are its benefits?* BibLus. https://biblus.accasoftware.com/en/8d-bim-what-is-it-and-what-are-its-benefits/
[28] Leynaud, X., Giammalvo, P. D., & Moine, J. Y. (2019). Multi-Dimensional Project Breakdown Structures - The Secret to Successful Building Information Modeling (BIM) Integration. *DCB Publishing*.
[29] Arba, D. (2021). Best Tested and Proven Practices for Hospital Construction: Standardized Multidimensional WBS/CBS Coding Structures. *PM World Journal*, *10*(2). https://pmworldlibrary.net/wp-content/uploads/2021/02/pmwj102-Feb2021-Arba-standardized-multidimensional-wbs-cbs-for-hospital-construction.pdf

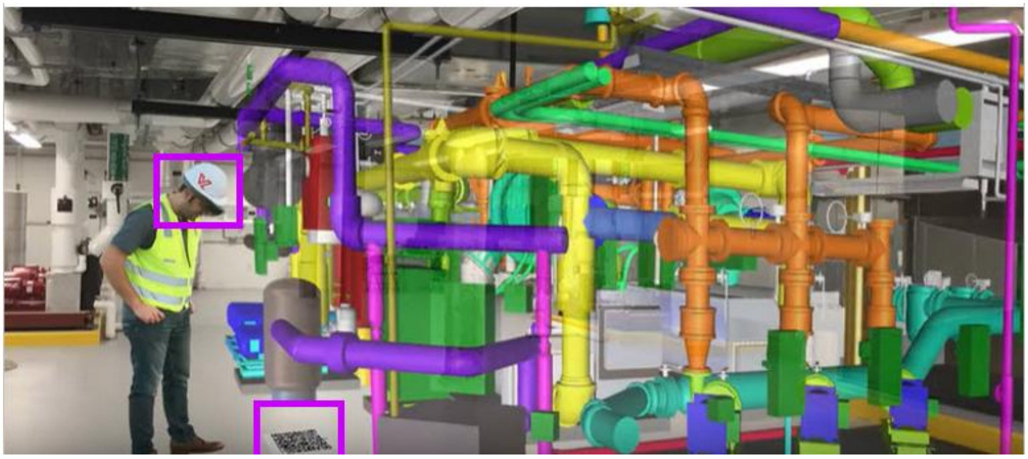

Figure 8 The example of using Augmented Reality in Piping Construction

This multi-dimensional WBS refers to the Tesseract analogy, where tasks and deliverables organize work and additional factors like time, cost, risk, and resources (see Figure 9).[30] Organizations can significantly enhance project performance and results using the object-oriented multi-dimensional WBS.

Figure 9 Multi-dimensional WBS in Project Management [31]

[30] Andrian, Y. P. (2024). Building an Econometrics Model for Pier Construction in an Indonesian Oil and Gas Company; *PM World Journal*, Vol. XIII, Issue IV, April. https://pmworldlibrary.net/wp-content/uploads/2024/04/pmwj140-Apr2024-Andrian-building-an-econometrics-model-for-pier-construction.pdf
[31] Leynaud, X., Giammalvo, P. D., & Moine, J. Y. (2019). Multi-Dimensional Project Breakdown Structures - The Secret to Successful Building Information Modeling (BIM) Integration. *DCB Publishing*.

This is why OmniClass offers 15 hierarchical tables, each representing a different facet of construction information. Each table can be used independently to classify a particular type of information or entries, and it can be combined with entries on other tables to classify more complex subjects.[32] [33]

They are set up as relational or object-oriented databases; we can sort of sub-sort by any combination of 866 of the 15 Tables. There is no rigid hierarchy or order between the 15 Tables.[34] The 15 OmniClass tables are shown in **Error! Reference source not found.** with their explanation.

[32] Omniclass. (2020). *About Omniclass™*. Construction Specifications Institute. https://www.csiresources.org/standards/omniclass/standards-omniclass-about
[33] Vyčítal, M. (2019). *On BIM based automatized and modelling for construction management* [Doctoral dissertation]. https://core.ac.uk/download/326321885.pdf
[34] Giammalvo, P. D., & PTMC. (2021, October 14). *1.4.1.4 Unit 4- Managing scope*. https://build-project-management-competency.com/1-4-1-4-unit-4/

Table 1 The 15 interrelated OmniClass tables with their explanation [35]

OmniClass™ Table		Description
Table 11	**Construction Entities by Function**	Construction Entities by Function are significant, definable units of the built environment comprised of elements and interrelated spaces and characterized by function.
Table 12	**Construction Entities by Form**	Construction Entities by Form are significant, definable units of the built environment comprised of elements and interrelated spaces and characterized by form.
Table 13	**Spaces by Function**	Spaces by Function are basic units of the built environment delineated by physical or abstract boundaries and characterized by function.
Table 14	**Spaces by Form**	Spaces by Form are basic units of the built environment delineated by physical or abstract boundaries and characterized by physical form.
Table 21	**Elements**	An Element is a major component, assembly, or "construction entity part which, in itself or in combination with other parts, fulfills a predominating function of the construction entity"
Table 22	**Work Results**	Work Results are construction results achieved in the production stage or phase or by subsequent alteration, maintenance, or demolition processes and identified by one or more of the following: the particular skill or trade involved; the construction resources used; the part of the construction entity which results; the temporary work or other preparatory or completion of work which is the result.
Table 23	**Products**	Products are components or assemblies of components for permanent incorporation into construction entities.
Table 31	**Phases**	For purposes of usage in OmniClass™ classifications, a Stage is a higher-level of categorization and a Phase is a subordinate level of titling within a Stage. - Stage: A categorization of the principal segments of a project. Stages usually are: Conception, Project Delivery Selection, Design, Construction Documents, Procurement, Execution, Utilization, and Closure. - Phase: A portion of work that arises from sequencing work in accordance with a predetermined portion of a Stage.
Table 32	**Services**	Services are the activities, processes and procedures relating to the design, construction, maintenance, renovation, demolition, commissioning, decommissioning, and all other functions occurring in relation to the life cycle of a construction entity.
Table 33	**Disciplines**	Disciplines are the practice areas and specialties of the actors (participants) that carry out the processes and procedures that occur during the life cycle of a construction entity.
Table 34	**Organizational Roles**	Organizational Roles are the functional positions occupied by the participants, both individuals and groups, that carry out the processes and procedures which occur during the life cycle of a construction entity.
Table 35	**Tools**	Tools are the resources used to develop the design and construction of a project that do not become a permanent part of the facility
Table 36	**Information**	Information is data referenced and utilized during the process of creating and sustaining the built environment.
Table 41	**Materials**	Materials are substances used in construction or to manufacture products and other items used in construction.
Table 49	**Properties**	Properties are measurable or definable characteristics of construction entities.

