Optimizing Fuel Pump and Filling Shed with Standardized Multidimensional-WBS and Bidding Template for FEL Improvement [1,2]

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ABSTRACT

The increased urgency to revitalize pump and filling shed assets identified as high-criticality components is driven by growing fuel demand in Indonesia and ageing fuel terminals. The National Oil and Gas Company continues to use a discipline-based, unidimensional WBS and ad hoc bidding templates, resulting in weak FEL, misalignment between FEL estimates, contract prices, and outturn costs, and a high incidence of overruns. This paper explores the potential for a uniform OmniClass-based multidimensional WBS and United States National Park Service (NPS) Class A bidding template to improve FEL, estimate accuracy, and bid evaluation for fuel pump and filling shed projects. The study is based on the NPS Class A structure, and all Engineering, Construction, and Handover activities are mapped to the OmniClass tables. Sullivan's engineering-economic analysis procedure is used. The activities are divided into a summary bid template and a detailed breakdown. The results demonstrate that this asset-oriented, WBS-driven template enhances scope completeness, traceability, and bid comparability, simplifies change order control, and provides a stronger foundation for future FEL estimates and cost database development.

Keywords: *Bidding Template, Front End Loading, Multidimensional, Omniclass, WBS, Project Control*

INTRODUCTION

A. The Need for Revitalization of the Pump and Filling Shed

"Indonesia ranks as the world's fourth most populous country, estimated to have a population of around 277.5 million people in 2023"[3].

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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/

[3] Badan Pusat Statistik. (2023). Statistik Indonesia 2023 [Indonesia Statistics 2023]. *BPS–Statistics Indonesia.* *https://www.bps.go.id*

“It is an archipelagic state with a total area of about 1.9 million square kilometers and is commonly cited as roughly the 14th–15th largest country in the world by land area”[4]. “Given its large population, oil and gas in Indonesia remain the dominant energy sources across sectors, with total consumption in 2022 reaching approximately 477.82 million barrels of oil equivalent (BOE)”[5]. As shown in Figure 1, oil products have remained a major component of Indonesia’s final energy consumption over the past two decades.

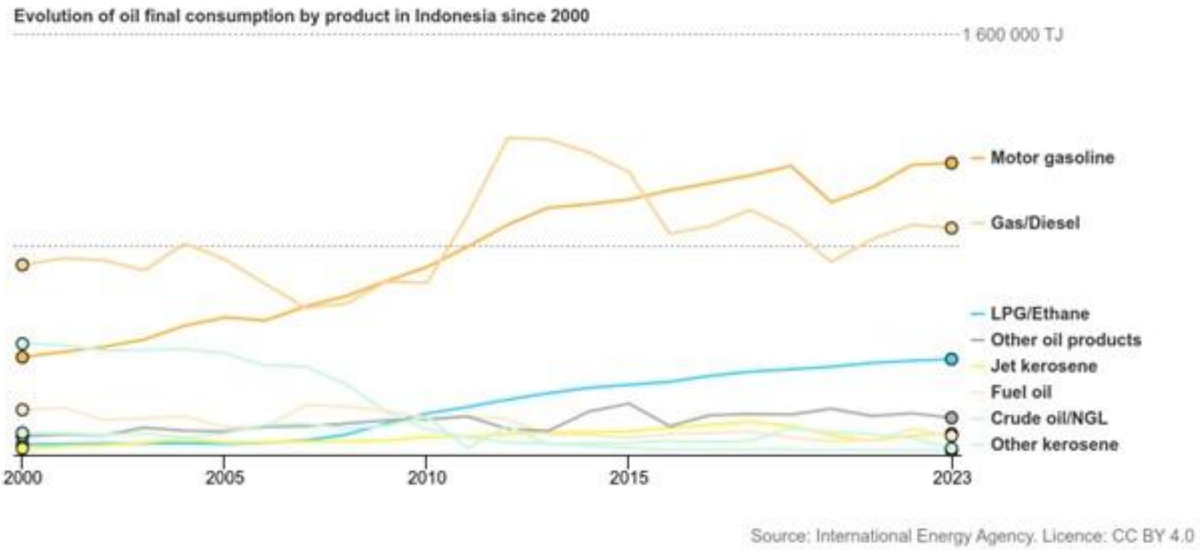

Figure 1. “Oil final consumption in Indonesia by product, 2000–2023 ”[6]

“More than 160 aviation fuel depots (Depot Pengisian Pesawat Udara, DPPU) and fuel terminals (Terminal Bahan Bakar Minyak, TBBM) are operated by the Indonesian national oil and gas company and are spread all over the archipelago” [7]. These facilities are the backbone of downstream fuel distribution, providing gasoline, diesel, aviation fuel, and other products to transportation, industry, and the public.

[4] Encyclopaedia Britannica. (2023). Indonesia. *In Encyclopaedia Britannica.* https://www.britannica.com/place/Indonesia
[5] International Energy Agency. (2023). *Indonesia: Energy profile. IEA. https://www.iea.org/countries/indonesia*
[6] International Energy Agency. (2021). *Evolution of oil final consumption by product in Indonesia since 2000.* https://www.iea.org/countries/indonesia/oil
[7] Badan Pengatur Hilir Minyak dan Gas Bumi. (n.d.). *BPH Migas.* https://www.bphmigas.go.id

Figure 2. "Distribution of National Oil and Gas Company's Aviation Fuel Depots (DPPU) and Fuel Terminals (TBBM) in Indonesia (2024) "[8]

Within a fuel terminal, pump systems and filling sheds are not only the main interface between storage and outbound distribution but also among the most critical components from a risk and reliability perspective. A recent criticality analysis of an Indonesian fuel oil storage terminal "using the FMECA method found that pumps have the highest Risk Priority Number (RPN) among ten major subsystems"[9]. At the same time, "the filling shed system and loading/unloading piping systems also rank as high criticality elements"[10] that require prioritized maintenance and monitoring to avoid supply disruptions and safety incidents. In this situation, projects that renew, expand, or modernize pump systems and filling sheds become "strategically important to maintain service continuity, support national fuel distribution, and avoid disruptions caused by equipment failures or project delays"[11,12,13].

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[8] Badan Pengatur Hilir Minyak dan Gas Bumi. (n.d.). *BPH Migas. https://www.bphmigas.go.id*
[9] Wijanarto, B., Zaman, M. B., & Cahyono, B. (2024). Critically analysis for fuel oil storage facilities using FMECA method. *IOP Conference Series: Earth and Environmental Science*, *1423*(1), 012037. https://doi.org/10.1088/1755-1315/1423/1/012037
[10] Ibid
[11] American Petroleum Institute. (2014). *API Recommended Practice 2610: Design, construction, operation, maintenance, and inspection of terminal and tank facilities* (3rd ed.). American Petroleum Institute. https://www.api.org
[12] Energy Institute. (2018). *Guidance for design, construction and operation of road tanker loading and unloading facilities at petroleum terminals and depots*. Energy Institute. https://www.energyinst.org
[13] McPherson, T. (2011). Design considerations for petroleum product storage terminals and truck loading facilities. *Journal of Loss Prevention in the Process Industries, 24*(5), 635–642. https://doi.org/10.1016/j.jlp.2011.03.010

