Developing a Standardized WBS and Bidding Template Using International "Best Tested and Proven" Practice for the Boiler Project [1, 2]

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ABSTRACT

National Oil Company plans to build several oil refinery development projects in Indonesia to meet domestic fuel demand. One of the facilities to be built is a Boiler Unit to produce steam and power. The objective of this paper is to improve the Front-End Loading Phase by preparing a standardized WBS Structure and Bidding Template for the New Boiler project. The Methodology involves the use of "Best Tested and Proven" Practice in preparing the WBS Structure and Bidding Template as the Company's new standard. The study concludes that the ideal choice for the Standardized WBS Structure is to adopt the Omniclass Table because it offers significant advantages in terms of standardization, efficiency, data management, and project control. Meanwhile, the US-National Park Service Class A Cost Estimate Template is an ideal choice to be adopted as a standardized Bidding Template because it offers precise, comprehensive, and standardized cost data. By having the best standards, it can significantly improve project management, reduce cost overruns, achieve project schedule and in the future can be integrated with BIM technology.

Keywords: Work Breakdown Structure, WBS, Boiler, Omniclass, Building Information Modeling, BIM, Oil Refinery, National Park Service, NPS, Bidding Template, Decision Support Package, Cost Estimate, Front-End Loading, National Oil Company

INTRODUCTION

A. The Needs of The Oil Refinery Development Projects in Indonesia

The trend of fuel oil demand in Indonesia continues to increase by 3% per year and is predicted to reach 1.5 million barrels/day in 2030. Meanwhile, the existing oil refinery owned by the National Oil Company can only produce around 729 thousand barrels daily.

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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/

Therefore, Indonesia must meet domestic needs through imports. This condition will undoubtedly affect Indonesia's state finances. Hence, through its National Oil Company, Indonesia plans to increase the production capacity of oil refineries to meet domestic fuel needs by building new and expanding the capacity of existing oil refineries through the Refinery Development Masterplan (RDMP) program.

The trend of demand for fuel oil in Indonesia continues to increase, as per the figure below:

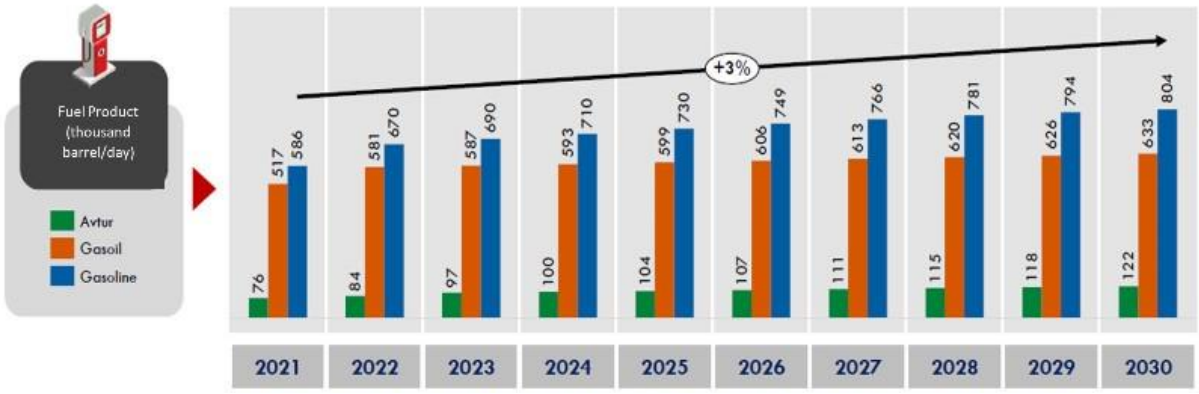


Figure 1. The Trend of Domestic Demand for Fuel Products [3]

According to the Roadmap for Oil Refinery Development by National Oil Company throughout Indonesia (Figure 2), NOC plans to increase the national oil refinery production capacity through 10 Existing Oil Refinery Development Projects (RDMP) and four new oil and petrochemical refinery development projects (grass root refinery) (blue color).

[3] Pertamina Energy Institute. (2022, July 22). *Pertamina Energy Outlook 2021, A Perspective to 2060*. Pertamina. Retrieved August 28, 2024, from: https://www.pertamina.com/id/digital-media/pertamina-energy-institute

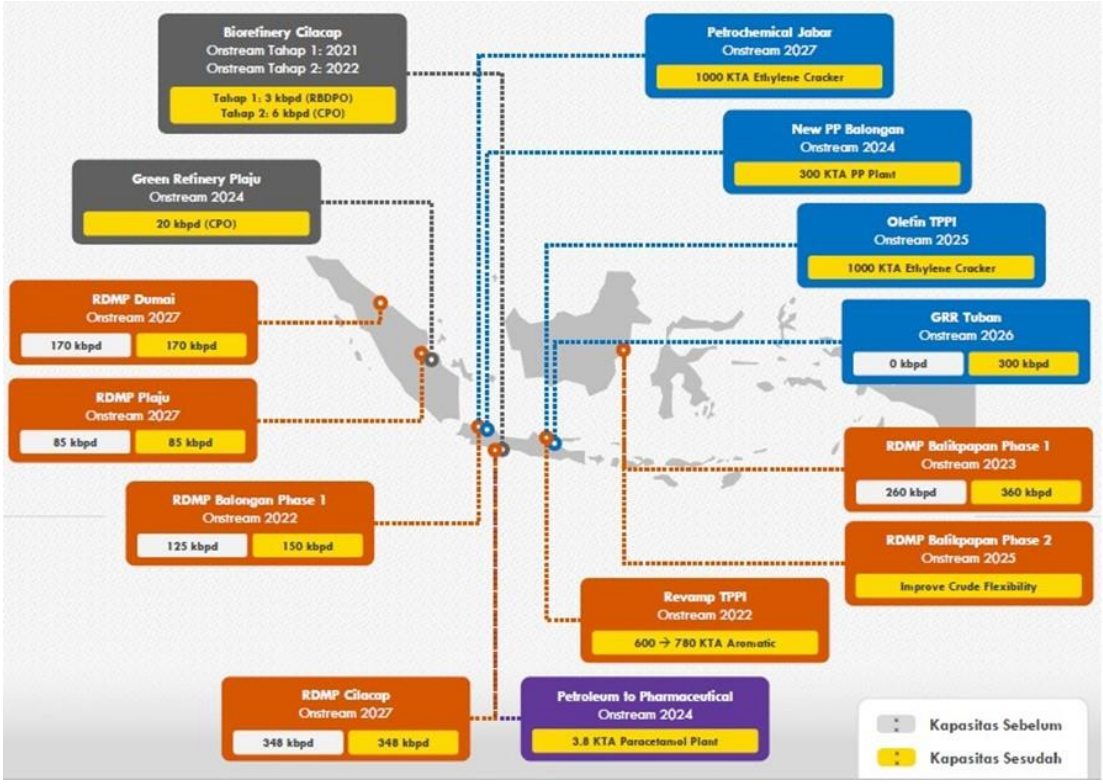


Figure 2. The Roadmap of Oil Refinery Development by National Oil Company [4]

B. Installation of Boiler Facilities in Refinery Development Projects

The addition of Utility facilities, including Boiler Facilities, will follow the planning of the oil refinery development. For example, for the existing oil refinery development project in Balikpapan, Indonesia, there will be an addition of 5 New HHP Boiler units and 1 New LP Boiler unit from the previous Balikpapan Oil Refinery, which only had six existing Boiler units, with the following data:

No	Utility Facilities	Capacity/unit	Remark
1	HHP Boiler, 6 unit	@70 Ton/h	Existing
2	HHP Boiler, 5 unit	@262 Ton/h	Future (New)
3	LP Boiler, 1 unit	@15 Ton/h	Future (New)

Table 1. Data of Boiler Facilities in the Balikpapan Oil Refinery [5]

[4] Pertamina. (2022, July 20). *Refinery & Refinery Development Sector*. Pertamina. Retrieved August 27, 2024, from: https://www.pertamina.com/id/refinery--refinery-development-sector/
[5] Pertamina. (2022, July 20). *Profil Refinery Unit V Balikpapan*. Pertamina. Retrieved August 27, 2024, from: https://www.pertamina.com/id/refinery-unit-v-balikpapan

A boiler is a pressure vessel that provides a heat transfer surface (generally a set of tubes) between the combustion products and the water. It is usually integrated into a system with many components. The generation part of a steam system uses a boiler to add energy to a feedwater supply to generate steam. [6]

The National Oil Company's implementation of oil refinery development projects in other regions in Indonesia will be followed by the construction of numerous boiler facilities to adjust the needs of each Oil Refinery. In this paper, the author will focus on the Construction of Boiler Facilities in the Balikpapan Oil Refinery.

Based on the historical projects of the National Oil Company implemented in the Balikpapan Oil Refinery area, at least 90% of the projects have been delayed from the planned schedule. According to Wisnugroho, "At least about 56% of projects experience 10% cost and schedule overrun, and 36% of projects experience up to 25% cost and schedule overrun at 45 samples of Indonesian Oil & Gas projects." [7] Therefore, an improvement strategy is needed from the early stages of project planning to achieve the planned target of "on schedule and on budget."