The Standardized WBS of the Amine Regeneration Unit (ARU) Project from OmniClass Tables 11, 22, 23, 31, 32, 33, and 41, as shown in **Figure 10**, and its details can be seen

[35] Omniclass. (2020). *About Omniclass™*. Construction Specifications Institute. https://www.csiresources.org/standards/omniclass/standards-omniclass-about

in Appendix 1, along with the details of WBS Elements from OmniClass Tables in Appendix 2.

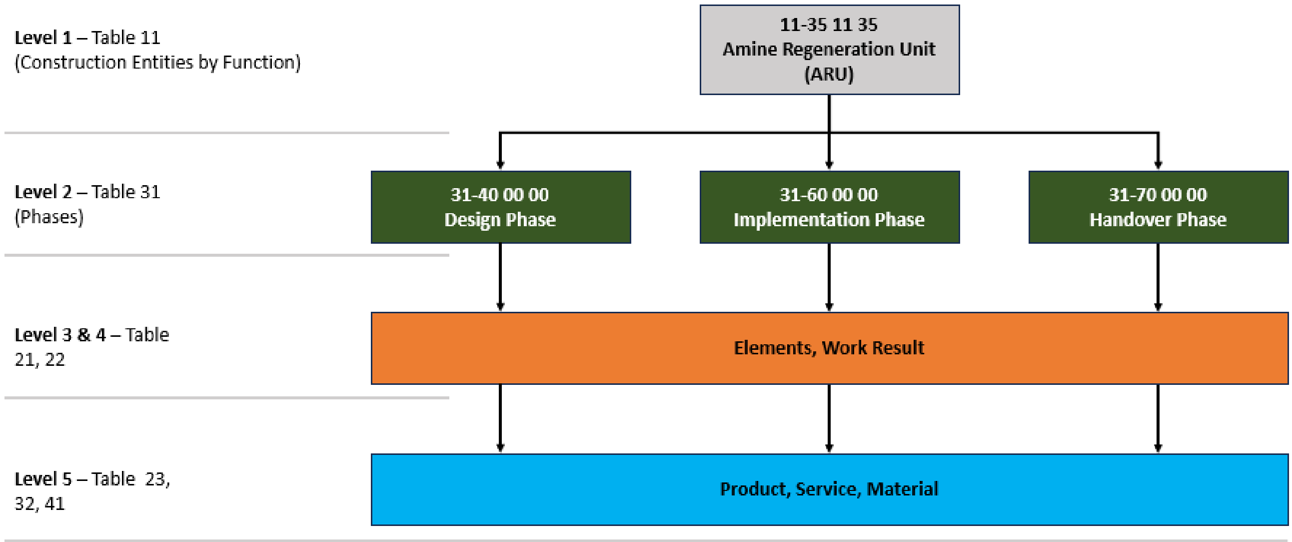

Figure 10 Standardized WBS Level from OmniClass for Amine Regeneration Unit (ARU) Project [36]

Based on the Company's current practices, all bidding activities conducted at Class 2 Estimate Class, where the maturity level of project definition deliverables is already around 30-75% refer to AACE Recommended Practice 18R-97.

[36] By Author

Table 2 Cost Estimate Classification Matrix for Process Industries [37]

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges at an 80% confidence interval
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

As detailed in Table 2 above, all WBS necessary for the Amine Regeneration Unit (ARU) Project shall be reorganized and integrated into the Company's standard bidding template. The Company's bidding template typically categorizes each project's scope of work into specific disciplines, such as Civil Worker, Structure, Mechanical, Electrical, and Instrumentation. Meanwhile, Project Management, HSE, and Engineering activities are categorized as Preparation Work, as shown in Figure 11Figure *11*.

The Company's workflow for preparing the bidding template is outlined as follows:

1. Define project assets within the approved scope.
2. Develop a Work Breakdown Structure (WBS) in flat-file format, organized by discipline.
3. Estimate resources for each WBS element, classified into materials and services.
4. Document asset-specific technical and commercial requirements.
5. Apply profit and risk allowances in accordance with internal estimating guidelines, scaled to overall project value.

Organizing the Work Breakdown Structure (WBS) at the top level (level 1) by disciplines has presented challenges in tracking project resources and facilitating the bidding

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[37] AACE International. (2020). *AACE International Recommended Practice No. 18R-97 Cost Estimate Classification System – As Applied in Engineering, Procurement, And Construction for The Process Industries*

process. This approach needs to demonstrate the number of resources required for each asset. Consequently, it hinders the accurate calculation of asset costs and limits the reproduction of these calculations.