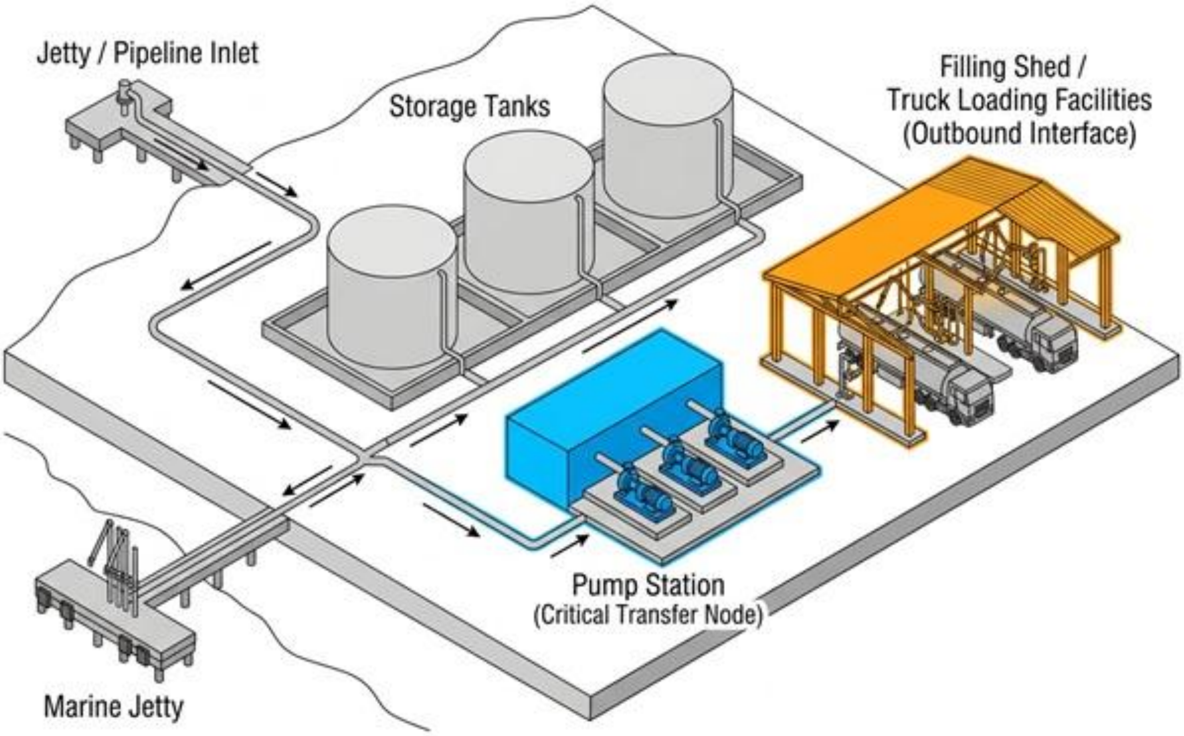

Figure 3. "Simplified Fuel Terminal / Aviation Terminal illustration, with Pump Station and Filling Shed highlight."[14]

The urgency to improve the performance of fuel pump and filling shed assets has been growing in line with both asset aging—many depots and terminals are now more than 25–30 years old—and "rising energy demand"[15,16]. In many of these facilities, the systems that handle loading, unloading, and transfer of fuels were installed decades ago and are now approaching or exceeding their original design life. Aging of such critical equipment has raised concerns about reliability, safety, metering accuracy, loading efficiency, and compliance with evolving technical and HSE standards. As a consequence, "both state-owned and private operators are planning and implementing a growing number of projects focused specifically on the rehabilitation, upgrading,

[14] Generated by AI with reference to American Petroleum Institute. (2014). *API Recommended Practice 2610: Design, construction, operation, maintenance, and inspection of terminal and tank facilities* (3rd ed.). American Petroleum Institute. https://www.api.org
[15] MEMR. (2023). *Handbook of energy & economic statistics of Indonesia 2022*. Ministry of Energy and Mineral Resources, Republic of Indonesia. https://www.esdm.go.id
[16] MEMR. (2022). *Handbook of energy & economic statistics of Indonesia 2021*. Ministry of Energy and Mineral Resources, Republic of Indonesia.

debottlenecking, and partial replacement of fuel pumps, associated piping, metering systems, and filling sheds across the national terminal network"[17,18].

B. Front End Loading (FEL) and WBS Importance in Project Management

"Project overruns in the construction industry are an international phenomenon"[19]. It is confirmed by a conducted survey in Australia by KPMG and AIPM, with "the result only 32% projects were finished on time, and 36% projects were delivered on budget"[20] (Figure 4). This means that project delays and cost overruns are some of the major challenges faced by construction companies around the globe. "Even with this negative outcome, 43% of those surveyed believe their organisation manages projects and programmes effectively or very effectively, indicating a gap between perceived ability and actual performance."[21]. This misalignment can lead to underestimation of systemic weaknesses in planning and control, and ultimately to missed business objectives and reduced profitability.

***Figure 4* – "Project Deliver Performance on KPMG & Australian Institute of Project Management"** [22]

[17] MEMR. (2023). *Handbook of energy & economic statistics of Indonesia 2022*. Ministry of Energy and Mineral Resources, Republic of Indonesia. https://www.esdm.go.id
[18] MEMR. (2022). *Handbook of energy & economic statistics of Indonesia 2021*. Ministry of Energy and Mineral Resources, Republic of Indonesia.
[19] Sambasivan, M., & Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. International Journal of Project Management, 25(5), 517-526. Retrieved from: https://doi.org/10.1016/j.ijproman.2006.11.007
[20] KPMG, & Australian Institute of Project Management (AIPM). (2022). Project Delivery Performance. The state of project management in Australia 2022.
[21] McPherson, T. (2011). Design considerations for petroleum product storage terminals and truck loading facilities. *Journal of Loss Prevention in the Process Industries, 24*(5), 635–642. https://doi.org/10.1016/j.jlp.2011.03.010
[22] KPMG, & Australian Institute of Project Management (AIPM). (2022). Project Delivery Performance. The state of project management in Australia 2022.

"One factor that contributes to persistent overruns is overconfidence and optimism bias during the early stages of project planning"[23]. When management and project teams are overly optimistic, "they may omit probable scope from estimates, overlook plausible risks, and rely on unrealistic assumptions about productivity, costs, and durations"[24]. Such biases are especially problematic in large-scale, capital-intensive projects—such as fuel terminal rehabilitation and pump/filling shed upgrades—where small percentage deviations in cost or time can translate into substantial absolute impacts on business value and risk exposure.

Against this backdrop, Front End Loading (FEL) has been promoted by AACE International, GAO, NASA, and other bodies as a structured approach to "improve the quality of early-stage project definition and decision-making"[25,26,27]. FEL emphasizes the development of progressively more detailed and reliable information packages, often referred to as "Decision Support Packages (DSPs) or engineering deliverables across FEL stages 1–3 to support go/kill/hold decisions at each gate"[28]. An earlier but robust estimate and scope definition are required to support the decision to pursue, defer, or reject a project, ensuring that "business objectives are translated into feasible project options with clearly understood cost, schedule, and risk implications"[29,30]. Refer to Paulson and subsequent cost estimating guidance by the U.S. Department of Energy, which reinforces "that the ability to influence project outcomes is highest and the cost of making changes is lowest at the earliest stages of the project, while the range of estimate accuracy narrows as the level of project definition increases"[31,32].

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[23] Flyvbjerg, B. (2023, December 13). *A Conversation with Bent Flyvbjerg, the World's Leading Megaproject Expert on How Big Things Get Done*. Interview by V. Shah MBE DL. https://thoughteconomics.com/bent-flyvbjerg/
[24] Ibid
[25] AACE International. (2019). Cost estimate classification system – As applied in engineering, procurement, and construction for the process industries (Recommended Practice No. 18R 97). AACE International. https://web.aacei.org/resources/publications/recommended-practices
[26] GAO. (2020). GAO cost estimating and assessment guide: Best practices for developing and managing program costs (GAO 20 195G). U.S. Government Accountability Office. https://www.gao.gov/products/gao-20-195g
[27] NASA. (2015). NASA cost estimating handbook (Version 4.0). National Aeronautics and Space Administration. https://www.nasa.gov/offices/ocfo/nasa-cost-estimating-handbook
[28] AACE International. (2019). Cost estimate classification system – As applied in engineering, procurement, and construction for the process industries (Recommended Practice No. 18R 97). AACE International.
[29] Ibid
[30] Giammalvo, P. D. (2014). Defining, validating and classifying project management "good practices": A case for owner-centric project governance. *Project Management World Journal, 3*(2), 1–25. https://pmworldlibrary.net/wp-content/uploads/2014/02/pmwj19-feb2014-GIAMMALVO-governance-through-good-practices-Featured-Paper.pdf
[31] Paulson, B. C. (1976). Designing to reduce construction cost. *Journal of the Construction Division, 102*(C04), 587–592. Retrieved from https://www.danieldavis.com/papers/boyd.pdf
[32] U.S. Department of Energy. (2011). *Cost estimating guide*. U.S. Department of Energy. https://www.energy.gov