As explained above, Boiler facilities are mainly important in an oil refinery development project because they produce steam and power. This situation presents a great opportunity for improvement to make designing activities and keeping track of the new Boiler system easier than before. We can do this using a set plan or a "Standardized WBS Template" coupled with a "Standardized Bidding Template" that can be copied into other projects, making the process much more straightforward and efficient.

C. New Boiler System WBS and Procurement Activities

In order to make the New Boiler System construction and monitoring activities easier, the author believes that the three things that the National Oil Company needs to address are shown below:

1. The New Boiler Specification Standardization

The purpose is that the Boiler facilities to be built have relatively few variances or, in other words, similar standards. This will make it easier for the Company to plan the construction of boilers that will be used for several refinery development projects in Indonesia.

[6] ABMA. (2024, January 2). *Boiler 101: What is a Boiler?* ABMA. Retrieved August 27, 2024, from: https://www.abma.com/boiler-101

[7] 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. https://pmworldlibrary.net/wp-content/uploads/2020/02/pmwj90-Feb2020-Wisnugroho-benchmarking-indonesia-og-cost-estimating-vs-international3.pdf

2. Standardized Work Breakdown Structure (WBS) for New Boiler Project

"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 major causes of cost overrun: "Omit Probable Scope from Estimate and Omit Probable Risk from Analysis." [8]

According to Andrian [9], "Standardizing the WBS is essential for creating a reliable database, enhancing data collection and sharing across programs. This standardization leads to more accurate cost estimates, effective resource allocation, reduced budget risks, and improved project completion rates."

3. Standardized Bidding Template for New Boiler Project

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

a) The Company can better manage project costs and stay within previously authorized and appropriate limits.
b) Project costs and scope changes (in this case, Boiler) 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.
e) Improved estimate documentation will improve review efficiencies and shorter review cycle times.
f) Facilitate 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." [10]

Based on The Company's current practices, all bidding activities conducted at Class 2 Estimate Class where maturity is already around 30-75% refer to AACE Recommended

[8] 1.4.1.10 Unit 10- *Managing cost estimating and budgeting*. (2022, October 24). PTMC. https://build-project-management-competency.com/1-4-1-10-unit-10/
[9] 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
[10] National Park Services. (2023). *Construction Cost Estimating Requirements Handbook*. National Park Service (NPS) - Denver Service Center (DSC).

Practice 18R-97. The problem arises because, until now, our current bidding template has yet to be measured or compared to other best practices bidding templates, such as the National Park Service. Comparing the bidding templates of the companies and other institutions could help the companies obtain the "best tested and proven practices" and develop specific recommendations to improve our Company's bidding template.

	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 2. Cost Estimate Classification Matrix for Process Industries [11]

Based on the information above, through this paper, the author will develop a standardized WBS and Bidding Template to answer the following research questions:

1. What is the suitable Work Breakdown Structure (WBS) / Cost Breakdown Structure (CBS) for the New Boiler Project that covers all aspects and phases of the project, allowing various stakeholders to utilize it for cost estimation and scheduling?
2. What is the best format for a bidding template that can be used as a standard for the New Boiler Project?

METHODOLOGY

The author will develop a methodology referring to the procedure described by Sullivan.[12] In **Error! Reference source not found.**.

[11] 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.
[12] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2020). *Chapter 2 Cost Concepts and Design Economics*. In Engineering Economy Global Edition (17th ed.). Pearson UK.

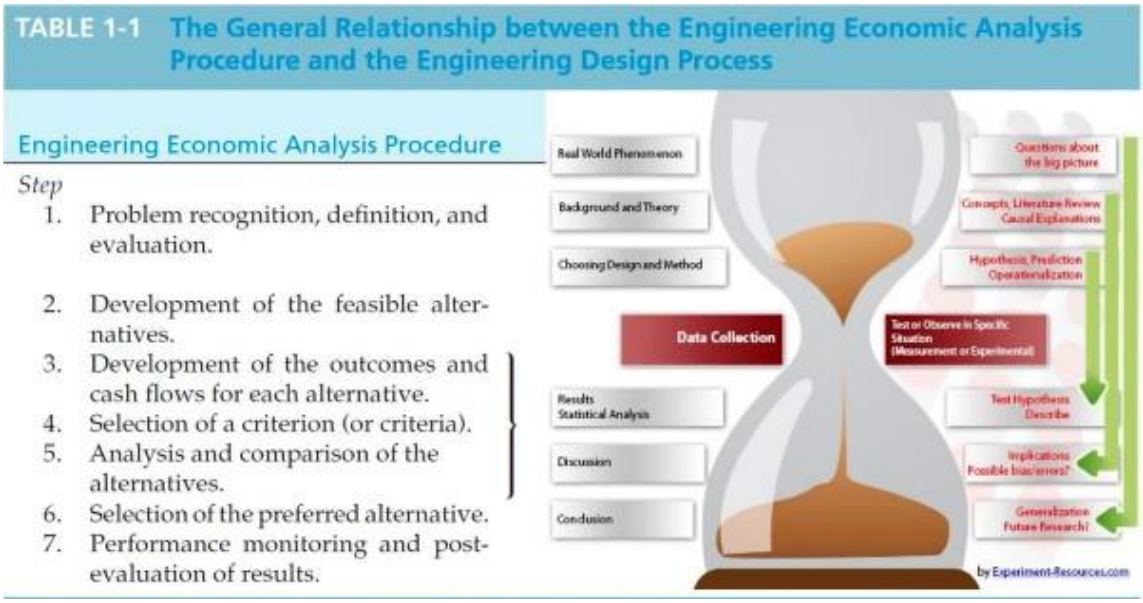


TABLE 1-1 The General Relationship between the Engineering Economic Analysis Procedure and the Engineering Design Process

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

Figure 3. Engineering Economic Analysis Procedure [13] & Step of the Scientific Process [14]

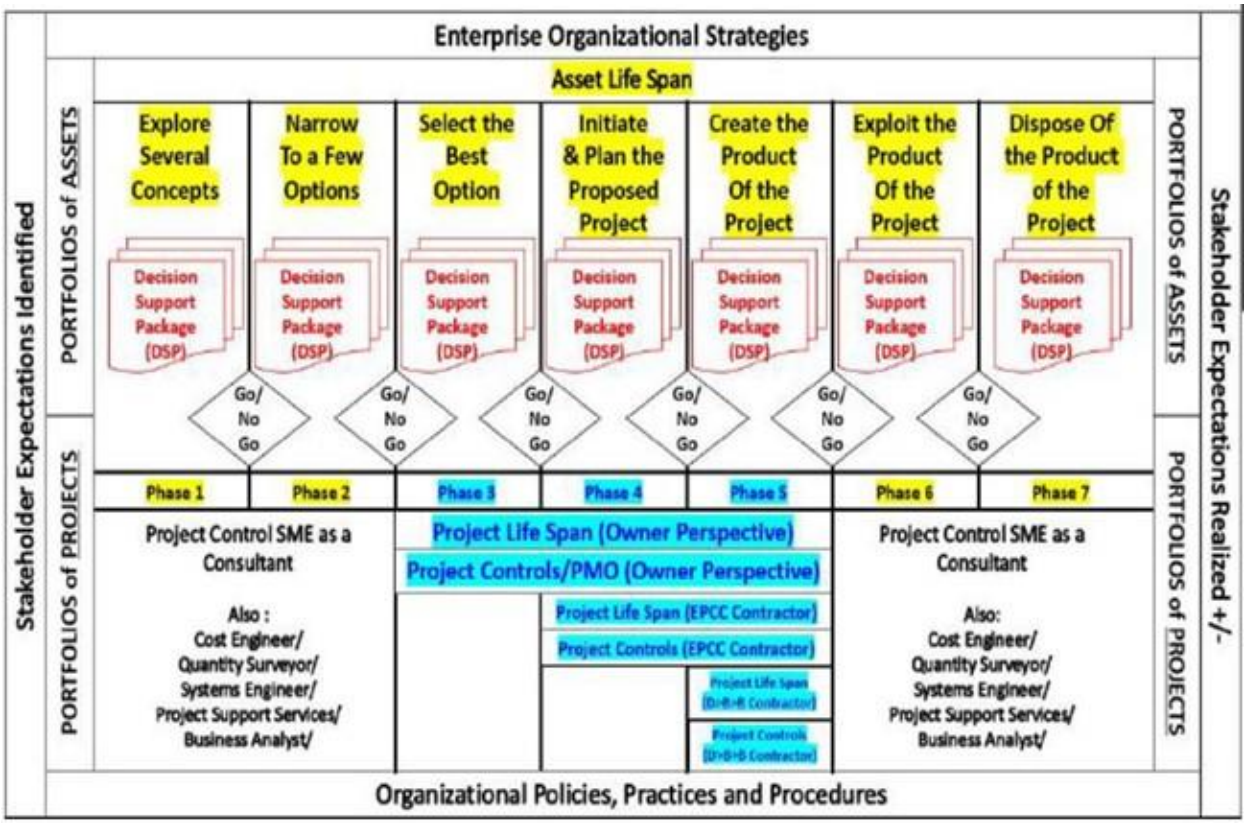
The explanation as shown in **Error! Reference source not found.** is explained in detail below:

1. "**Problem Recognition** is a clear description of the identified essential issues; this step is followed by the Refining the Research Paper Question phase to break it down into more specific problems.
2. **Development of Feasible Alternatives** is a verification process that involves other researchers reviewing the results, replicating the experiment, and assessing its reliability to develop a range of alternative possibilities.
3. **Development of the Outcomes for Each Alternative** accurately describes the data collection methods and tools.
4. **Selection of a Criterion (or Criteria)** explains how raw data is compiled and analyzed."
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.