Bill of Quantity/BoQ
Project Title
Revision ... Date ....

No	Work Detail	Volume	Units	Unit Price		Total Price	
				Material	Services	Material	Services
I.	PREPARATION WORK						
1	Mobilitation and Demobilitation	xxx	xx	0	$	0	$
2	Permit & Engineering	xxx	ls	0	$	0	$
3	....	xxx	ls	0	$	0	$
	Total I					0	$
II	CIVIL WORK						
1	Conrete	xxx	xx	$	$	$	$
2	....	xxx	xx	$	$	$	$
	Total II					$	$
III	MECHANICAL						
1	Piping	xxx	xx	$	$	$	$
2	....	xxx	xx	$	$	$	$
	Total II					$	$
IV	CLOSING						
1	Commissioning & Testing	xxx	xx	0	$	0	$
2	....	xxx	xx	0	$	0	$
	Total IV					$	$
		SUM OF MATERIAL + SERVICES (I+II+III+IV)				$	$
		CONTRACTOR PROFIT AND RISK (8% OR 10% OR 15%)					$
		TOTAL					$

Figure 11 The Company's Bidding Template[38]

Step 2 – Development of the Feasible Alternative (US-National Park Service Bidding Template)

The US National Park Service (NPS) is a bidding template that understands the Contractor's scope perspective quite well and will be the best example for the Company. The bidding template that the NPS uses is the template format for cost estimation, which they urge all estimators to follow according to its usage. Based on Table 3 below, the US NPS Cost Estimation Handbook classified the estimation classes into three class levels: C, B, and A. These classifications are determined by the level of design detail/project definition underlying the estimate. The definition of each class is as follows[39]:

[38] Ardiansyah. (2017). *Indonesian State-Owned Oil and Gas Company Cost Estimating against GAO and NPS Best Practice: A benchmarking study*. PM World Journal, VI(XI), 24–44. https://pmworldlibrary.net/wp-content/uploads/2017/11/pmwj64-Nov2017-Ardiansyah-indonesian-cost-estimating-against-gao-and-nps-best-practices.pdf
[39] Pradibta, I. (2024). *Developing a Standardized, Multidimensional WBS/CBS Coding Structure for Storage Tanks*; PM World Journal, Vol. XIII, Issue III, March. https://pmworldlibrary.net/wp-content/uploads/2024/03/pmwj139-Mar2024-Pradibta-Standardized-Multidimensional-WBS-CBS-for-Storage-Tanks.pdf

1. Class A Construction Cost Estimate

Class A Construction Cost Estimates, often called **actual estimates**, apply when the work scope (WBS) definition is around 65 to 100%. These estimates are achievable with 100% Draft Construction Documents (Draft CD), 100% Complete Construction Documents (Complete CD), or Final Construction Documents. Their accuracy ranges from -3% to +10%.

Table 3 US NPS Estimate Classification and Accuracy[40]

Department of the Interior **DOI Estimate Type**	**AACE Class**	**Typical Use**	**End Usage**	**Project Definition**	**Low Expected Accuracy**	**High Expected Accuracy**
Class C	Class 5	Predesign	Concept Screening	0% to 2%	-20%	+50%
Class C	Class 4	Schematic Design	Study or Feasibility	1% to 15%	-15%	+30%
Class B	Class 3	Schematic Design	Budget Authorization	10% to 40%	-10%	+20%
Class B	Class 2	Design Development	Control	30% to 75%	-5%	+15
Class A	Class 1	Construction Documents	Check Estimate	65% to 100%	-3%	+10

2. Class B Construction Cost Estimate

Any cost estimate could fall into this Class B cost estimate, usually known as **budgetary estimates**, if the Statement of Work (SOW) definition is around 10 to 75%. The minimum design shall be as follows: Schematic Design (SD) submittal of the preferred design alternative, Design Development (DD) submittal, or other intermediate design level for budget purposes. Class B estimates have an accuracy range of -10 % to +20%.

3. Class C Construction Cost Estimates

Class C Construction Cost Estimates, often called **conceptual estimates**, are rough estimates (0% to 15%) that provide a general idea of the services or assets involved, along with their business case. The estimates inferred from various factors such as General Management Plans (GMP), Condition Assessments Cost (CAC) estimates using FMSS and CESS, Preliminary cost estimates for project initiation and entry into the Project Management Information System (PMIS), Pre Design (PD) programming

[40] National Park Services. (2023). *Construction Cost Estimating Requirements Handbook*. National Park Service (NPS) - Denver Service Center (DSC).

estimates to develop project scope and validate PMIS Estimate, and Schematic Design (SD) concept estimates for comparing design alternatives in Value Analysis studies during the early Schematic Design Phase. Class C estimates can be accurate within -20 % to +50% range**.**

Considering various resources[41], the Class A Construction Cost Estimate Format is the most appropriate estimation class, incorporating the Contractor's Point of View on the scope of work. This implies that most of the resources required for the asset are explicitly identified and predetermined. Table 4 shows the template the US National Park Service uses for estimating projects at the Class A level.