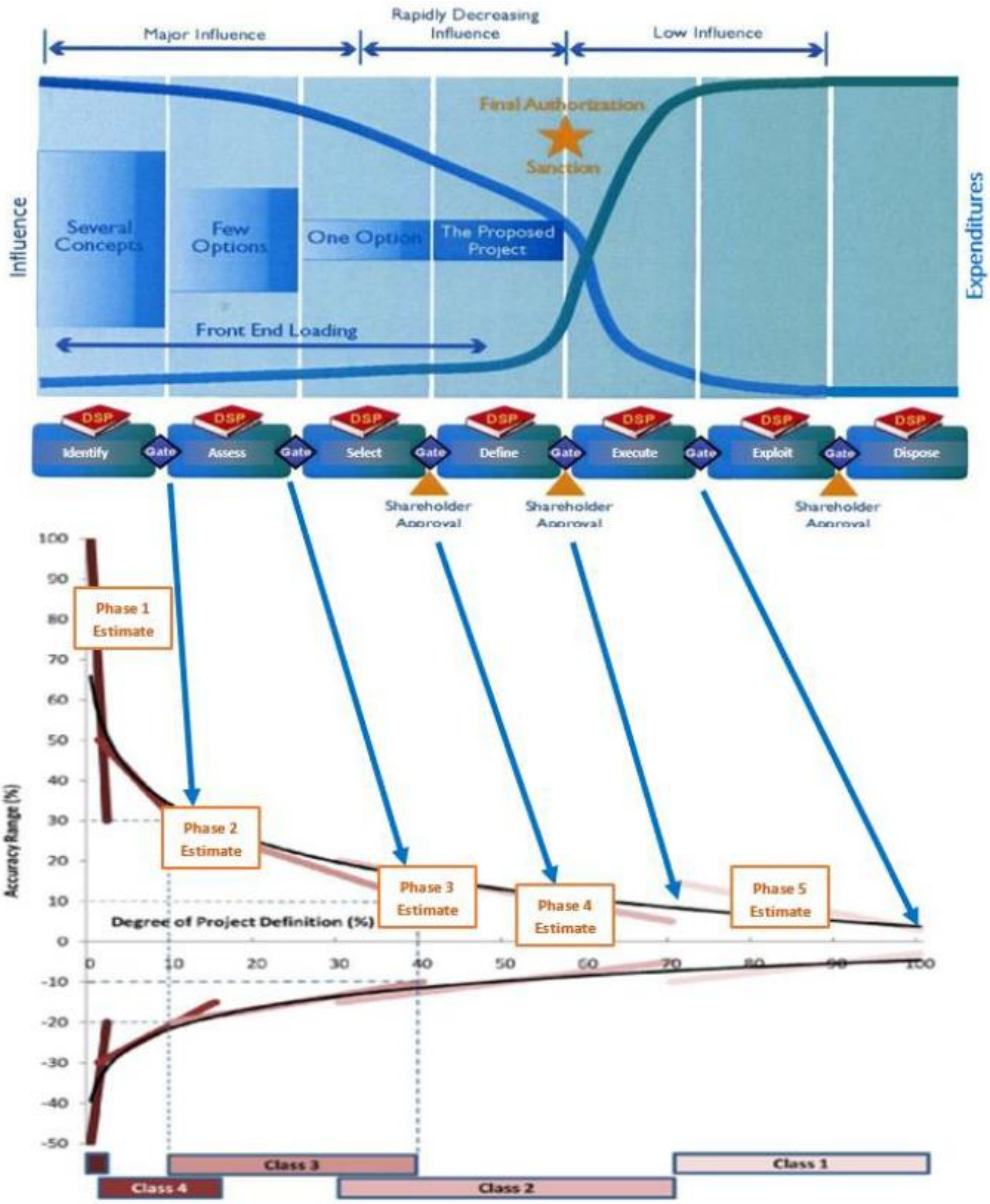

Figure 5. **– "Relationship between asset life span, ability to influence outcomes, cost to make changes, and variability in estimate accuracy/uncertainty as project definition progresses"** [33,34]

[33] Paulson, B. C. (1976). Designing to reduce construction cost. *Journal of the Construction Division, 102*(C04), 587–592. Retrieved from https://www.danieldavis.com/papers/boyd.pdf
[34] U.S. Department of Energy. (2011). *Cost estimating guide*. U.S. Department of Energy. https://www.energy.gov

"The quality of these early decisions is heavily dependent on how well the project scope is structured and communicated"[35,36,37]. In most organizations, scope definition in FEL is operationalized through a Work Breakdown Structure (WBS) as a hierarchical representation of project deliverables. However, "the WBS used in many organizations remains predominantly unidimensional, usually decomposing the project along a single primary dimension such as physical deliverables or execution phases, often relying on ad-hoc or company-specific coding structures"[38,39]. This approach is often insufficient to meet the cross-functional information needs that arise during FEL, "including the integration of technical scope with the Cost Breakdown Structure (CBS), Organizational Breakdown Structure (OBS), Risk Breakdown Structure (RBS), and contract/package breakdowns" [40,41,42]. "As a result, gaps frequently emerge between the way scope is defined at the technical level and the information required for cost control, scheduling, risk management, and project governance at the asset-owner level"[43,44]. From an owner-centric perspective, "this structural misalignment in early scope definition reduces decision usefulness: management is asked to commit to major investments based on information that is not fully integrated, not easily traceable across functions, and thus less reliable for evaluating cost and risk consequences" [45,46].

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[35] AACE International. (2019). Cost estimate classification system – As applied in engineering, procurement, and construction for the process industries (Recommended Practice No. 18R 97). AACE International. https://web.aacei.org/resources/publications/recommended-practices

[36] GAO. (2020). GAO cost estimating and assessment guide: Best practices for developing and managing program costs (GAO 20 195G). U.S. Government Accountability Office. https://www.gao.gov/products/gao-20-195g

[37] NASA. (2015). NASA cost estimating handbook (Version 4.0). National Aeronautics and Space Administration. https://www.nasa.gov/offices/ocfo/nasa-cost-estimating-handbook

[38] U.S. Department of Energy. (2011). *Cost estimating guide*. U.S. Department of Energy. https://www.energy.gov

[39] Giammalvo, P. D. (2019). Improving project governance and asset management through better designed project data structures. Project Management World Journal, 8(5), 1–30. https://pmworldlibrary.net/wp-content/uploads/2019/05/pmwj81-May2019-Giammalvo-improving-project-governance-through-better-data-structures.pdf

[40] AACE International. (2019). Cost estimate classification system – As applied in engineering, procurement, and construction for the process industries (Recommended Practice No. 18R 97). AACE International. https://web.aacei.org/resources/publications/recommended-practices

[41] GAO. (2020). GAO cost estimating and assessment guide: Best practices for developing and managing program costs (GAO 20 195G). U.S. Government Accountability Office. https://www.gao.gov/products/gao-20-195g

[42] NASA. (2015). NASA cost estimating handbook (Version 4.0). National Aeronautics and Space Administration. https://www.nasa.gov/offices/ocfo/nasa-cost-estimating-handbook

[43] Giammalvo, P. D. (2014). Defining, validating and classifying project management "good practices": A case for owner-centric project governance. *Project Management World Journal, 3*(2), 1–25. https://pmworldlibrary.net/wp-content/uploads/2014/02/pmwj19-feb2014-GIAMMALVO-governance-through-good-practices-Featured-Paper.pdf

[44] Giammalvo, P. D. (2019). Improving project governance and asset management through better designed project data structures. Project Management World Journal, 8(5), 1–30. https://pmworldlibrary.net/wp-content/uploads/2019/05/pmwj81-May2019-Giammalvo-improving-project-governance-through-better-data-structures.pdf

[45] Giammalvo, P. D. (2014). Defining, validating and classifying project management "good practices": A case for owner-centric project governance. *Project Management World Journal, 3*(2), 1–25. https://pmworldlibrary.net/wp-content/uploads/2014/02/pmwj19-feb2014-GIAMMALVO-governance-through-good-practices-Featured-Paper.pdf

[46] Giammalvo, P. D. (2019). Improving project governance and asset management through better designed project data structures. Project Management World Journal, 8(5), 1–30. https://pmworldlibrary.net/wp-

C. The Need for Developing a Standardized WBS in Pump and Filling Shed Projects.

In response to the limitations of traditional, unidimensional WBS structures, "the concept of a multidimensional WBS, explicitly structured using a recognized classification system such as OmniClass, has emerged as a promising approach to bridge cross-functional information needs during FEL"[47]. OmniClass, developed for the built environment, provides coordinated tables that classify construction information by work results, elements, spaces, facilities, products, disciplines, phases, and other views. "Leveraging OmniClass as the backbone for the WBS enables a consistent, interoperable coding system that can serve design, cost estimating, scheduling, procurement, and asset management needs across the project life cycle"[48].