[13] Ibid
[14] Shuttleworth, M. (2008, February 2). *What is research?* https://explorable.com/what-is-research

7. The Company will carry out **performance monitoring and post-evaluation** results after implementation to determine the performance and understand the effectiveness of the selected alternative."[15]

As a project owner, National Oil Company views a project as an investment center. From the Owner's perspective, National Oil Company is more appropriate in viewing a project in the framework of Asset life Span rather than project life span, so it not only requires tactics in completing the project but also requires a strategy for managing its assets. For this reason, National Oil Company needs to view projects as a whole that are integrated with the Company's strategy in managing Asset Life Span. Figure 4 shows that The Asset Life Span consists of 7 phases. The Bidding Process stage is included in phase 4: "Initiate & Plan the Proposed project." Phase 4 is where the Owner will start to involve the contractor.[16] Figure 5 explains The Decision Support Package for Phase 4.



[15] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2020). *Chapter 2 Cost Concepts and Design Economics*. In Engineering Economy Global Edition (17th ed.). Pearson UK.
[16] Giammalvo, P. D., & PTMC. (2024, April 22). *1.4.1.1 Unit 1- Governance and Integration*. https://build-project-management-competency.com/1-4-1-1-unit-1/

Figure 4. Waterfall Model of the Integrated Asset, Portfolio, Program, and Project Management Methodology [17]

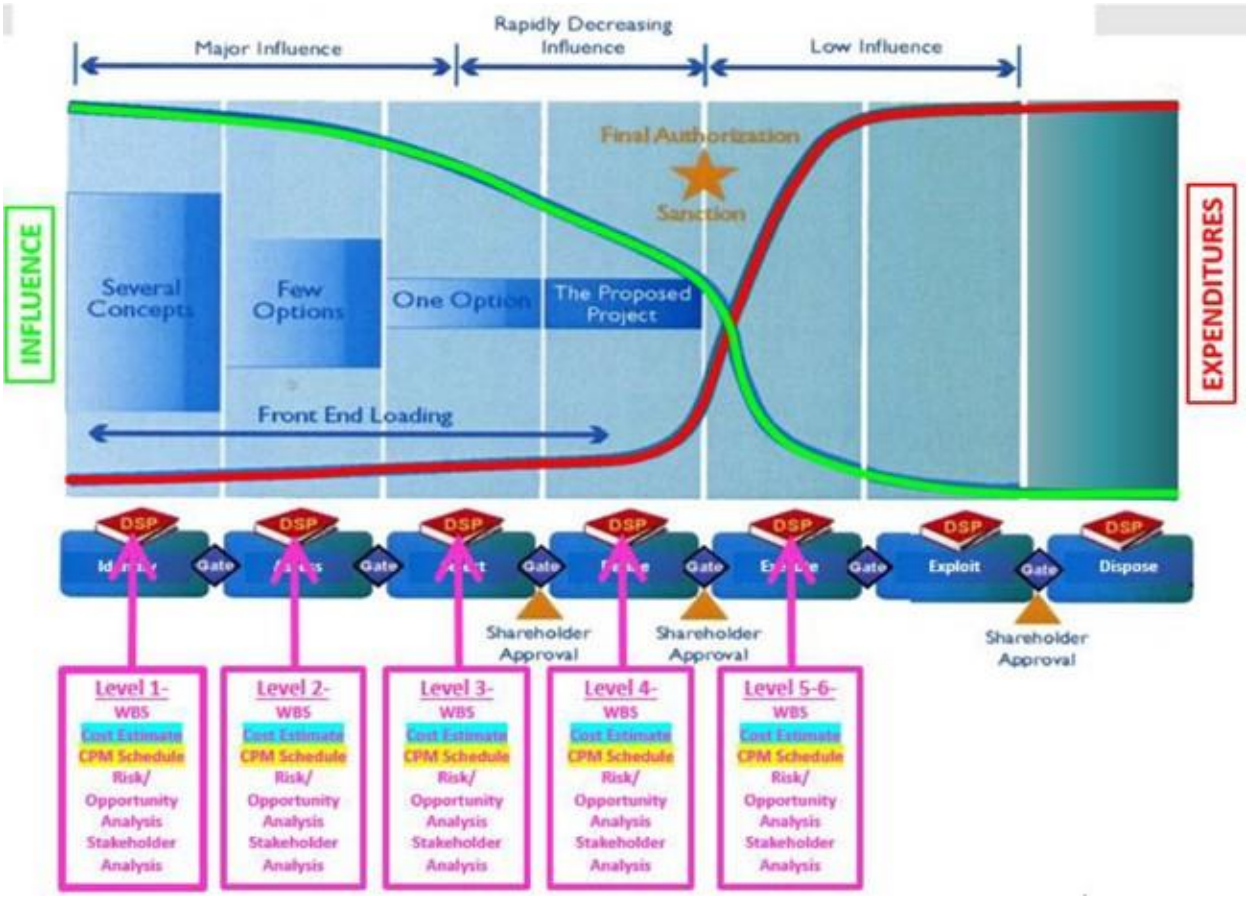


Figure 5. Decision Support Package (DSP) Information (MacLeamy, Paulson, or Boehm Curve) [18]

In Figure 5, we can see the Minimum list of deliverables expected to be included in each Decision Support Package (DSP) to help the appropriate stakeholders make the "Go/No Go" decision. The graph explains that the better the work done in the Front-End Loading (FEL) phase, namely defining what we need and want as early as possible in the asset life span, the cheaper it will be to make changes early on. Likewise, if we do not prepare the FEL phase well, it will be more expensive to fix it in the project execution phase. [19]

As illustrated in Figure 5, by the time we get to Phase 4, we should have sufficient detail to be able to put the project out for bid, namely Level 4 WBS, which should be defined

[17] Ibid
[18] Giammalvo, P. D., & PTMC. (2024, April 22). *1.4.1.4 Unit 4- Managing Scope*. https://build-project-management-competency.com/1-4-1-4-unit-4/
[19] Ibid

before going out to bid. The author will develop the standardized Level 4 WBS in the New Boiler Project.