Table 4 US National Park Services Bidding Template (Class A Construction Cost Estimate) [42]

Bid Item No.	Bid Item Description	Total Material Cost	Total Labor Cost	Total Equipment Cost	Total Direct Construction Costs	Design Contingency	General Conditions	General Contractor Overhead	General Contractor Profit	Contracting Method Adjustment	Inflation Escalation	Bid Item Total
						0,00%	0,00%	0,00%	0,00%	0,00%	APR 0,00% / Months 0	
Bid Item: 1	Asset / Project Element 1					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
Total - Bid Item 1	Asset / Project Element 1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bid Item: 2	Asset / Project Element 2					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
Total - Bid Item 2	Asset / Project Element 2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bid Item: 3	Asset / Project Element 3					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
Total - Bid Item 3	Asset / Project Element 3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bid Item: 4	Asset / Project Element 4					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
Total - Bid Item 4	Asset / Project Element 4	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bid Item: 5	Asset / Project Element 5					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
	WBS L2 WBS Description	$ -	$ -	$ -	$ -							
Total - Bid Item 5	Asset / Project Element 5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total Bid Items 1-6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Step 3 – Development of the Outcome of The Alternative

Based on the analysis of the information provided in Steps 1 and 2, a fundamental distinction emerges between the US NPS Bidding Template and the Company's current Bidding Template, especially in how the bidding template organizes the Work Breakdown Structures (WBS). The US NPS Bidding Template categorizes all WBS under their respective assets or services. Meanwhile, the Company’s Bidding Template categorizes

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[41] 1.4.1.4 unit 4- Managing Scope. (2021). PTMC. https://build-project-management-competency.com/1-4-1-4-unit-4/.

[42] National Park Service. (2021, May 27). Class A Construction Cost Estimate Template. NPS.gov (U.S. National Park Service). https://www.nps.gov/dscw/upload/ClassAConstructionCostEstimate_Template_5-27-21.xlsx

WBS under its discipline. This difference may hold significant implications when considering the preferences of stakeholders.

While the Company's Bidding Template structure may be suitable for those seeking discipline-specific information, it could be better for effective communication between the Contractor and the Company. Therefore, with its asset- or service-based organization, the US NPS Bidding Template is deemed more intuitive and advantageous.

Given these considerations, the Author concludes that the US NPS Bidding Template, aligned with the US NPS Class A Construction Cost Estimate format, is preferable for the Amine Regeneration Unit (ARU) Project.

Step 4 – Selection of the Criteria

As explained, the US NPS Class A Construction Cost Estimate format organizes all Work Breakdown Structures (WBS) under the respective assets or services, as follows: the detailed list of these services and corresponding assets for the Amine Regeneration Unit (ARU) Project.

Table 5 Amine Regeneration Unit (ARU) Project Scope of Works[43]

Group of Attributes	Purposes	Criteria
Design / Engineering	These attributes are designed to evaluate whether the WBS standard comprehensively describe the work package required for the Amine Regeneration Unit (ARU) during the design phase.	Surveying
		Soil Investigation
		Design
		Drawing
Implementation / Construction	These attributes consist of essential components / elements that must be meticulously constructed and inspected during the construction phase. It aims to evaluate whetеher the WBS standard meet these specific attributes. These represent fundamental criteria that the WBS should fulfill.	Civil Work
		Static Equipment
		Rotating Equipment
		Piping
		Insulation
		Electrical Equipment
		Instrument & Control Equipment
Commissioning	These attributes consist of activities required for final testing that must be fulfilled at commissioning and handover phase	Hydrotest
		Pressure Test
		Loop Check Test

[43] By Author

FINDINGS

Step 5 – Analysis of Each Criterion

Following the development of the OmniClass WBS system of Work Breakdown Structure (WBS), as shown in Figure 10 (Details can be seen in Appendix 1), and the comprehensive list of all components (Appendix 2) for the Amine Regeneration Unit (ARU) Project, the author integrated those databases into a Bidding Template, a standardized document designed to facilitate bidding processes. Refer to the NPS Standard Bidding Template, as shown in Table 6**Error! Reference source not found.**.

This bidding template is an essential document for both Companies and/or Contractors during the bidding process. Utilizing this standardized bidding template will provide a comprehensive overview of the project requirements, enabling contractors to understand the scope of work and develop the commercial bid proposal in the same way as the other bidders. Thus, it will ensure transparency and competitiveness among the bidders.

Table 6 Bidding Template for Amine Regeneration Unit (ARU) Project [44]

Bid Item No.	Bid Item Description	Total Material Cost	Total Labor Cost	Total Equipment Cost	Total Direct Construction Costs	Design Contingency	General Conditions	General Contractor Overhead	General Contractor Profit	Contracting Method Adjustment	Inflation Escalation	Bid Item Total
						0,00%	0,00%	0,00%	0,00%	0,00%	APR 0,00% / Months 0	
Bid Item: 1	Engineering / Design Phase					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	33-21 31 Civil	$ -	$ -	$ -	$ -							
	33-21 31 17 Mechanical	$ -	$ -	$ -	$ -							
	33-21 31 24 Process	$ -	$ -	$ -	$ -							
	33-21 31 21 Electrical	$ -	$ -	$ -	$ -							
Total - Bid Item 1	Engineering / Design Phase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bid Item: 2	Construction / Implementation Phase					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	33-21 31 Civil	$ -	$ -	$ -	$ -							
	33-21 31 17 Mechanical	$ -	$ -	$ -	$ -							
	33-21 31 24 Process	$ -	$ -	$ -	$ -							
	33-21 31 21 Electrical	$ -	$ -	$ -	$ -							
Total - Bid Item 2	Construction / Implementation Phase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Bid Item: 3	Commissioning & Start-up / Handover Phase					TOTAL VALUE OF GOVERNMENT FURNISHED PROPERTY (if any):						$ -
	22-01 83 00 Hydrotest	$ -	$ -	$ -	$ -							
	22-31 09 16 Foundation Test	$ -	$ -	$ -	$ -							
	22-40 96 30 Loop Check Test	$ -	$ -	$ -	$ -							
Total - Bid Item 3	Commissioning & Start-up / Handover Phase	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Total Bid Items 1-3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Step 6 – Selection of the Preferred Alternatives

The NPS Bidding Template consists of two primary templates. The initial templates (bid item summary), as illustrated in Table 6 above, the template's purpose is for Request for Quotation (RFQ) activities. In the context of the procurement/tender process, this phase occurs during the Bidding Phase, where multiple Companies or Contractors submit their prices for the project as bidders[45] [46].