The purpose of this paper is to develop and propose a conceptual framework that explains the role of an OmniClass-based multidimensional WBS as an enabler of Front-End Loading in fuel pump and filling shed projects in the oil and gas industry, with particular reference to the National Oil and Gas Company. The main contributions of this paper are:

1. Developing an OmniClass-based multidimensional WBS that can be designed and used strategically during FEL for fuel pump and filling shed projects in Indonesia; and

2. Provide a standardized OmniClass-based multidimensional WBS aiming to improve FEL on estimate accuracy and scope definition for fuel pump and filling shed projects in Indonesia.

3. Develop a standardized bidding template based on an OmniClass-driven multidimensional WBS to be used by both owners and contractors to improve the consistency, transparency, and accuracy of cost estimation and bid evaluation for these projects.

METHODOLOGY

The author will be developing a methodology that refers to "procedure as described by Sullivan"[49]

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[47] Construction Specifications Institute. (2012). *OmniClass Construction Classification System: Table introduction & overview*. *Construction Specifications Institute.* https://www.csiresources.org/standards/omniclass

[48] Ibid

[49] 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.

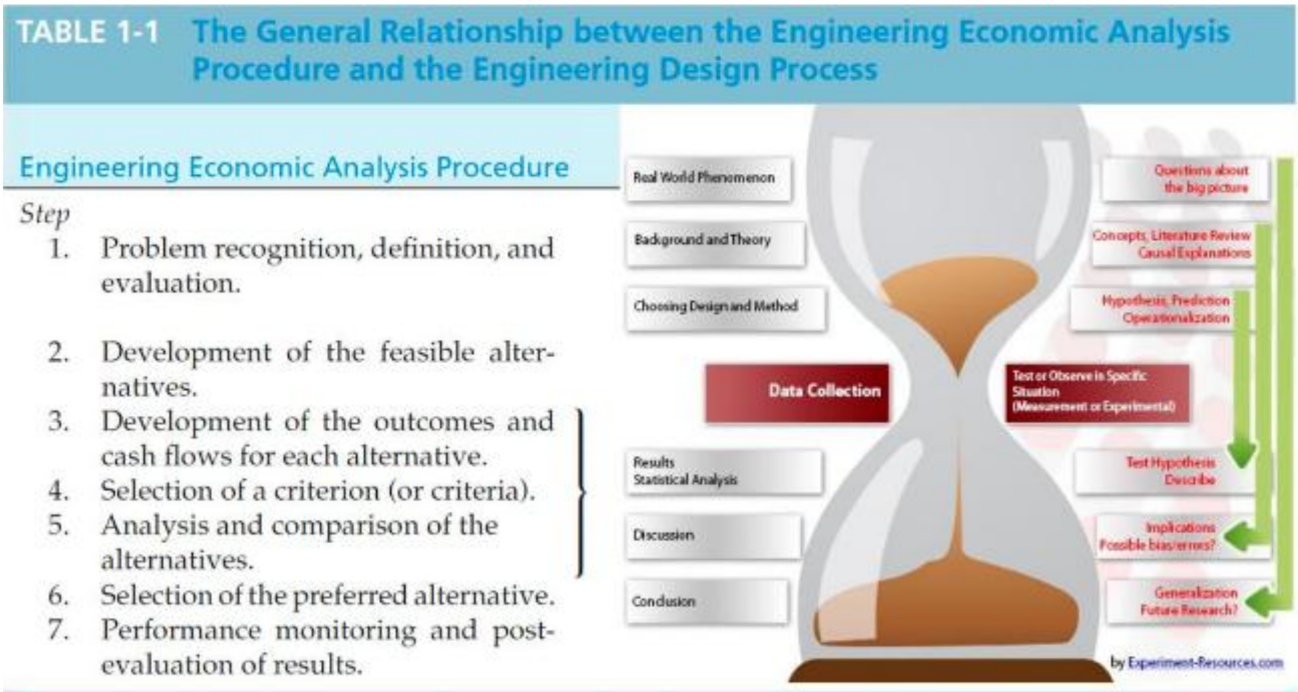

TABLE 1-1 The General Relationship between the Engineering Economic Analysis Procedure and the Engineering Design Process

Engineering Economic Analysis Procedure

Step
1. Problem recognition, definition, and evaluation.
2. Development of the feasible alternatives.
3. Development of the outcomes and cash flows for each alternative.
4. Selection of a criterion (or criteria).
5. Analysis and comparison of the alternatives.
6. Selection of the preferred alternative.
7. Performance monitoring and post-evaluation of results.

Figure 61. – Engineering Economic Analysis Procedure [50]& Step of the Scientific Process[51]

Step 1 - Problem Definition

As discussed in the Introduction, pump stations and filling sheds in Indonesia's fuel and aviation terminals are aging, high-criticality assets, and revitalization projects for such systems are becoming more frequent. KPMG and AIPM report that "only about one-third of projects are completed on time and just over one-third are completed within budget, indicating that schedule and cost overruns remain pervasive"[52]. Within the National Oil and Gas Company, similar patterns appear in pump and filling shed projects, where FEL estimates, contract prices, and outturn costs are often poorly aligned, this is stated by published paper by Zain that analyzed data specific for Jetty Construction during 2019 - 2024, confirm this unpleasant situation which indicates "most of the company projects is in Jetties Construction are over budget and behind schedule"[53].

[50] 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.
[51] Martyn Shuttleworth (2008). What is Research? Retrieved from: https://explorable.com/what-is-research
[52] International Energy Agency. (2021). *Evolution of oil final consumption by product in Indonesia since 2000.* *https://www.iea.org/countries/indonesia/oil*
[53] Zain, R. A. (2024). Developing Parametric Modelling for Class 4 Estimate of Pier and Jetty Construction. *Developing Parametric Modelling for Class 4 Estimate of Pier and Jetty Construction by Analyzing Historical Databases using AI Tools & EVM Techniques*, *12*(2024)