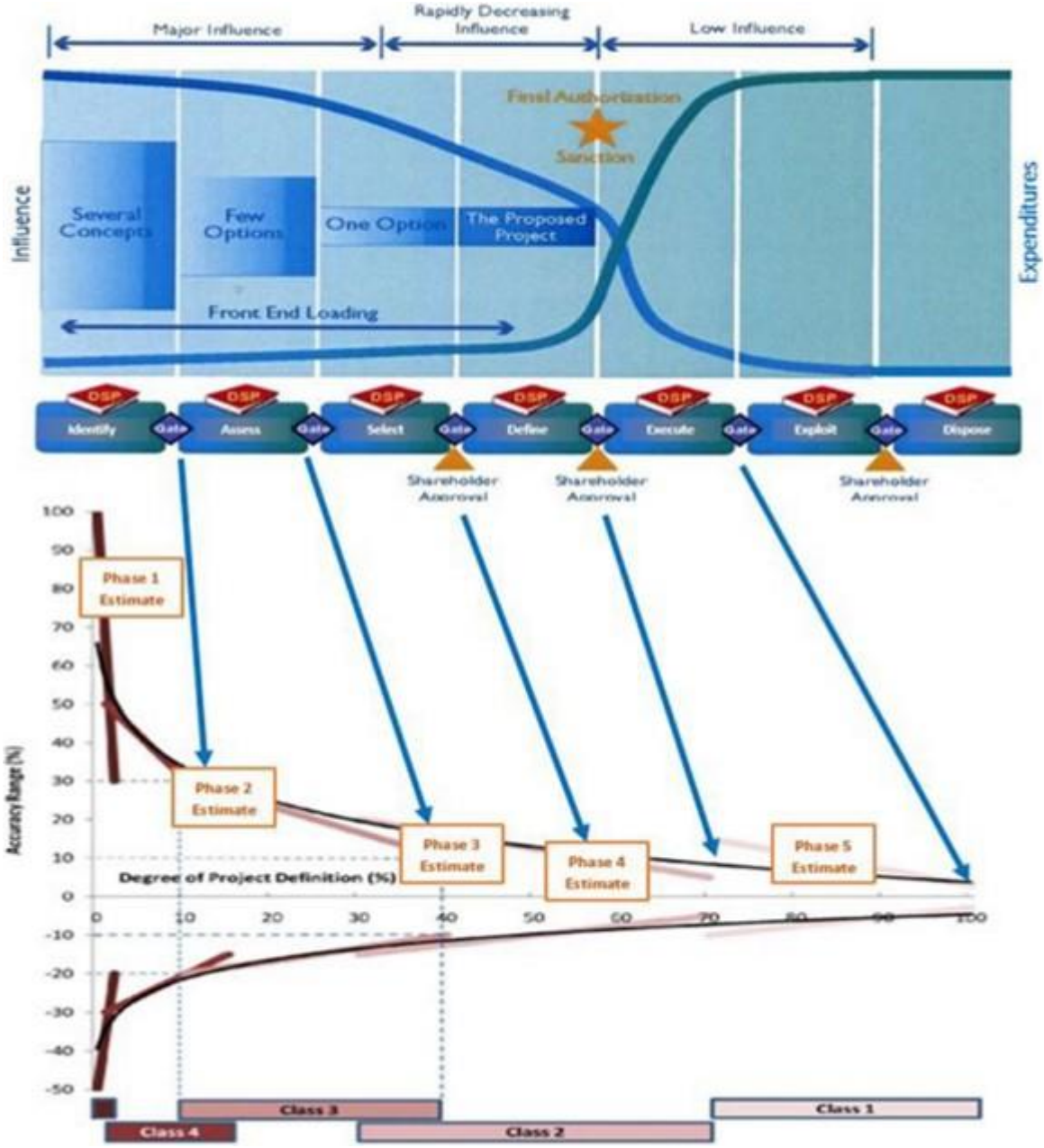


Figure 6. Relationship between Estimate Phase and Cost Estimate Classification

The relationship between the Estimate Phase from Figure 5 and the Cost Estimate Class can be seen in Figure 6. From Figure 6, we can see that in phase 4, especially for the bidding phase, Class 2 or even Class 1 can be used. In Class 2, the estimated maturity level is 30 to 75%. Currently, the National Oil Company uses Class 2 Estimate Class for all bidding activities. The author will compare the current Company's Bidding Template

with other best practices bidding templates, such as the National Park Service, to obtain the "best tested and proven practices" and to improve the Company's bidding template.

The author will then develop the standardized level 4 - WBS in the New Boiler Project using the Tables in Omniclass, namely Tables 11, 21, 22, 23, 31, 32, 33, and 36, with the following explanation:

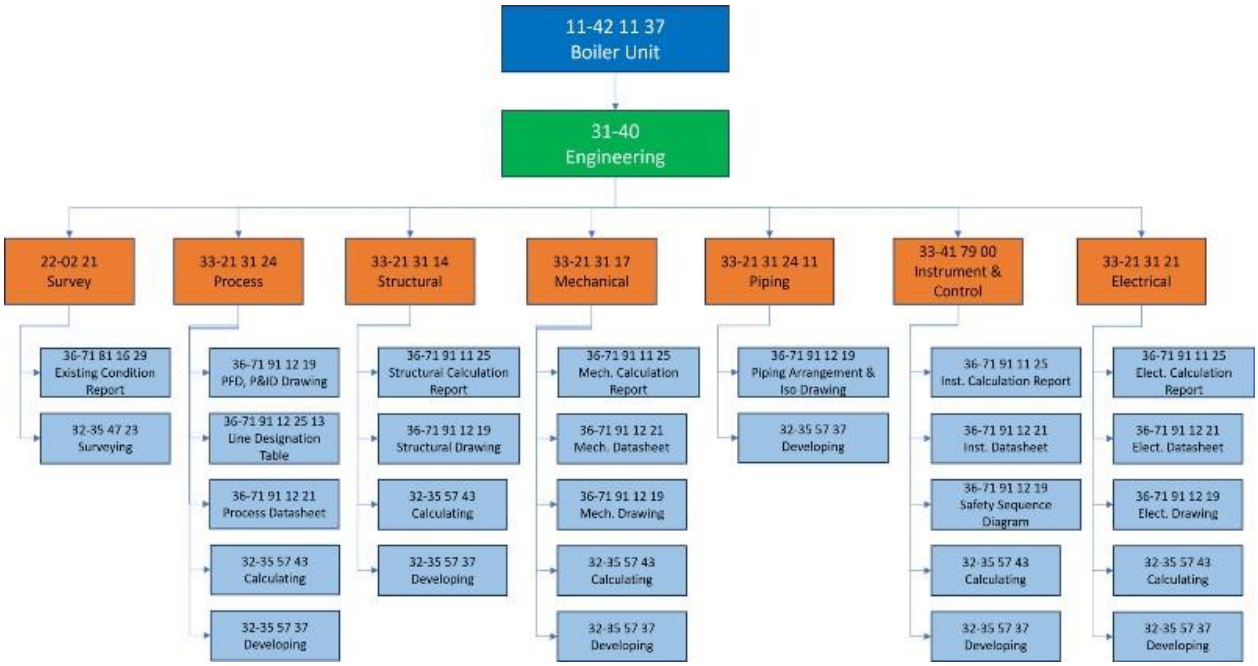
Table ID	Name	Definition	WBS Usage
Table 11	Construction Entities by Function	The table categorise any definable units/building/entities of the environment where construction happening that consist of interelated spaces and elements and characterized by function. E.g. : Single Family Residence, Mining Facility, Local Transit Bus Station, Interstate Highway	Can be used as Level 1 of WBS
Table 21	Element	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" (ISO 12006-2:2015). Predominating functions include, but are not limited to, supporting, enclosing, servicing, and equipping a facility. Functional descriptions can also include a process or an activity. E.g. : Structural Floors, Exterior Walls, Storm Sewer Utility, Stairs, Roof Framing, Furniture and Fittings, HVAC Distribution	Can be used for displaying information about element that New Boiler Unit need in the design phase and implementation phase, abstract of parts that should be fullfiled for this project that can be met by "work result" (Table 22)
Table 22	Work Result	Work Results are construction results achieved in the production stage 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 work which results. (ISO 12006-2). E.g.: Cast-in-Place Concrete, Structural Steel Framing, Finish Carpentry, Built-Up Bituminous Waterproofing, Glazed Aluminum Curtain Walls	Can be used for displaying the "work result" / realization of elements that design for the Boiler Unit according to Table 21
Table 23	Products	Products are components or assemblies of components intended for permanent incorporation into construction entities. E.g.: Concrete, Common Brick, Door, Metal Window, Electrical Junction Boxes, Pipe Culverts, Fire Tube Boiler, Curtain Walls, Textured Paints	Can be used since it shows the kind of products / semi finished material needed to realize the table 21 and table 22
Table 31	Phases	A phase is a period of time in the duration of a construction project identified by the overall character of the construction processes which occur within it. E.g.: Inception Phase, Conceptualization Phase, Criteria Definition Phase, Design Phase, Coordination Phase, Implementation Phase	Can be used for showing Phases of New Boiler Unit Project
Table 32	Service	Services are the activities, processes and procedures provided by participants in the design and construction process, and relating to the construction, design, maintenance, renovation, demolition, commissioning, decommissioning, and all other functions occurring in relation to the life cycle of a construction entity. E.g.: Programming, Bidding, Estimating, Constructing, Surveying, Maintaining, Inspecting.	Can be used to show activities needed in design phase, construction phase and handover phase.
Table 33	Disiplines	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. E.g.: Architecture, Interior Design, Mechanical Engineering, General Contracting, Legal Services, Finance, Real Estate Sales.	Can be used for displaying information about Disiplines that New Boiler Unit need in the design phase.
Table 36	Information	Information is data referenced and utilized during the process of creating and sustaining the built environment. E.g.: Guides, Periodicals, Design Drawings, Specifications, Codes, Leases, Deeds, Catalogs, Operations and Maintenance Manuals	Can be used since it shows the kind of product (in information form) needed to realize the table 33 of design phase.

Table 3. Omniclass Table for the New Boiler Project [20]