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[44] By Author
[45] Giammalvo, P. D., & PTMC (2021). Unit 4 - Managing Scope. https://build-project-management-competency.com/1-4-1-4-unit-4/
[46] Pradibta, I. (2024). Developing a Standardized, Multidimensional WBS/CBS Coding Structure for Storage Tanks; PM World Journal, Vol. XIII, Issue III, March. https://pmworldlibrary.net/wp-content/uploads/2024/03/pmwj139-Mar2024-Pradibta-Standardized-Multidimensional-WBS-CBS-for-Storage-Tanks.pdf

Once the bidding process concludes and a Winning Bidder is appointed, the Winning Bidder must provide a detailed breakdown of their price calculations, as depicted in the Detailed Bid Item Table. These details serve as the basis for negotiations whenever a change order/variation order is requested.

To ensure the seamless continuation of the Bidding Template for the Winning Bidder, the author has introduced a detailed Bidding Template, as shown in Appendix 3.

The detailed Bidding Template presented 3 (three) main Bid Items tables following the standardized Work Breakdown Structure (WBS). Bid Item 1 contains the requirements for the Engineering/Design Phase. The Engineering Design phase entails the creation of detailed specifications, datasheets, and drawings for the Amine Regeneration Unit (ARU), referring to International, National, and Company Standards, drawing upon the field data collected in preceding stages.

Bid Item 2 contains the Construction/Implementation Phase requirement, which involves the material supply and construction activities of the Amine Regeneration Unit (ARU) on the designated site, utilizing the specifications, datasheets, and drawings developed during the Engineering Design Phase.

Bid Item 3 contains the Commissioning & Start-Up/Handover Phase requirement, which involves final inspection and commissioning activities upon the construction of the Amine Regeneration Unit (ARU) and its accessories. This ensures that the facility operates at total capacity per design without defects or deficiencies.

Step 7 – Building Standard Procedure for Bidding Template

The new standardized bidding template shall be the reference for activities related to the construction of the Company's Amine Regeneration Unit (ARU). To assess and monitor the effectiveness of the standardized WBS and bidding template, it is essential to conduct a stage-gate review process to identify any components or elements of the Amine Regeneration Unit (ARU) project during the construction phase or bidding process that both the WBS and Bidding Template Format are aligned. To implement those, it is recommended for the Company to do the following activities before and during the implementation, as follows:

1. Pre-Implementation Review

The Company should determine whether the WBS and the Bidding Template are feasible to use with current practices by personnel in charge of the planning, bidding, and construction team of the Amine Regeneration Unit (ARU) project. A detailed evaluation shall be conducted to ensure that the template and formats are consistent with the required activities and can be practically executed.

Refer to the Unified Theory of Acceptance and Use of Technology (UTAUT) initially created by Davis, et al in 1989 and adjusted by Venkatesh, et al in 2003, "The perceived likelihood of adopting the technology is dependent on the direct effect of four key constructs, namely performance expectancy, effort expectancy, social influence, and facilitating conditions."[47]

a. Performance expectancy refers to the extent to which a consumer believes using a particular system will help them perform their tasks more effectively.

b. Effort expectancy refers to how much effort a person needs to use a new system or technology. Users with low effort expectancy are more likely to adopt a new technology.

c. Social influence refers to how much someone cares about what their family and friends think about them using a new system or technology.

d. Facilitating conditions refer to how much someone thinks their organization will help them use a new system by providing resources and technical support.[48]

The Company must consider these four factors to ensure the new system functions effectively and smoothly.

2. Establish Key Performance Indicators (KPIs)

Define specific KPIs related to the objectives of the standardized WBS and Bidding Template. These KPIs shall be measured targets related to cost accuracy, resource allocation, schedule implementation, and variance analysis.

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[47] Marikyan, D., Papagiannidis (2023). *Unified Theory of Acceptance and Use of Technology: A review.* https://open.ncl.ac.uk/theories/2/unified-theory-of-acceptance-and-use-of-technology/
[48] Nurfitriyani, S.J., (2020). *Mengenal UTAUT2 sebagai Salah Satu Technology Acceptance*. https://sis.binus.ac.id/2020/07/20/mengenal-utaut2-sebagai-salah-satu-technology-acceptance/

3. Regular Review Meetings

Conduct regular reviews with all relevant stakeholders to assess the standardized WBS and Bidding Template and identify opportunities for system improvement and prompt issue resolution.

CONCLUSION

Incorporating the Amine Regeneration Unit (ARU) into the refinery development project is crucial, given that the quantity of H_2S present in the refinery process will increase in direct proportion to the expansion of the refinery's capacity. From the perspective of health, safety, and the environment, the new refinery would not have been operational without the completion of this unit. It is, therefore, essential to manage the construction planning and methodology effectively to ensure smooth construction execution to result in the OTOBOSOR (On Time, On Budget, On Specification, On Regulation) target.

It is essential to create standardized WBS and Bidding Templates using the best-proven methods as part of improving the Company's Front-End Loading (FEL) using database automation, which has some benefits: “reducing costs, minimizing risks, meeting the schedule within deadlines, a diligent approval system, corporate alignment, transparent communication, and achieving success at the end of the project.”