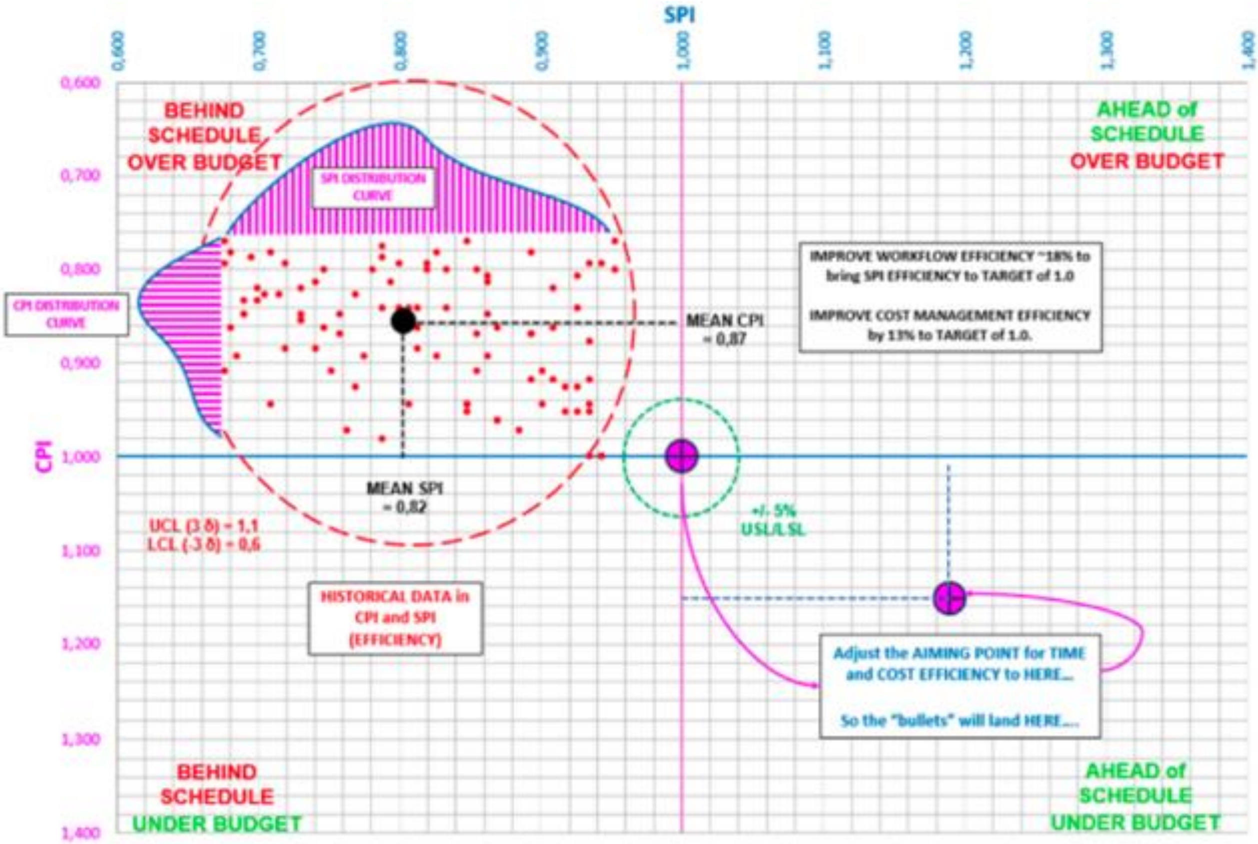

***Figure 7.* – "CPI/SPI Performance of Jetty Construction during 2019 – 2024"** [54]

As explained in the previous chapter of the paper, the Standardized Work Breakdown Structure (WBS) will be using Omniclass Tables that are the best tested and proven tools stated by Andrian, "using a standardized WBS/CBS coding structure based on OmniClass enables the development of reliable econometric cost models for pier construction projects"[55]. The Fuel Pumps and Filling Shed Project will use standardized WBS/CBS from Omniclass Tables 11, 21, 22, 23, 31, 32, as shown in Appendix 1, along with the details of WBS Elements from Omniclass Tables in Appendix 2.

The company currently conducts all competitive bidding only after the project has reached the Class 2 estimate stage, meaning that "the scope and design have typically achieved a maturity level of roughly 30–75%, and the estimating process is expected to

[54] Zain, R. A. (2024). Developing Parametric Modelling for Class 4 Estimate of Pier and Jetty Construction. *Developing Parametric Modelling for Class 4 Estimate of Pier and Jetty Construction by Analyzing Historical Databases using AI Tools & EVM Techniques*, *12*(2024)

[55] Andrian, E. (2024). Building an econometrics model for pier construction: A standardised WBS/CBS approach. Project Management World Journal, 13(4), 1–18. https://pmworldlibrary.net/wp-content/uploads/2024/04/pmwj140-Apr2024-Andrian-building-an-econometrics-model-for-pier-construction.pdf

conform to the classification criteria and accuracy expectations"[56] set out in AACE Recommended Practice 18R-97.

	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%

Table 1. "Cost Estimate Classification Matrix for Process Industries" [57]

In current practice, the WBS is essentially unidimensional and ad hoc, organized typically by physical components (e.g., pumps, piping, electrical works) or by project phases, using engineer-point-of-view codes that are not aligned to any external classification standard. Typically, the relationship between WBS elements and cost items is implicit or loose since cost estimates are often developed directly from spreadsheets or BoQs without a clear and stable coding backbone. Therefore, the BoQs and bid schedules are project-specific and developed on a case-by-case basis. The line items are not always derived from a common WBS structure. This is seen in the company bidding template shown in Table 2 and Figure 8.

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[56] 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.
[57] Ibid

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%)					**$**
		TOTAL					**$**

Table 2. "Company Bidding Template" [58]

[58] 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.

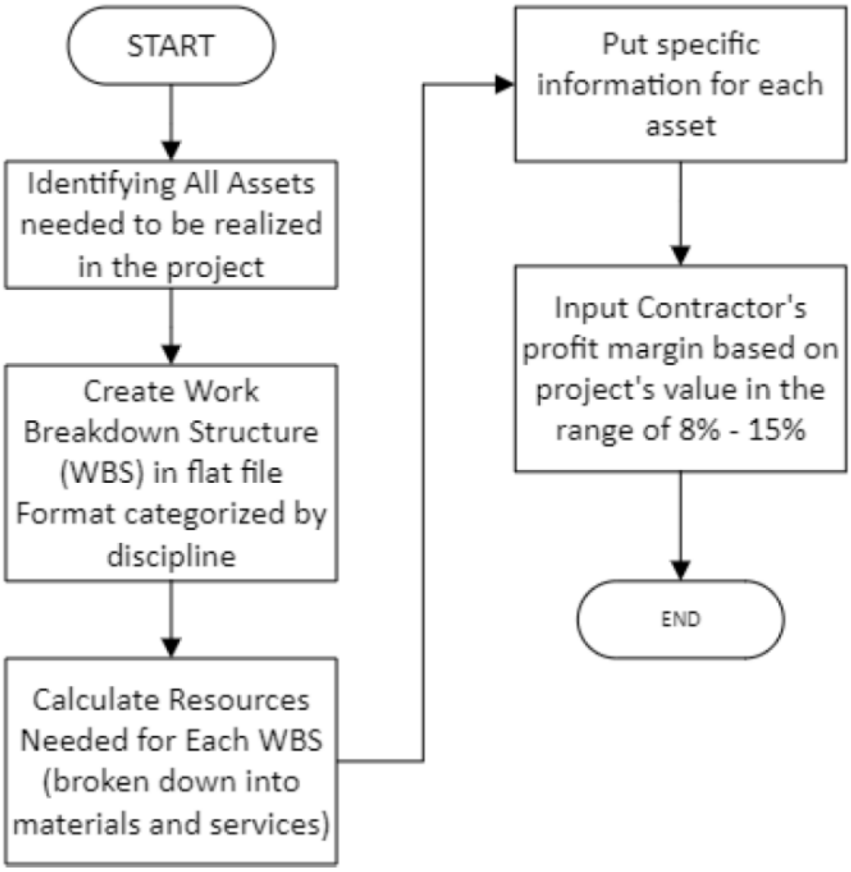

Figure 8. "The Company's Current Process for Building Bidding Template" [59,60]

Structuring the Work Breakdown Structure (WBS) at the top level by discipline has created significant difficulties in achieving consistency, transparency, and accuracy in both cost estimation and bid evaluation. Because this approach does not clearly allocate material quantities and labor to individual assets, it becomes hard to calculate asset-level costs in a repeatable way and to reconcile estimates with bids. In practice, this configuration obscures the link between scope and price, making the process cumbersome and error-prone for both owners and contractors.

[59] Pradibta. (2024, March). Standardised multidimensional WBS-CBS for storage tanks. PM World Journal. https://pmworldlibrary.net/wp-content/uploads/2024/03/pmwj139-Mar2024-Pradibta-Standardised-Multidimensional-WBS-CBS-for-Storage-Tanks.pdf
[60] Pragitatama. (2024, Oct–Nov). Standardised bidding documents for jetty/pier project. PM World Journal. https://pmworldlibrary.net/wp-content/uploads/2024/11/pmwj146-OctNov2024-Pragitatama-standardised-bidding-documents-for-jetty-pier-project-2.pdf

Step 2 - Identify The Feasible Alternative (United States National Park Service /NPS Bidding Template)

"The United States National Park Service (NPS) bidding template is designed to work together with its estimate classification system so that every estimate—early or late—uses the same WBS-aligned bid structure"[61]. Instead of having separate formats for conceptual, design, and construction estimates, NPS organizes all DOI estimate types (Class C, B, and A, which can be seen in Table 3) within one consistent set of bid items and codes; what changes is the level of project definition and expected accuracy, not the underlying structure. Giammalvo emphasizes that "owners should manage scope using a single, coherent breakdown structure that drives estimating, contracting, and reporting, rather than allowing each function to invent its own coding scheme"[62]. This is exactly what the NPS approach achieves and why it is relevant as a reference for designing a standardized, WBS-driven bidding template for pump and filling shed projects.

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

Table 3. "NPS Estimate Classification and Accuracy" [34]

DOI Class C, DOI Class B, or DOI Class A. The underlying WBS/bid structure can be the same in all three, but the target level of project definition and accuracy differs as follows :

A. Alternative 1 – DOI Class C–Based Bidding Template

Class C (AACE Classes 5 and 4) is used at predesign and early schematic design, with 0–15% project definition and a wide accuracy range (about −20% to +50% / −15% to +30%). It is suitable for concept screening and feasibility, but still relies

[61] National Park Services. (2023). Construction Cost Estimating Requirements Handbook. National Park Service (NPS) - Denver Service Centre (DSC).
[62] Giammalvo, P. D., & PTMC (2021). Unit 4 - Managing Scope. https://build-project-management-competency.com/1-4-1-4-unit-4/

on aggregated, parametric pricing, even though it uses the same WBS/bid structure that can later be refined.