Step 1 – Problem Definition

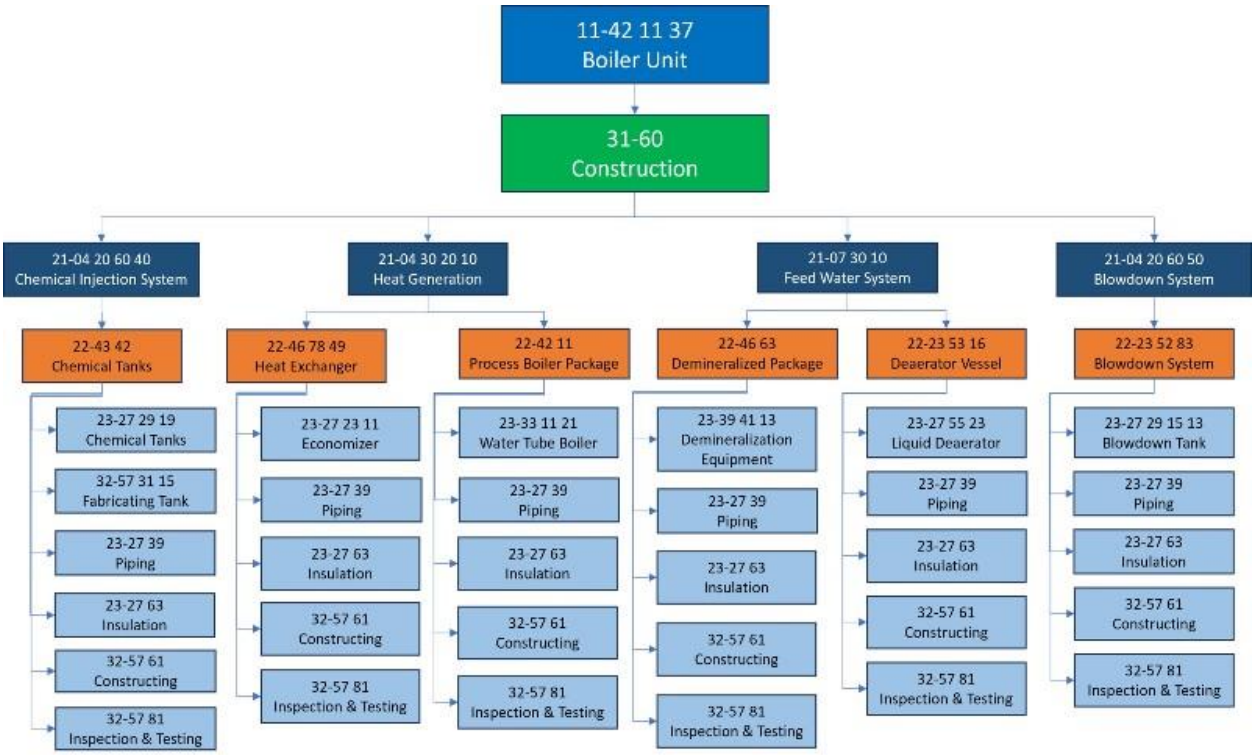
As explained previously, the National Oil Company wants to complete all its projects, especially the New Boiler project, on schedule and within budget. According to Wisnugroho, "At least about 56% of projects experience 10% cost and schedule overrun, and 36% of projects experience up to 25% cost and schedule overrun at 45 samples of Indonesian Oil and gas projects." [21] Therefore, improvements need to be made since the Early Front-End Loading (FEL) phase, one of which is using Level 4 WBS in Phase 4 of FEL, as illustrated in Figure 5, and then continuing by utilizing the proper standardized bidding template.

Based on Table 3, the author has developed the Omniclass table (Table 11, 21, 22, 23, 31, 32, 33, and 36) into a Level 4 WBS structure for the New Boiler Unit as shown in Figure 7 below, along with the detail of WBS Elements from said Omniclass Tables (Table 4). Figure 7 is presented more entirely in **Appendix 1**, while Table 4 is presented more thoroughly in **Appendix 2**.



[20] Omni Class. (2020). *Construction Entity by Function - Table 11, 21, 22, 23, 31, 32, 33 and 36*. Retrieved from: https://www.csiresources.org/standards/OmniClass

[21] 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



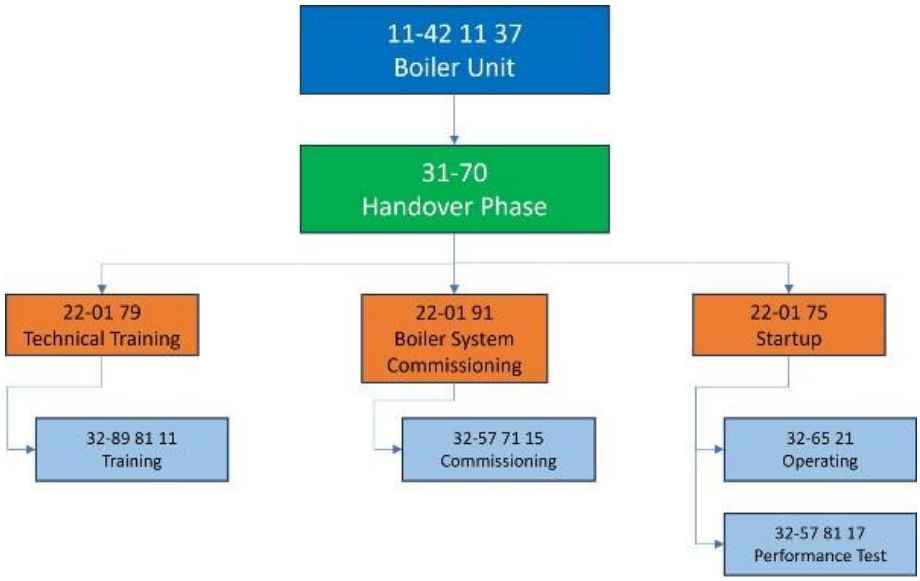


Figure 7 – The Omniclass WBS Organization for New Boiler Unit [22] [23]

OmniClass Number	Omniclass Title	Criterion Fullfiled
Table 11 (Construction Entities by Function)		
11-42 11 37	Steam Production Facility	Level 1
Table 31 (Phases)		
31-40 00 00	Design Phase	Engineering Phase
31-60 00 00	Implementation Phase	Construction Phase
31-70 00 00	Handover Phase	Handover Phase
Table 33 (Disiplines)		
33-21 31 24	Process Engineering	Process
33-21 31 14	Structural Engineering	Structural
33-21 31 17	Mechanical Engineering	Mechanical
33-21 31 24 11	Piping Engineering	Piping
33-41 79 00	Control and Communication Services	Instrument & Control
33-21 31 21	Electrical Engineering	Electrical
Table 32 (Service)		
32-35 47 23	Surveying	Surveying
32-35 57 43	Calculating	Calculating
32-35 57 37	Developing	Developing
32-57 61	Constructing	Constructing
32-57 71	Post Construction	Post Construction
32-57 81	Assuring	Inspection
32-57 31 15	Fabricating	Fabricating Tank
32-57 81	Assuring	Inspection & Testing
32-57 61 29	Installing	Installing
32-89 81 11	Training	Training
32-57 71 15	Commissioning	Commissioning
32-65 21	Operating	Operating
32-57 81 17	Testing	Performance Test

Table 4 – Proposed Codes for New Boiler Unit WBS [24] [25]

To obtain the Bidding Template standardization according to the initial purpose of this paper, all WBS needed to realize The New Boiler Unit will be rearranged and put into the Company's bidding template. However, before proceeding, we need to review the Company's currently used bidding template.

To obtain the Standardized Bidding Template according to the initial purpose of this paper, all Omniclass WBS needed to realize The New Boiler Unit will be rearranged and put into the bidding template. The problem is which Bidding template should be used, whether to use the current Company's Bidding template or the "best tested and proven practices" bidding template in the world. A comprehensive evaluation must be done to determine

[22] Author
[23] Omni Class. (2020). *Construction Entity by Function - Table 11, 21, 22, 23, 31, 32, 33 and 36*. Retrieved from: https://www.csiresources.org/standards/OmniClass
[24] Author
[25] Omni Class. (2020). *Construction Entity by Function - Table 11, 21, 22, 23, 31, 32, 33 and 36*. Retrieved from: https://www.csiresources.org/standards/OmniClass

which bidding template will be selected before it is used as a standardized one. National Oil Company needs to create the best standardized WBS and standardized bidding template that can be used effectively and accurately not only in the Balikpapan RDMP project but also in similar projects within the National Oil Company and its subsidiaries.

Step 2 – Development of Feasible Alternatives

In developing the standardized bidding template, the author tried to look at 2 alternative bidding templates as follows:

A. Current Company's Bidding Template

The National Oil Company's bidding template usually categorizes each scope of work based on discipline (Civil, Mechanical, Piping, Electrical, Instrumentation, & Control) as a Direct Cost component, as shown in Figure 8 (The Company's Bidding Template). Other components, such as Site Office Cost, Engineering Services, Training, Commissioning, and startup, are included in the Indirect Cost component.

BRAKDOWN OF PROJECT COST
PROJECT TITLE
Revision: .....
Date: .....

No	Item Description	Volume	Units	Unit Price		Total Price	
				Material	Services	Material	Services
A.	**DIRECT COST**						
I.	**CIVIL WORK**						
1	Site Survey	xxx	xx	$	$	$	$
2	Foundation	xxx	xx	$	$	$	$
3	.....	xxx	xx	$	$	$	$
	Sub-Total I					$	$
II.	**MECHANICAL WORK**						
1	Vessel	xxx	xx	$	$	$	$
2	Tank	xxx	xx	$	$	$	$
3	.....	xxx	xx	$	$	$	$
	Sub-Total II					$	$
III.	**PIPING WORK**						
1	Condensate Line	xxx	xx	$	$	$	$
2	Fuel Gas Line	xxx	xx	$	$	$	$
3	.....	xxx	xx	$	$	$	$
	Sub-Total III					$	$
IV.	**ELECTRICAL WORK**						
1	Electrical Cable	xxx	xx	$	$	$	$
2	Cathodic Protection	xxx	xx	$	$	$	$
3	.....	xxx	xx	$	$	$	$
	Sub-Total IV					$	$
V.	**INSTRUMENT & CONTROL WORK**						
1	Field Instrument	xxx	xx	$	$	$	$
2	Instrument Cable	xxx	xx	$	$	$	$
3	.....	xxx	xx	$	$	$	$
	Sub-Total V					$	$
	Total Direct Cost = (I+II+III+IV+V)					$	$
B.	**INDIRECT COST**						
1	Site Office Cost	xxx	xx	0	$	0	$
2	Engineering Services	xxx	xx	0	$	0	$
3	Training	xxx	xx	0	$	0	$
4	Commissioning & Startup	xxx	xx	0	$	0	$
5	.....	xxx	xx	0	$	0	$
	Total Indirect Cost					0	$
		TOTAL DIRECT + INDIRECT COST				$	$
		CONTRACTOR PROFIT & RISK (8% OR 10% OR 15%)					$
		TOTAL COST					$