Based on the author's study, the research question could be answered as follows:

1. The proper Bidding Template that the Company can use for the Amine Regeneration Unit (ARU) Project is the Class A Cost Estimate Template produced by the United States of America’s National Park Service (US-NPS)

2. The information provided in the Bidding Template must align with the Work Breakdown Structure (WBS) for the Amine Regeneration Unit (ARU) to ensure the bids accurately reflect the specific conditions and the requirements of the project.

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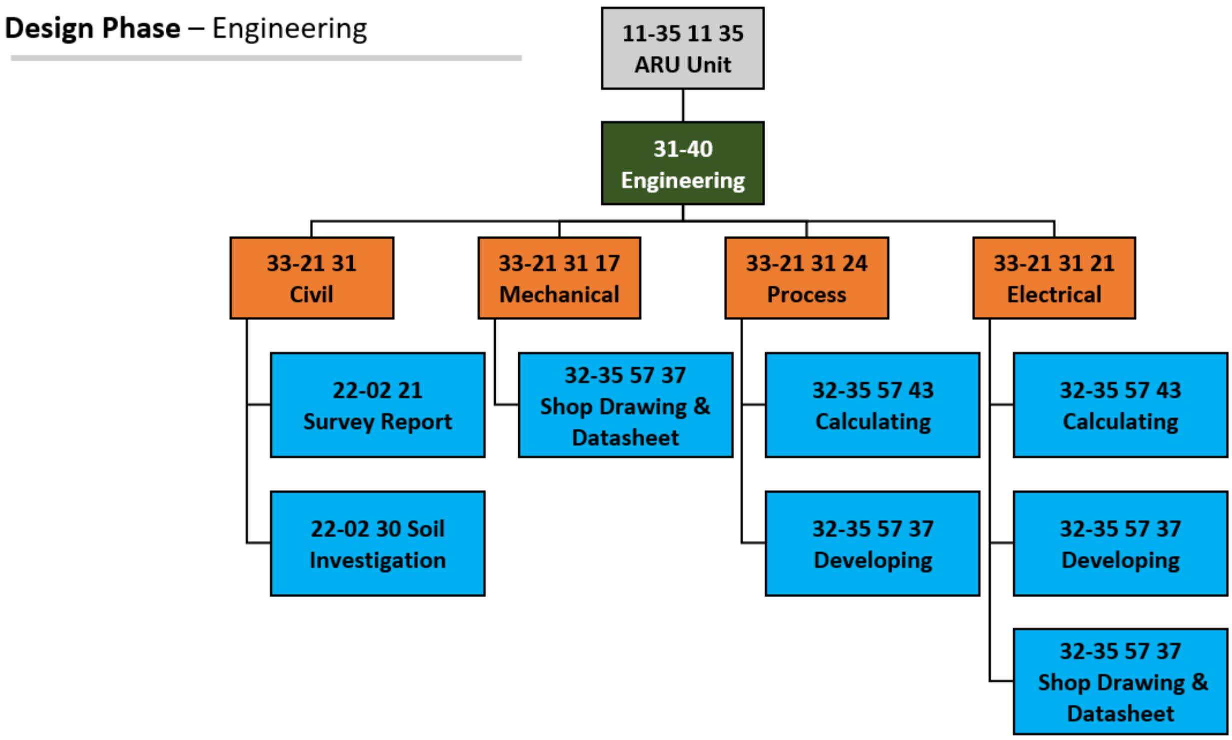
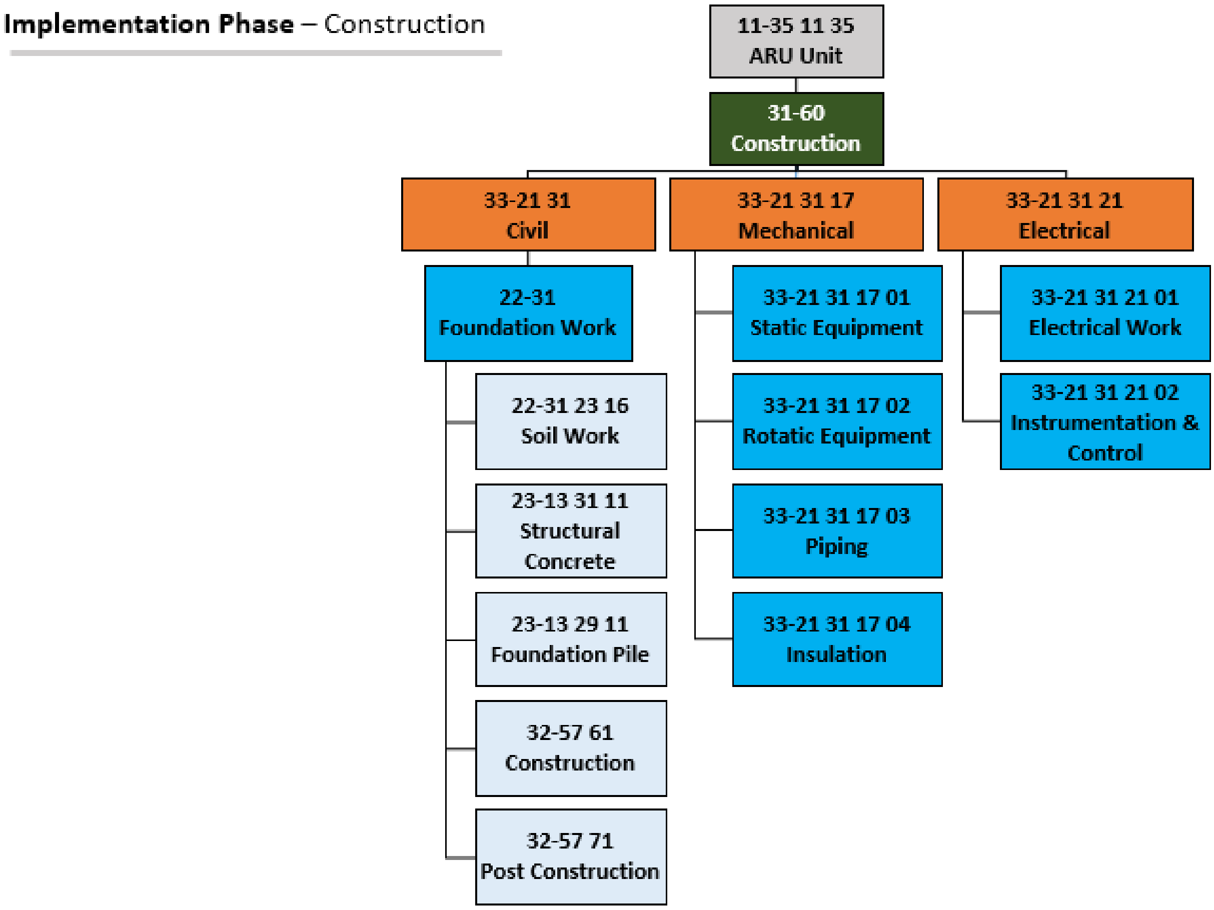
APPENDICES