B. Alternative 2 – DOI Class B–Based Bidding Template

Class B (AACE Classes 3 and 2) is used at schematic design and design development, with 10–75% project definition and tighter accuracy (about −10% to +20% / −5% to +15%). It supports budget authorization and control estimates using the same WBS-aligned bidding structure, but with more line items populated with project-specific quantities and unit rates.

C. Alternative 3 – DOI Class A–Based Bidding Template

Class A (AACE Class 1) is used at the construction documents stage, with 65–100% project definition and an accuracy range of about −3% to +10%. Here, the estimate and the bidding template are effectively the same: every WBS/bid item is fully defined with explicit quantities and unit prices, ready for direct use in bidding, evaluation, contract award, and cost control.

Finally, Class A estimates are equivalent to AACE Class 1 and are prepared at the construction documents stage, with 65–100% project definition and an accuracy of about −3% to +10%. The estimate and the bidding template are now on the same level: each WBS/bid item is fully defined with explicit quantities and unit prices, ready to be used directly for bidding, evaluation, contract award, and cost control.

The full correspondence between estimate and bid is the highest accuracy. The DOI Class A, as the bidding template target, is the maximum project definition. consistent with NPS and Giammalvo, this choice provides a sufficiently detailed, stable reference for final estimates, competitive bidding, contract award and cost control. The following sections will review three options and make a case for the DOI Class A for pump and filling shed projects. This is shown in Table 4, "the template for Class A Level Construction Cost Estimate used by the U.S. National Park Service".[63]

[63] National Park Services. (2023). Construction Cost Estimating Requirements Handbook. National Park Service (NPS) - Denver Service Centre (DSC).

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 APR	Inflation Escalation Months	Bid Item Total
						0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	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	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -

Table 4. "National Park Services Bidding Template (Class A Construction Cost Estimate)" [64]

Step 3 - Development of The Feasible Alternative

Given that Step 2 has already positioned DOI Class A (AACE Class 1) as the most mature estimate class, the key issue in this step is its economic and risk implications for pump and filling shed projects. By basing the standardized bidding template on Class A, the company ensures that competitive bids are requested only when scope and design have been developed to a level at which quantities and unit rates can be specified in detail for each WBS/bid item. NPS explicitly states that "check estimates prepared from construction documents should be organized in the same work breakdown and bid schedule format that will be used for contractor bidding and contract administration"[65]. This one-to-one correspondence between the internal estimate and the bid schedule

[64] National Park Services. (2023). Construction Cost Estimating Requirements Handbook. National Park Service (NPS) - Denver Service Centre (DSC).
[65] Ibid

reduces ambiguity, reduces the chance of scope change orders, and improves the owner's position to determine if contractor prices are within reason.

From a governance and learning perspective, a Class A-based template is a big plus, for traceability and for making useful decisions. Each bid item is directly tied to a well-defined WBS element. This enables the owner to compare bids line-by-line, identify pricing outliers, and systematically record awarded and actual costs in a structured historical database. The Author concludes that although the upfront design and estimating effort required to achieve Class A readiness is greater than that required to operate at earlier classes, the reduction in cost uncertainty, improvement in bid comparability, and stronger basis for future FEL estimates, in combination, make DOI Class A-based bidding the most economically and operationally attractive alternative for the National Oil and Gas Company to adopt.

Step 4 - Selection of The Criteria

As described earlier, the NPS Class A Cost Estimate Template structures the Work Breakdown Structure (WBS) by grouping every work item under the specific asset or service outcome it is intended to deliver, rather than simply by discipline or trade. For pump and filling shed projects, this means all civil, mechanical, electrical, and instrumentation activities are structured under well-defined asset headings like pump stations, filling bays, product piping, metering systems, and associated safety systems. This asset-oriented structure makes it easier to see exactly which pieces of work contribute to each functional part of the terminal, and to evaluate their costs consistently across projects. Table 4 below presents the detailed list of services and shows which physical assets are associated with each service for the pump and filling shed scope. This layout is intended to support a Class A (AACE Class 1) level of definition, where every WBS element for pumps and filling sheds is fully specified and ready to be used directly in the standardized bidding template.

Group of Attributes	Purpose	Item
Engineering	These attributes are intended to assess how effectively the WBS standard captures and describes all work packages required for the pump and filling shed project during the design phase.	Temporary Office and Workshop
		Survey
		Soil Investigation
		Project Administration & Management
		Detail Engineering Design (DED)
		Mobilization & Demobilization of Material and Personnel
		Site Clearing and Grading
Construction	These attributes represent critical elements that must be carefully developed and verified during the construction phase of the pump and filling shed project. The author aims to evaluate whether the proposed WBS standard can adequately satisfy these attributes, which constitute the fundamental criteria that the WBS should meet for this type of project.	Piping Support Foundation and Pump Foundation
		MCC and Fuel Pump Room
		Fuel Filling Shed
		Underground Pipe
		Fuel Pumps
		Truck Refueler Receiving Shed
		Fabrication Pipe Spool
		Welding
		Pipe Support
		Pipe Fittings & Flanges
		Valves
		Distribution Panel
		Low Voltage Power Cable
		UPS incl. Battery Pack
		Local Control Switch
		Grounding and Bonding for Electrical Systems
		Cathodic Protection System
		Indoor Lighting and Receptacle Lighting
		Air Conditioning
		Control Room
		Process Control Systems (PCS)
		Safety & Integration System (SIS)
		Metering System Packages
		Field Instrument
		Fiber Optic Cable
		Instrument & Control Cable
		Foam System Packages (Fire Protection)
		Fire Extinguishers
Finishing	These attributes encompass the activities required for final testing of the pump and filling shed systems that must be carried out during the commissioning and handover phases.	Calibrating & Certificate Equipment
		Radiography Test
		Penetrant Test
		Hydrostatic Test
		Cleaning
		Pre Start-Up & Safety Review (PSSR)
		Mechanical Completion & Commissioning

Table 5. "Pump and Filling Shed Project Scope of Works" [66]

[66] By Author

FINDING

Step 5 - Analysis of Alternative

Before any bidding template can be meaningfully developed, it is essential first to establish a clear and detailed Work Breakdown Structure (WBS). In the case of the Fuel Pump and Filling Shed Project, the overall structure of the WBS has already been organized and presented in Appendix 1. At the same time, Appendix 2 provides a comprehensive breakdown of all relevant construction components mapped to the OmniClass WBS system. Together, these appendices define not only what needs to be built but also how each element is categorized and coded in a standardized manner.

The author, hereinafter the person in charge, selects and refines the specific WBS elements relevant to bidding on the foundation built up. The elements selected that represent the major physical assets and associated work packages for the Fuel Pump and Filling Shed Project are then summarized and structured in Table 5. Table 5 provides a bridge from the high-level WBS in the appendices to the practical needs of the bidding process by translating the OmniClass-based breakdown into a concise, project-specific list of bid-relevant items.

The WBS elements, once well defined, are arranged in Table 5 and then included in a standard Bidding Template based on the NPS Standard Bidding Template shown in Table 4. This is a critical step as it moves the company's bidding format in line with a best-tested asset-oriented structure where each bid item is directly linked to a well-defined WBS element as opposed to a loose discipline-based grouping. Thus, the bidding template is not a price form but a direct reflection of the project scope hierarchy and coding logic.

The final bidding templates, shown in Table 6, are the outcome of this entire process. These documents form the main basis for any prospective bidders. They represent the complete set of project requirements in a structured and consistent format, including the key assets, activities, and deliverables that need to be priced. The use of the standardized WBS and OmniClass coding as the basis of each item in Table 6 facilitates the bidders' understanding of the exact scope associated with each line and the development of technically and commercially comparable proposals.

Thus, the owner makes the playing field level: all bidders get the same, well-defined structure and are asked to price the same work packages based on work breakdown structure (WBS). This greatly increases transparency, reduces the risk of scope misunderstandings, and promotes healthy competition as differences between bids can be traced back to real commercial and productivity assumptions rather than to inconsistent interpretation of the scope. Over time, this standardized, WBS-driven bidding process helps to build a reliable cost history database that can be used to enhance future estimates and project planning for similar Fuel Pump and Filling Shed Project works.