Figure 8- The Company's Bidding Template

According to The Company's Bidding Templates (Figure 8), The National Oil Company builds the bidding template using these steps:

1. The first step is to identify all assets that will be realized in a project based on the prepared Scope Of Work. These assets are then broken down into a more detailed Work Breakdown Structure and created per discipline.
2. The second step is to calculate the Unit Price value for materials and services in each WBS and then calculate the total value.
3. After that, we put the specification information for each asset in this project.
4. Finally, the bidding template would allow the cost estimator to input the contractor's profit margin amount. Company policy limits the margin to 5% of the contract value if the transaction is in US Dollars. [26]

B. US-National Park Service (NPS) Bidding Template

The US National Park Service (NPS) has developed a Complete Bidding template that understands the contractor's scope perspective well and uses that knowledge to its advantage. [27]

NPS creates a standardized Bidding Template for cost estimation that all estimators must follow in its institution. There are several levels of cost estimation according to their use, which are regulated in detail in the NPS Construction Cost Estimating Requirements Handbook. Several levels of cost estimation are addressed in the Estimate Classifications and Accuracy table below:

DOI Estimates 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%

[26] Kilang Pertamina Internasional. (2023). *TKI Pembuatan Owner Estimate No.C06-001/KPI73000/2023-S9*. Kilang Pertamina Internasional (KPI).
[27] 1.4.1.4 Unit 4- Managing Scope. (2021). PTMC. https://build-project-management-competency.com/1-4-1-4-unit-4/

Table 5 – NPS Estimate Classification and Accuracy [28]

NPS recognizes three levels of estimating: Class C, Class B, and Class A. The following shows cost-related submissions and the level of estimate required through design:

a) 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 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 the range of -20 % to +50%.

b) Class B Construction Cost Estimate

Any cost Estimate could fall into this Class B cost estimate, usually known as **budgetary estimates** if the 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 budget purposes. Class B estimates have an accuracy range of -10 % to +20%.

c) 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%.

Based on the explanation above, The Class A (Class 1) Format is the most suitable estimation class incorporating the Contractor's Point of View on the scope of work. This format is detailed enough to be used by Contractors in submitting bids or Owners in preparing accurate Owner Estimates.

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

Figure 9 illustrates the template the National Park Services uses for estimating projects at the Class A level.

Project:	Project Name										Estimate By:		Estimator Name	
Park:	Park Name										Date:		Estimate Date	
Park Alpha:	Park Alpha Code										Reviewed By:			
PMIS Number:	TBD or PMIS number if known										Date:			
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	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	
Bid Item: 6	Asset / Project Element 6							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 6	Asset / Project Element 6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	
Bid Item: 7	Asset / Project Element 7							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 7	Asset / Project Element 7	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	
Bid Item: 8	Asset / Project Element 8							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 8	Asset / Project Element 8	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	
Bid Item: 9	Asset / Project Element 9							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 9	Asset / Project Element 9	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	
Bid Item: 10	Asset / Project Element 10							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 10	Asset / Project Element 10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	
	Total Bid Items 1-10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		$ -	

Figure 9- National Park Services Bidding Template (Class A Cost Estimate) [29]

[29] 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

Step 3 – Development of the Outcomes for Each Alternative

After analyzing the information in steps 1 and 2 above, it can be concluded that there are several fundamental differences between the NPS Bidding Template and the Company Bidding Template, including the following:

NPS Bidding Template	Company Bidding Template
1. All WBS are organized under Assets or Project Elements / Services. This is preferred as it is ideal for communication between the Contractor and the company's Project Control personnel in monitoring budget and work schedule progress.	1. All WBS are organized under disciplines, making it easier to search for information based on discipline, but not ideal for communication between contractor and the Company's project control personnel in terms of monitoring budget and work schedule progress.
2. The price components consist of material costs, labor costs, equipment costs and direct construction costs so that there is more detail in budget planning and monitoring.	2. The price components only consist of material costs and labor costs (service costs) so there is a lack of detail in budget planning and monitoring.
3. The Preparation and Handover Phase components are included in the main components (Bid items) and are separate.	3. The preparation & Handover Phase components are not included in the main components (Bid items) but are combined into one in the Indirect Cost component.

Table 6 – Differences between NPS Bidding Template and Company Bidding Template

Based on the comparison above, the author found that the NPS Bidding Template, aligned with the NPS Class A Estimate format, is the ideal choice because it is superior in several aspects, as explained in the table above.

Step 4 – Selection of Criteria

As explained previously, the author has created a Level 4 WBS structure for the New Boiler Unit, as shown in Figure 7. From the WBS structure, we can determine the criteria we will include in the Bidding Template. Based on Table 7, the author describes the Scope of Work of the New Boiler Unit Project into 3 phases: Engineering, Construction, and Handover Phases. Specifically for the Engineering phase, the author describes it in the form of scientific disciplines to make it easier for the Engineering department to work on and monitor the results of their work, While the Construction and Handover Phases are described in the form of Assets/elements/services.

We need a Bid Template that can accommodate the criteria in Table 7 while remaining consistent with the Level 4 WBS structure described in Figure 7.

Group of Attributes	Purpose	Criteria
ENGINEERING	In the Engineering Design phase, the division of work per discipline will make it easier for each department to work on and monitor the results of their work. These attributes consist of WBS components in the engineering phase that must be completed in the design of the New Boiler Unit.	Surveying
		Process Design
		Structural Design
		Mechanical Design
		Piping Design
		Instrument & Control Design
		Electrical Design
CONSTRUCTION	The construction phase is an important phase in a project where in this phase the construction of the New Boiler Unit and its supporting components is carried out based on the drawings and documents that have been made in the previous Engineering design phase. The attributes include important WBS components that must be built and inspected carefully during the construction phase.	Foundation of Chemical Tanks
		Foundation of Heat Exchanger
		Foundation of Boiler Package
		Foundation of Demineralized Package
		Foundation of Deaerator Vessel
		Foundation of Blowdown System
		Foundation of BFW Pump
		Foundation of Chemical Dosing Pump
		Foundation of Treated Water Pump
		Foundation of Draft Fan
		Foundation of Piperack
		Foundation of Equipment Structure
		Piperack
		Equipment Structure
		Chemical Tanks
		Heat Exchanger
		Boiler Package (Including Stack)
		Demineralized Package
		Deaerator Vessel
		Blowdown System
		BFW Pump
		Chemical Dosing Pump
		Treated Water Pump
		Draft Fan
		Instrumentation & Control Work
		Common Work for Electrical
		Cathodic Protection
HANDOVER PHASE	These attributes consist of WBS activities related to the final phase of the New Boiler Unit Project and to test the entire system before declaring Operational Acceptance.	Technical Training
		Boiler System Commissioning
		Startup & Performance Test

Table 7. New Boiler Unit's Scope of Work [30]

Step 5 – Analysis of The Alternatives

The author then tried to use the NPS Class A Bidding Template to create a Project Cost summary as follows:

Bid Item No.	Bid Item Description	Total Material Cost	Total Labor Cost	Total Equipment Cost	Total Direct Construction Costs	Bid Item Total
Bid Item: 1	**Engineering**					$ -
22-02 21	Survey	$ -	$ -	$ -	$ -	
33-21 31 24	Process Engineering	$ -	$ -	$ -	$ -	
33-21 31 14	Structural Engineering	$ -	$ -	$ -	$ -	
33-21 31 17	Mechanical Engineering	$ -	$ -	$ -	$ -	
33-21 31 24 11	Piping Engineering	$ -	$ -	$ -	$ -	
33-41 79 00	Instrument & Control Engineering	$ -	$ -	$ -	$ -	
33-21 31 21	Electrical Engineering	$ -	$ -	$ -	$ -	
Total - Bid Item 1	**Engineering**	$ -	$ -	$ -	$ -	$ -
Bid Item: 2	**Construction**					$ -
22-43 42	Foundation of Chemical Tanks	$ -	$ -	$ -	$ -	
22-46 78 49	Foundation of Heat Exchanger (Economizer)	$ -	$ -	$ -	$ -	
22-42 11	Foundation of Boiler Package	$ -	$ -	$ -	$ -	
22-46 63	Foundation of Demineralized Package	$ -	$ -	$ -	$ -	
22-23 53 16	Foundation of Deaerator Vessel	$ -	$ -	$ -	$ -	
22-23 52 83	Foundation of Blowdown system	$ -	$ -	$ -	$ -	
22-23 53 13	Foundation of BFW Pump	$ -	$ -	$ -	$ -	
22-46 33 66	Foundation of Chemical Dosing Pump	$ -	$ -	$ -	$ -	
22-43 21	Foundation of Treated Water Pump	$ -	$ -	$ -	$ -	
22-23 51 13 13	Foundation of Draft Fan	$ -	$ -	$ -	$ -	
22-33 05 16	Foundation of Pipe Rack	$ -	$ -	$ -	$ -	
22-13 34	Foundation of Equipment Structure	$ -	$ -	$ -	$ -	
22-33 05 16	Pipe Rack Structure	$ -	$ -	$ -	$ -	
22-13 34	Equipment Structure	$ -	$ -	$ -	$ -	
22-43 42	Chemical Tanks	$ -	$ -	$ -	$ -	
22-46 78 49	Heat Exchanger (Economizer)	$ -	$ -	$ -	$ -	
22-42 11	Boiler Package	$ -	$ -	$ -	$ -	
22-46 63	Demineralized Package	$ -	$ -	$ -	$ -	
22-23 53 16	Deaerator Vessel	$ -	$ -	$ -	$ -	
22-23 52 83	Blowdown system	$ -	$ -	$ -	$ -	
22-23 53 13	Boiler Feed Water (BFW) Pump	$ -	$ -	$ -	$ -	
22-46 33 66	Chemical Dosing Pump	$ -	$ -	$ -	$ -	
22-43 21	Treated Water Pump	$ -	$ -	$ -	$ -	
22-23 51 13 13	Draft Fan	$ -	$ -	$ -	$ -	
22-33 09	Instrument & Control	$ -	$ -	$ -	$ -	
22-26 05	Common Work for Electrical	$ -	$ -	$ -	$ -	
22-26 42	Cathodic Protection	$ -	$ -	$ -	$ -	
Total - Bid Item 2	**Construction**	$ -	$ -	$ -	$ -	$ -
Bid Item: 3	**Handover Phase**					$ -
22-01 79	Technical Training	$ -	$ -	$ -	$ -	
22-01 91	Commissioning of Boiler System	$ -	$ -	$ -	$ -	
22-01 75	Startup of Boiler System	$ -	$ -	$ -	$ -	
Total - Bid Item 3	**Handover Phase**	$ -	$ -	$ -	$ -	$ -
	Total Bid Items 1-3	$ -	$ -	$ -	$ -	$ -