APPENDIX 1 - WBS FROM OMNICLASS FOR AMINE REGENERATION UNIT PROJECT (1/3)[49]



[49] By Author

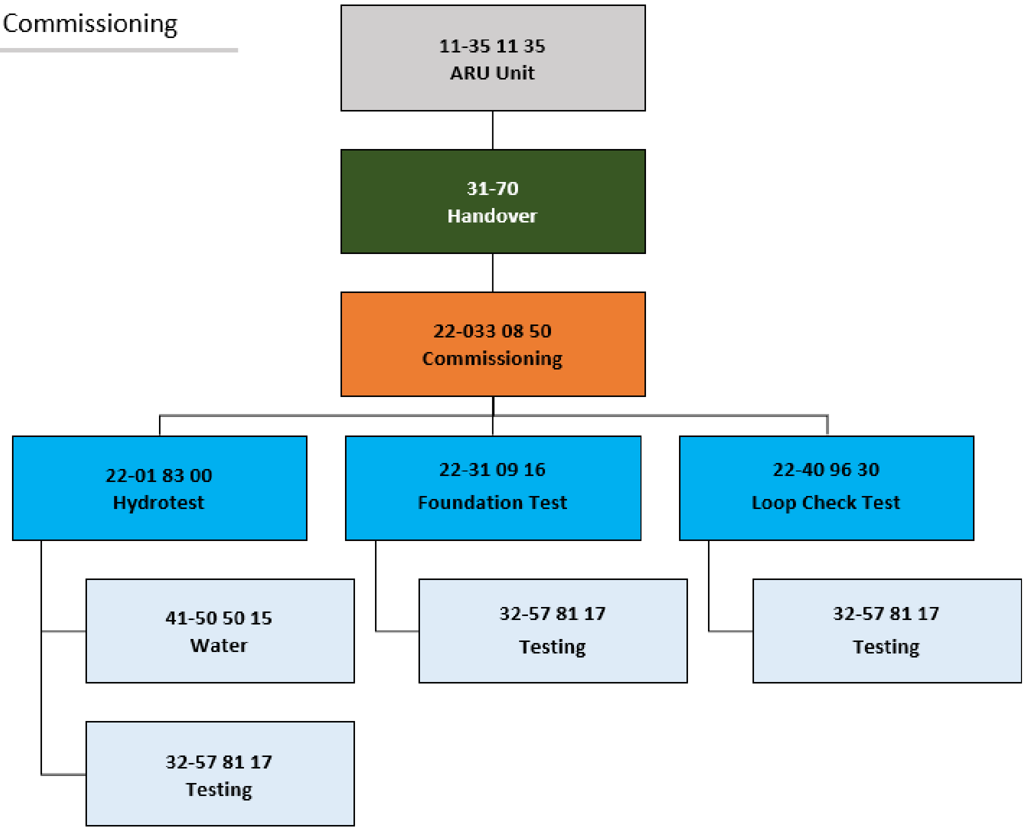
APPENDIX 1 - WBS FROM OMNICLASS FOR AMINE REGENERATION UNIT PROJECT (2/3)[50]



[50] By Author

APPENDIX 1 - WBS FROM OMNICLASS FOR AMINE REGENERATION UNIT PROJECT (3/3) [51]

Handover Phase – Commissioning



[51] By Author

APPENDIX 2 - WBS CODING FOR Amine Regeneration Unit (ARU) Project[52]