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
													APRX	Months	
								0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0	
Bid Item :	1	Engineering/Design/Preparation Phase						TOTAL VALUE OF COMPANY FURNISHED PROPERTY (if any):							Rp -
		22-01 50 00	Temporary Office and Workshop	Rp -	Rp -	Rp -	Rp -								
		22-02 21 00	Survey	Rp -	Rp -	Rp -	Rp -								
		22-02 30 00	Soil Investigation	Rp -	Rp -	Rp -	Rp -								
		22-01 31 00	Project Administration & Management	Rp -	Rp -	Rp -	Rp -								
		22-01 33 23	Detail Engineering Design (DED)	Rp -	Rp -	Rp -	Rp -								
		22-01 71 13	Mobilization & Demobilization of Material and Personnel	Rp -	Rp -	Rp -	Rp -								
Total - Bid Item	1	Engineering/Design/Preparation Phase		Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -		Rp -
Bid Item :	2	Construction Phase						TOTAL VALUE OF COMPANY FURNISHED PROPERTY (if any):							Rp -
		21-02 10	Civil & Structure Works	Rp -	Rp -	Rp -	Rp -								
		21-04 30 10	Mechanical Works	Rp -	Rp -	Rp -	Rp -								
		21-04 30 10 10	Piping Works	Rp -	Rp -	Rp -	Rp -								
		21-04 50	Electrical Works	Rp -	Rp -	Rp -	Rp -								
		21-07 40 10 90	Instrument & Control Works	Rp -	Rp -	Rp -	Rp -								
		21-04 00	Fire Protection System Works	Rp -	Rp -	Rp -	Rp -								
Total - Bid Item	2	Construction Phase		Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -		Rp -
Bid Item :	3	Handover Phase						TOTAL VALUE OF COMPANY FURNISHED PROPERTY (if any):							Rp -
		22-41 36 29	Calibrating & Certificate Equipment	Rp -	Rp -	Rp -	Rp -								
		22-41 36 29 33	Radiography Test	Rp -	Rp -	Rp -	Rp -								
		22-41 36 29 16	Penetrant Test	Rp -	Rp -	Rp -	Rp -								
		22-33 05 05 31	Hydrostatic Test	Rp -	Rp -	Rp -	Rp -								
		22-42 30 00	Cleaning	Rp -	Rp -	Rp -	Rp -								
		22-01 77 16	Pre Start-Up & Safety Review (PSSR)	Rp -	Rp -	Rp -	Rp -								
		22-01 91 00	Mechanical Completion & Commissioning	Rp -	Rp -	Rp -	Rp -								
Total - Bid Item	3	Handover Phase		Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -		Rp -
		Total Bid Items 1-3		Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -		Rp -

Table 6. "Bidding Template for Fuel Pump and Filling Shed Construction Project" [67]

Step 6 - Selection of the Preferred Alternative

The NPS-inspired bidding approach in this paper uses two complementary templates, consistent with best practice distinctions between summary and detailed cost representations. The initial template, shown in Table 5, is used for Request for Quotation (RFQ) during the Bidding Phase, when multiple bidders compete. This follows the U.S. Department of Energy Cost Estimating Guide, which states that "summary cost estimates should be supported by detailed cost build-ups in separate backup documentation to facilitate review and analysis"[68] and GAO's guidance that "a well-documented cost estimate presents a summarized view for decision makers while maintaining detailed, traceable calculations and assumptions in supporting materials"[69]

After a Winning Bidder is selected, the contractor must submit a detailed breakdown of its price build-up, which then becomes the main reference for evaluating change orders and contract adjustments. DOE emphasizes that "detailed cost backup is essential to

[67] By Author
[68] U.S. Department of Energy. (2011). Cost estimating guide. U.S. Department of Energy. https://www.energy.gov
[69] U.S. Government Accountability Office. (2020). GAO cost estimating and assessment guide: Best practices for developing and managing program costs (GAO-20-195G). U.S. Government Accountability Office. https://www.gao.gov/products/gao-20-195g

support the summary estimate and to provide a sound basis for evaluating scope changes and modifications”[70]. To support this, the author has prepared a detailed Bidding Template in Appendix 3. Appendix 3 – Part A provides the WBS breakdown for Bid Item 1 (Engineering/Design/Preparation), covering all front-end work (Temporary Office and Workshop, Survey, Soil Investigation, Project Administration & Management, DED, Mobilization & Demobilization) needed to define the project and prepare it for construction.

Appendix 3 – Part B presents the WBS for Bid Item 2 (Construction Phase), in which the Fuel Pump and Filling Shed Project is physically built on the site using the specifications, procedures, datasheets, and drawings from the Engineering Design Phase, and meeting applicable international and company standards. Appendix 3 – Part C provides the WBS for Bid Item 3 (Handover Phase), including final inspection, testing, calibration, and commissioning, to ensure the facility operates at full capacity with no outstanding issues.

Step 7 - Performance Monitoring and Post-Evaluation of Results

The new standardized bidding template will serve as the primary reference for all activities related to the Fuel Pump and Filling Shed Revitalization Project within the company. To evaluate its effectiveness, it is important to determine whether the template can be applied readily in practice. The proposed implementation roadmap, together with the approach for monitoring and continuous improvement, can be outlined as follows:

7.1 Pilot Projects Implementation

a. Select some pump and filling shed revitalization projects for pilot projects.
b. Implement the OmniClass-based WBS and standard bidding template end-to-end (FEL estimates, tender, contract and cost control).

7.2 Standard Development and Institutionalization

a. Formalize the WBS for the pump and filling shed scope based on the OmniClass (coding manual, examples).
b. Develop a corporate standard for the bidding template (mandatory columns, coding rules, examples of line items)
c. Update internal procedures to ensure FEL estimates and tenders for these projects are done using the new structures.

7.3 Training and Systems Integration

[70] U.S. Department of Energy. (2011). Cost estimating guide. U.S. Department of Energy. https://www.energy.gov

a. Train estimators, planners, project managers, procurement staff, and key contractors on the new WBS and bid template.
b. Embed codes and template in estimating tools, scheduling software, ERP/contract management systems.

7.4 Future Validation and Continuous Improvement

a. Compare new framework pilot projects with recent similar projects using the old approach on:
   - FEL estimate accuracy vs final cost,
   - Number and value of change orders,
   - Time and effort for bid preparation and evaluation,
   - Variance between the owner's estimate and bids.
b. Build a historical cost database keyed to the OmniClass codes and periodically review and refine WBS definitions, bid items, and estimating norms based on post-project audits.

CONCLUSION

The purpose of this paper is to investigate the feasibility of employing a standardized multidimensional WBS and bidding template based on OmniClass to improve the Front-End Loading (FEL), estimation accuracy, and bid evaluation in fuel pump and filling shed projects of the National Oil and Gas Company. The analysis finds that the:

1. **An OmniClass-based multidimensional WBS can be designed and used strategically during FEL for fuel pump and filling shed projects.**
   Appendices 1 and 2 show that all Engineering, Construction, and Finishing activities in Table 5 can be mapped to OmniClass tables (11, 21, 22, 23, 31, 32) and grouped under clear asset-based headings rather than disciplines. This asset-oriented structure supports FEL 1–3 by making the scope more complete, traceable, and easier to understand for both owner and bidders.

2. **A standardized WBS significantly improves estimate accuracy and scope definition.**
   The ambiguity in the discipline-based template (Table 2, Fig. 8) is resolved by translating the OmniClass WBS into a short list of bid-relevant items (Table 5) and a Class A bidding template (Table 6). Now, each bid item has a clear scope definition and hierarchy so missed probable scope and missed risks that led to overruns in the past are avoided.

3. **A standardized bidding template, modelled on the NPS Class A format, improves the consistency, transparency, and accuracy of cost estimation and bid evaluation.**
   The summary template in Table 6 (with details in Appendix 3, Parts A–C) ensures that all bidders price the same WBS work packages and that the Winning Bidder provides a traceable cost build-up for Engineering, Construction, and Handover. This dual-level approach satisfies DOE/GAO guidance, improves change-order evaluation, allows line-by-line bid comparisons, and develops a reliable historical cost database.

In summary, the results support the main paper stated in the Introduction: optimizing fuel pump and filling shed projects with a standardized OmniClass multidimensional WBS and NPS-inspired Class A bidding template does improve FEL and enhances the decision usefulness of estimates and bids.