Figure 10- NPS Project Cost Summary Template for New Boiler Unit (Class A Cost Estimate) [31]

[30] Author
[31] Author

Several steps to prepare a NPS Project Cost Summary (Class A Bidding Template) for a New Boiler Project are as follows:

1. Before creating a Bidding Template, we must prepare a Work Breakdown Structure (WBS). A detailed WBS is necessary to get accurate estimation results. In this case, the author prepared a Level 4 structure WBS based on Omniclass coding, as shown in Figure 7.
2. Then, the WBS in Figure 7 is rearranged in the Criteria / Scope of Work format described in Table 7.
3. Then, using the NPS Bidding Template (Class A Estimation) in Figure 9, we rearranged the WBS in Table 7 and Figure 7 to get the Real NPS Bidding Template for New Boiler Unit, as shown in Figure 10. Contractors can use this bidding template to submit bid proposals for New Boiler projects.

According to Step 4, the Bidding Template that we need is a Bidding Template that can accommodate the criteria in Table 7 appropriately. Based on the NPS Class A Cost Estimation Template, all WBS components are detailed under the assets/elements/services to be achieved to include all criteria in the NPS Bidding Template. Except for the Engineering phase, the author still divides it by discipline because it makes it easier for the Engineering department to divide work and monitor work.

Unlike the Current Company's Bidding Template (Figure 8), where the WBS components are broken down into disciplines. To rearrange the WBS from Figure 7 and Table 7 using the Company template becomes more difficult because it must be put in several separate disciplines. Other weaknesses as explained in Table 6.

Based on the explanation above, the NPS Bidding Template (Class A Construction Cost Estimates) is the ideal choice for utilizing the Level 4 WBS structure. For that, the author chose the NPS Bidding Template Class A Estimation to be used in the Standardization of Company Bidding Templates for the New Boiler Unit Project.

Step 6 – The Detail of The Bidding Template

In line with step 5, the author has chosen the NPS Bidding Template as the standardized Bidding Template for the New Boiler Project. The National Park Service has created a Bidding Template as a reference for its Estimators. For Class A Construction Cost Estimate, there are two distinct templates: the Project Cost Summary Worksheet and the Cost Detail Worksheet. [32]

[32] National Park Service. (2024, October 3). *Class A Construction Cost Estimate Template*. NPS.gov (US National Park Service). Retrieved from: https://www.nps.gov/dscw/upload/ClassACostEstimate_Instructions_12-17-10.docx

Project Cost Summary Worksheet

The author has created a Project Cost Summary template, as shown in Figure 10, using Omniclass WBS. The information presented in this template is a summary of the Detail Worksheet (Level 4 WBS). This template is usually used for Request for Quotation (RFQ) activities. In the bidding process, the Owner prepares the Owner Estimate using this template, and the contractor submits a bid using it. [33]

Cost Detail Worksheet

The cost detail worksheets are formatted to Level 4 WBS; however, the template is designed so that cost detail worksheets costs can, and should, be input at a higher level of detail. This feature is intended to force the estimator to at least consider the project in more detail. Seasoned estimators think this way anyway, and contractors will break things down even further when preparing their bids and can use it to create more detailed execution costs & Schedules at Levels 5 and 6 WBS. The author has created the Detailed Bid Template, as shown in Figures 11, 12, and 13.[34] Figures 11, 12, and 13 are presented more completely in **Appendix 3a, 3b and 3c**.

		Bid Item Number	Asset / Project Element	Size/Count	Units
		BID ITEM 1	ENGINEERING	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	22-02 21	Survey	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	33-21 31 24	Process Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	33-21 31 14	Structural Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4	33-21 31 17	Mechanical Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5	33-21 31 24 11	Piping Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6	33-41 79 00	Instrument & Control Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
7	33-21 31 21	Electrical Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$0**

Summary Item:	33-21 31 24	Process Engineering								Total Cost:	$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 Engineering										
	36-71 91 12 19	PFD, P&ID Drawing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	36-71 91 12 25 13	Line Designation Table	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	36-71 91 12 21	Process Datasheet	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-35 57 43	Calculating the Process Data	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-35 57 37	Developing the Process Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Process Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

[33] National Park Service. (2024, October 3). *Class A Construction Cost Estimate Template*. NPS.gov (US National Park Service). Retrieved from: https://www.nps.gov/dscw/upload/ClassACostEstimate_Instructions_12-17-10.docx
[34] Ibid

Summary Item:	33-21 31 14	Structural Engineering										Total Cost:	$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 14		Structural Engineering										
	36-71 91 11 25	Structural Calculation Report	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	36-71 91 12 19	Structural Drawing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-35 57 43	Calculating the structural data	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-35 57 37	Developing the Structural Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Structural Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Figure 11 – Detail of Bid Item 1 (Engineering) for New Boiler Unit [35]

Bid Item Number	Asset / Project Element	Size/Count	Units
BID ITEM 2	CONSTRUCTION	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	21-01 10	Foundations	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	21-06 10 20	Structure	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	21-04 20 60 40	Chemical Injection System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4	21-07 30 10	Feed Water System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5	21-04 30 20 10	Heat Generation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6	21-04 20 60 50	Blowdown System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
7	21-07 30 90 10	Pumps & Fan	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8	21-06 10 80	Instrumentation & Control System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
9	21-04 50	Electrical System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0

Summary Item:	21-04 30 20 10	Heat Generation										Total Cost:	$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
22-46 78 49		Heat Exchanger										
	23-27 23 11	Economizer Package	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 61	Constructing & Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Heat Exchanger	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
22-42 11		Process Boiler Package										
	23-33 11 21	Water Tube Boiler Package (including Chimney)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 61	Constructing & Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Process Boiler Package	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	21-06 10 80	Instrumentation & Control System										Total Cost:	$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
22-33 09		Instrumentation & Control										
	23-27 11 11	I&C for Temperature device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 11 13	I&C for Pressure device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 11 15	I&C for Flow device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 11 21	I&C for Level device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-29 29 13	Fire Detector device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-27 11 27	Gas I&C device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 61 29	Installing I&C device	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Instrumentation & Control	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

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Summary Item:	21-04 50	Electrical System										Total Cost:	$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
22-26 05		Common Work for Electrical										
	23-35 33	Electrical Ducting Wireways Components	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	23-13 23 21 15	Electrical Cable material	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 61 29	Installing Electrical cable & components	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Common Work for Electrical	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
22-26 42		Cathodic Protection										
	32-57 61 29	Installing Cathodic Protection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Cathodic Protection	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Figure 12 – Detail of Bid Item 2 (Construction) for New Boiler Unit [36]

Bid Item Number	Asset / Project Element	Size/Count	Units
BID ITEM 3	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	22-01 79	Technical Training	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	22-01 91	Commissioning of Boiler System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	22-01 75	Startup of Boiler System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$0

Summary Item:	22-01 79	Technical Training										Total Cost:	$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 79		Technical Training										
	32-89 81 11	Training for Operation & Maintenance	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Technical Training	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	22-01 91	Commissioning of Boiler System										Total Cost:	$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 91		Commissioning of Boiler System										
	32-57 71 15	Commissioning	0	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Commissioning of Boiler System	1	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	22-01 75	Startup of Boiler System										Total Cost:	$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 75		Startup of Boiler System										
	32-65 21	Operating (preparation & Startup)	0	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0
	32-57 81 17	Performance Test	0	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL		Startup of Boiler System	1	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Figure 13 – Detail of Bid Item 3 (Handover Phase) for New Boiler Unit [37]

Briefly, it can be explained as follows. Figure 11 presents the WBS for Detail of Bid Item 1, focusing on the Engineering Design Activities. In the Engineering Phase, a site survey is conducted to collect field data that will be used in Engineering design. The author

[36] Author
[37] Author

divides the engineering phase into several disciplines to help the Engineering Department in managing Engineering documents and monitoring Engineering activities. Deliverables from Engineering activities include Drawings, Datasheets, and Calculation Reports.