OmniClass Number	OmniClass Title	Criterion Fullfiled
Table 11	**Construction Entities by Function**	
11-35 11 35	Petroleum or Coal Products Manufacturing Facility	Level 1
Table 31	**Phases**	
31-40 00 00	Design Phase	Design Phase - Engineering
31-60 00 00	Implementation Phase	Construction Phase
31-70 00 00	Handover Phase	Handover Phase
Table 41	**Material**	
Table 32	**Service**	
32-35 47 23	Surveying	Survey
32-35 47 19	Investigating	Soil Investigation
32-35 57 37	Developing	Design
32-35 57 43	Calculating	
32-57 61 00	Constructing	Construction
32-57 71 00	Post Constructing	
32-57 81 17	Testing	Hydrotest and Other Tests.
Table 21	**Element**	
Table 22	**Work Result**	
22-02 21 00	Surveys	Survey Report
22-02 22 30	Soil Investigation	Soil Investigation
22-31 00 00	Foundation Work	Foundation Work
22-31 23 16	Soil Work	Soil Work
22-33 08 50	Commissioning of Fuel Distribution Utilities	Commissioning
22-01 33 16	Design Data	Design
22-01 33 23	Shop Drawings, Product Data, and Samples	
22-01 83 00	Facility Shell Performance Requirements	Hydrotest
Table 23	**Products**	
23-13 31 11	Structural Concrete	Structural Concrete
23-13 29 11	Foundation Pile	Foundation Pile
Table 33	**Disciplines**	
33-21 31 11	Civil Engineering	Civil
33-21 31 17	Mechanical Engineering	Mechanical
33-21 31 24	Process Engineering	Process
33-21 31 21	Electrical Engineering	Electrical

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APPENDIX 3 – DETAILED BIDDING TEMPLATE – PART A - BID ITEM 1 (ENGINEERING / DESIGN PHASE)[53]

Bid Item Number	Asset / Project Element / Description	Size/Count	Units
BID ITEM 1	Engineering / Design Phase	1	Unit

Item No.	WBS	Description	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
1	33-21 31	Civil	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	33-21 31 17	Mechanical	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	33-21 31 24	Process	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4	33-21 31 21	Electrical	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
33-21 31	Civil										
22-02 21	Surveying Activities that show the condition of the location that will be built Amine Regeneration unit (ARU)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
22-02 30	Soil Investigation (Borehole) of the location of Amine Regeneration unit and its related facilities	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Civil	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
33-21 31 17	Mechanical										
32-35 57 37	Drawing and building Datasheet based on Design result from Engineer. Usually conducted by drafter of minimum 2 years experience	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Mechanical	1000	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
33-21 31 24	Process										
32-35 57 43	The activity of Calculating Process paramater (usually done by Engineer with minimum of 7 years of experience) so that the Unit and other parameter are suitable (Ref. International and National Standard)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 37	Developing the Design based on the calculation in according to standard and the site condition	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Process	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
33-21 31 21	Electrical										
32-35 57 43	The activity of Calculating Electrical paramater (usually done by Engineer with minimum of 7 years of experience) so that the Unit and other parameter are suitable (Ref. International and National Standard)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 37	Developing the Design based on the calculation in according to standard and the site condition	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 37	Drawing and building Datasheet based on Design result from Engineer. Usually conducted by drafter of minimum 2 years experience	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Electrical	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

53 For further details and access to the complete research results (bidding template document), please get in touch with the author through: alvin.murad@gmail.com

APPENDIX 3 - DETAILED BIDDING TEMPLATE – PART B – BID ITEM 2 (CONSTRUCTION / IMPLEMENTATION PHASE) [54]

Bid Item Number	Asset / Project Element / Description	Size/Count	Units
BID ITEM 2	Construction / Implementation Phase	1	Unit

Item No.	WBS	Description	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
1	33-21 31	Civil	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	33-21 31 17	Mechanical	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	33-21 31 21	Electrical	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
33-21 31	Civil										
22-31	Concrete Foundation Construction (the price include tools and PPE)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
22-31 23 16	Soil Work: the process of preparing the soil for construction by removing, shaping, and reinforcing it	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
22-13 31 11	Structural Concrete	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
22-13 29 11	Foundation Pile	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Construction	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Civil	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
33-21 31 17	Mechanical										
33-21 31 17 01	Static Equipment installation inculding Accessories (the price include tools and PPE)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
33-21 31 17 02	Rotatic Equipment installation inculding Accessories (the price include tools and PPE)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
33-21 31 17 03	Piping installation inculding Accessories (the price include tools and PPE)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
33-21 31 17 04	Insulation installation inculding Accessories (the price include tools and PPE)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Mechanical	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
33-21 31 21	Electrical										
33-21 31 21 01	Electrical Work installation inculding Accessories (the price include tools and PPE)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
33-21 31 21 02	Instrumentation & Control Work installation inculding Accessories (the price include tools and PPE)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Electrical	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

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APPENDIX 3 - DETAILED BIDDING TEMPLATE – PART C – BID ITEM 3 (COMMISSIONING & START-UP / HANDOVER PHASE) [55]

Bid Item Number	Asset / Project Element / Description	Size/Count	Units
BID ITEM 3	Commissioning & Start-up / Handover Phase	1	Unit

Item No.	WBS	Description	Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Direct Cost/Unit	Total Direct Costs
1	22-033 08 50	Commissioning	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
22-01 83 00	Hydrotest										
31-50 50 15	Water Supply for Hydrotest	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81 17	Hydrotest Package	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Hydrotest	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
22-31 09 16	Foundation Test										
31-50 50 17	Deep foundation inspection to assess the quality, strength, and durability of various aspects of the deep foundation (incld. visual inspections, lateral load tests, integrity tests, and Osterberg Cell load tests)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Foundation Test	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

OmniClass WBS Code	Description	Quantity	Unit	MATERIAL		LABOR		EQUIPMENT		TOTALS	
				Material Cost/Unit	Total Material Cost	Labor Cost/Unit	Total Labor Cost	Equipment Cost/Unit	Total Equipment Cost	Total Cost/Unit	Total Cost
22-40 96 30	Loop Check Test										
31-50 50 17	Testing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Loop Check Test	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

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