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About the Author

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Peter Lewis Hamonangan Panjaitan is an engineer at the National Oil Company of Indonesia, possessing more than eight years of professional expertise in the oil & gas sectors. Additionally, he has served as an engineer for downstream oil and gas projects and contributed as an engineer on storage tanks, pipings, pumps, piers and other downstream projects across numerous provinces in Indonesia. He holds a bachelor's degree in Mechanical Engineering from University of Indonesia (UI). Currently, he is attending a distance learning mentoring course under the tutelage of Dr. Paul D. Giammalvo, CDT, CCE, MScPM, MRICS, GPM-m Senior Technical Advisor at PT Mitrata Citragraha, to attain Certified Cost Professional certification from AACE International.

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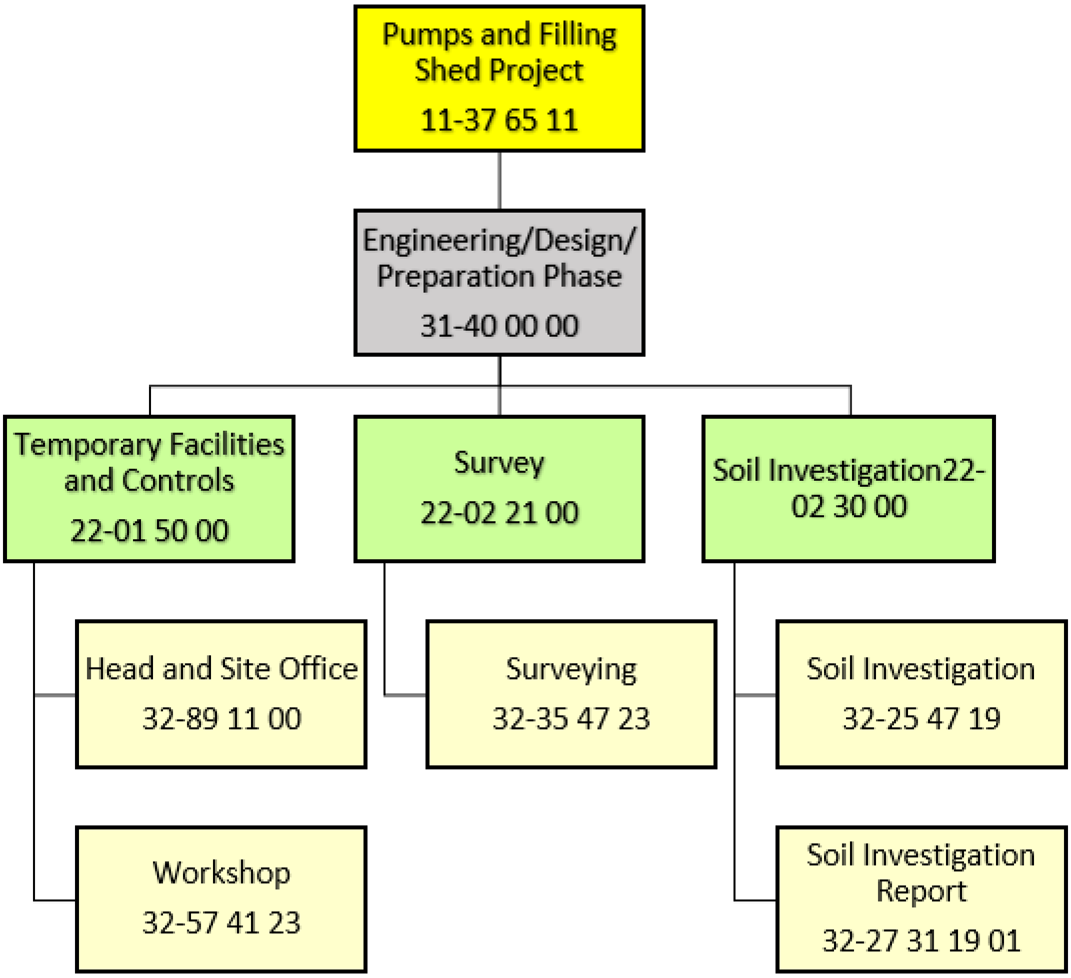
APPENDICES

APPENDIX 1 - WBS FROM OMNICLASS FOR FUEL PUMP AND FILLING SHED PROJECT (1/13)[71]



[71] By Author : **Complete Appendices demonstrating implementation details are available upon request. If you would like a copy of the full paper including complete appendices, please email the author at peter.l.panjaitan@gmail.com and the author will send the complete paper with appendices.**

APPENDIX 2 - OMNICLASS WBS CODING FOR FUEL PUMP AND FILLING-SHED PROJECTS (1/7)[72]

Omni Class Number	Table		Criteria Fulfilled
11-37 65 11	11	Construction Entities by Function	Construction of Pumps and Filling Shed Project
31-40 00 00	31	Phases	Engineering/Design/Preparation Phase
22-01 50 00	22	Work Results	Temporary Office and Workshop
32-89 11 00	32	Services	Head and Site Office
32-57 41 23	32	Services	Workshop
22-02 21 00	22	Work Results	Survey
32-35 47 23	32	Services	Surveying
22-02 30 00	22	Work Results	Soil Investigation
32-25 47 19	32	Services	Soil Investigation
32-27 31 19 01	32	Services	Soil Investigation Report
22-01 31 00	22	Work Results	Project Administration & Management
32-19 11 00	32	Services	Project Management
32-41 71 00 02	32	Services	Engineering Deliverable List
32-41 71 00 03	32	Services	Procedure
22-01 33 23	22	Work Results	Detail Engineering Design (DED)
32-35 57 43	32	Services	Calculating
32-35 57 37	32	Services	Developing
32-49 41 00	32	Services	Specifying
32-27 31 19 02	32	Services	Simulation Report HAZOP/HAZID
22-01 71 13	22	Work Results	Mobilization & Demobilization of Material and Personnel
32-57 41 11	32	Services	Mobilization & Demobilization of Personnel and Working Tools
32-57 41 17	32	Services	Material Transportation
31-60 00 00	31	Phases	Construction Phase
21-02 10	21	Elements	Civil & Structure Works
22-31 22 00	22	Work Results	Site Clearing and Grading
32-57 61 00 01	32	Services	Constructing
32-57 81 00 01	32	Services	QA/QC Process

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APPENDIX 3 - DETAILED BIDDING TEMPLATE (1/15)[73]

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	22-01 50 00	Temporary Office and Workshop	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
2	22-02 21 00	Survey	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
3	22-02 30 00	Soil Investigation	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
4	22-01 31 00	Project Administration & Management	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
5	22-01 33 23	Detail Engineering Design (DED)	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
6	22-01 71 13	Mobilization & Demobilization of Material and Personnel	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
		Subtotal Direct Construction Costs	**Rp -**	**Rp -**	**Rp -**	**Rp -**	**Rp -**	**Rp -**	**Rp -**	**Rp -**

22-01 50 00 Temporary Office and Workshop — **Total Cost:** Rp -

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 50 00	TEMPORARY OFFICE AND WORKSHOP										
32-89 11 00	Head and Site Office : Temporary facilities installed specifically to support construction activities on site, consisting of buildings or modular units used as field offices, administrative and meeting spaces, which are removed or relocated after construction is completed.	0	Manhour	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
32-57 41 23	Workshop : Temporary facilities installed specifically to support construction activities on site, consisting small workshops/storage areas for the contractor and/or supervision team, which are removed or relocated after construction is completed.	0	Manhour	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
SUBTOTAL	TEMPORARY OFFICE AND WORKSHOP	1	Unit	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -

22-01 33 16 Survey — **Total Cost:** Rp -

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 33 16	SURVEY										
32-35 47 23	Field and office activities required to establish, verify, or document horizontal and vertical control, property boundaries, and project layout, including setting out lines and grades, topographic and as-built surveys, and preparing associated survey records needed to support design, construction, and final documentation.	0	Manhour	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
SUBTOTAL	SURVEY	1	Unit	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -

22-02 30 00 SOIL INVESTIGATION — **Total Cost:** Rp -

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
22-02 30 00	SOIL INVESTIGATION										
32-25 47 19	Soil Investigation : field and laboratory work needed to determine subsurface soil and groundwater conditions—such as borings, sampling, and testing—required to support design and construction.	0	Manhour	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
32-27 31 19 01	Soil Investigation Report : the documented summary of soil and groundwater exploration results—presenting test data, analyses, and geotechnical recommendations needed for design and construction	0	Manhour	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -
SUBTOTAL	SOIL INVESTIGATION	1	Unit	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -	Rp -

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