While Figure 12 presents the WBS for Detail of Bid Item 2, focusing on the Construction Activities. In this phase, the project construction is carried out following the drawings and information generated from the Engineering phase. Construction activities include the construction of foundations, structures, equipment, instrumentation & electrical systems.

In the final phase there is a Handover Phase presented in Figure 13 Detail of Bid Item 3, focusing on the Commissioning & Startup Activities. In this phase, a Performance Test is also carried out on the Boiler System to obtain equipment that is in good performance before handover from the contractor to the Owner.

Finally, we have obtained the Standardized Bidding Template for the New Boiler Project by adopting the NPS Bidding Template Class A Construction Cost Estimate, as presented in Figures 10, 11, 12, and 13 above. Furthermore, the National Oil Company and its subsidiaries can use this Standardized Bidding Template to prepare project estimates.

Step 7 – Performance Monitoring and Post-Evaluation

Finally, we have the Standardized WBS and Standardized Bidding Template for the New Boiler Project. However, we have to evaluate to ensure this new system can be applied easily and effectively in actual conditions. The National Oil Company must take the following steps to guarantee the effectiveness of the Standardized WBS and the Standardized Bidding Template for the New Boiler Project:

1. **Preparation Phase:**
   - Evaluate whether the Standardized WBS and Standardized Bidding Template that have been created can be easily implemented by experienced Estimators from the Company.
   - Evaluate whether the contractor can easily use the Standardized Bidding Template to prepare and submit bids during the Bidding Process.
   - Based on the Technology Acceptance Model 2 (TAM 2), the theory put forward by Venkatesh and Davis in 2000, "The intention of someone adopting a new system/technology is influenced by their perceived ease of use of the new system and also the perceived usefulness of it." For this reason, we need to ensure that these two things are included in our standardized WBS and Bidding Template: ease and usefulness.
   - Develop company procedures and standards to serve as the foundation for implementing the Standardized WBS and Standardized Bidding Template during

the Front-End Loading phase of this project. In this way, all personnel involved have the same understanding of how this template is implemented.
- Provide training for schedulers and cost estimators on using this Bidding Template.

2. Execution Phase:
- Conduct a trial of the created Standardized WBS and Bidding Template. It is better to choose a small-scale Boiler project as a trial project.
- If the results are effective, then National Oil Company can apply the Standardized WBS and Bidding Template to larger Boiler projects in the National Oil Company and its subsidiaries.

3. Post Execution Phase
- The implementation of the standardized WBS and Bidding Template should be continuously evaluated, and improvements made according to the PDCA (Plan-Do-Check-Action) flow so that existing standards can be upgraded to better standards in the future.
- Create a standardized WBS structure and Bidding Template for equipment to be built in the Oil Refinery development project other than the Boiler, especially equipment that can be duplicated, such as flares, electric power substations, desalter systems, storage tanks, waste-water treatment, and others.
- Although the National Oil Company has not implemented BIM technology currently, in the future, the standardized WBS that has been created can be integrated with BIM software to provide more benefits, such as producing more accurate and precise construction cost estimates, assisting in decision-making, and minimizing human errors. [38]

CONCLUSION

The construction of Boiler Facilities is essential in developing the capacity of an Oil Refinery, especially for steam and power production. National Oil Company wants to increase the capacity of the Oil Refinery to meet domestic demand, so the Construction of Boiler Units is an essential concern for the Company. All critical decisions and preparations are made at the Front-End Loading (FEL) phase to lower risks, cut costs, and ensure the project is finished on schedule and within budget. [39]

[38] CIDB Malaysia. (2021). *Malaysia Building Information Modelling (BIM) Report 2021*. Retrieved from: https://www.cream.my/data/cms/files/BIM_%20REPORT.pdf?iframe
[39] The H+M Industrial Team. (2023, July 12). *Front-end loading project management: Planning for success*. H+M Industrial EPC. https://www.hm-ec.com/blog-posts/front-end-loading-project-management-planning-for-success-hm

When entering phase 4 of Front-End Loading (FEL), The National Oil Company needs to develop the standardized level 4 – WBS and standardized Bidding Template in the New Boiler Project to help management make more accurate and efficient decisions in the defining phase. In preparing the standardization of WBS and Bidding Template, it is necessary to use the "Best Tested and Proven Practice" that exists in the world that can help the Company in scheduling, cost estimating, and bidding process and can be used as a reference to be applied throughout the National Oil Company and its subsidiaries.

Based on The Author's study developing the standardized WBS and Bidding Template, the question for the research could be answered as follows:

a. What is the suitable Work Breakdown Structure (WBS) / Cost Breakdown Structure (CBS) for the New Boiler Project that covers all aspects and phases of the project, allowing various stakeholders to utilize it for cost estimation and scheduling?

   The suitable Work Breakdown Structure (WBS) / Cost Breakdown Structure (CBS) for the New Boiler Project is a Level 4 WBS/CBS Structure using the Omniclass Table, as shown in Figure 7, along with the detail of WBS Elements from Omniclass Tables (Table 4).

b. What is the best format for a bidding template that can be used as a standard for the New Boiler Project?

   The US-National Park Service (NPS) Bidding Template (Class A Construction Cost Estimates) is the ideal choice to utilize the Level 4 WBS structure. The author has created the Standardized Bidding Template for the New Boiler Project by adopting the NPS Bidding Template Class A Construction Cost Estimate as presented in Figures 10, 11, 12, and 13 above. Furthermore, the National Oil Company can use this Standardized Bidding Template to prepare estimates for projects within the National Oil Company and its subsidiaries.

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About the Author

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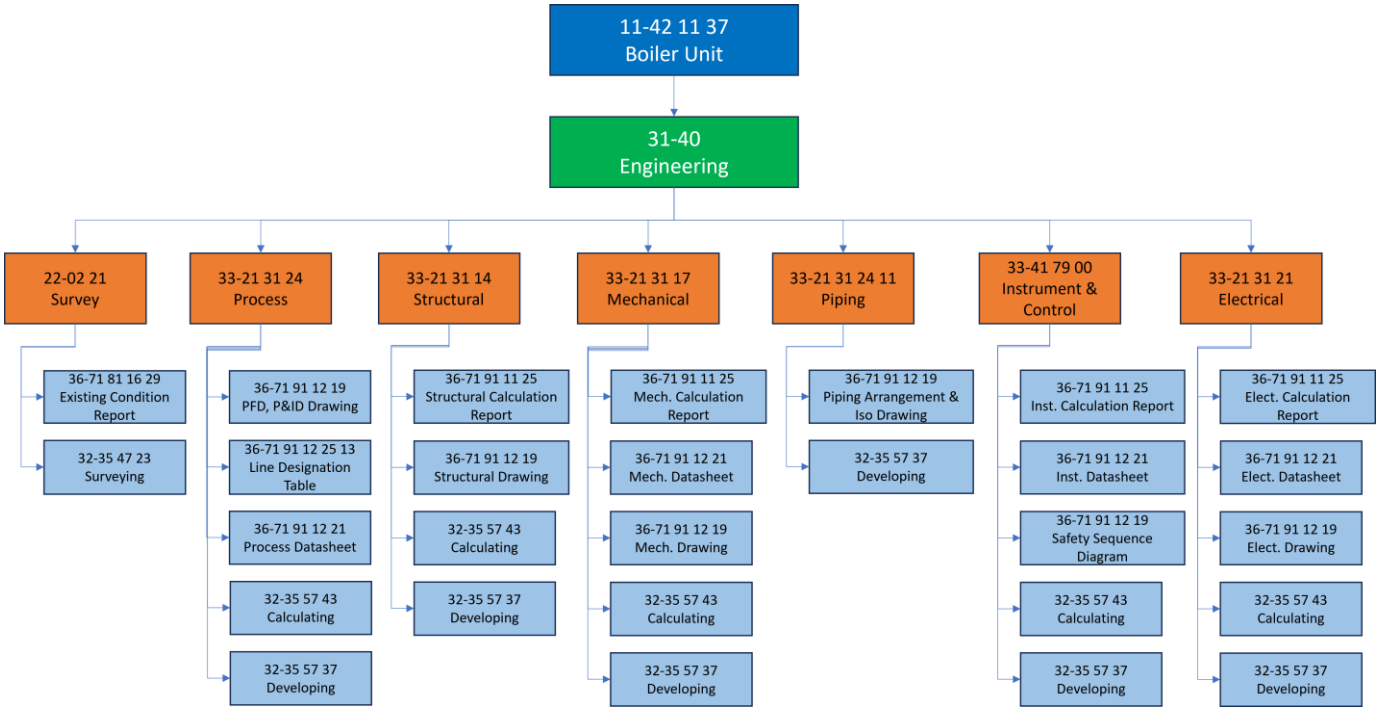
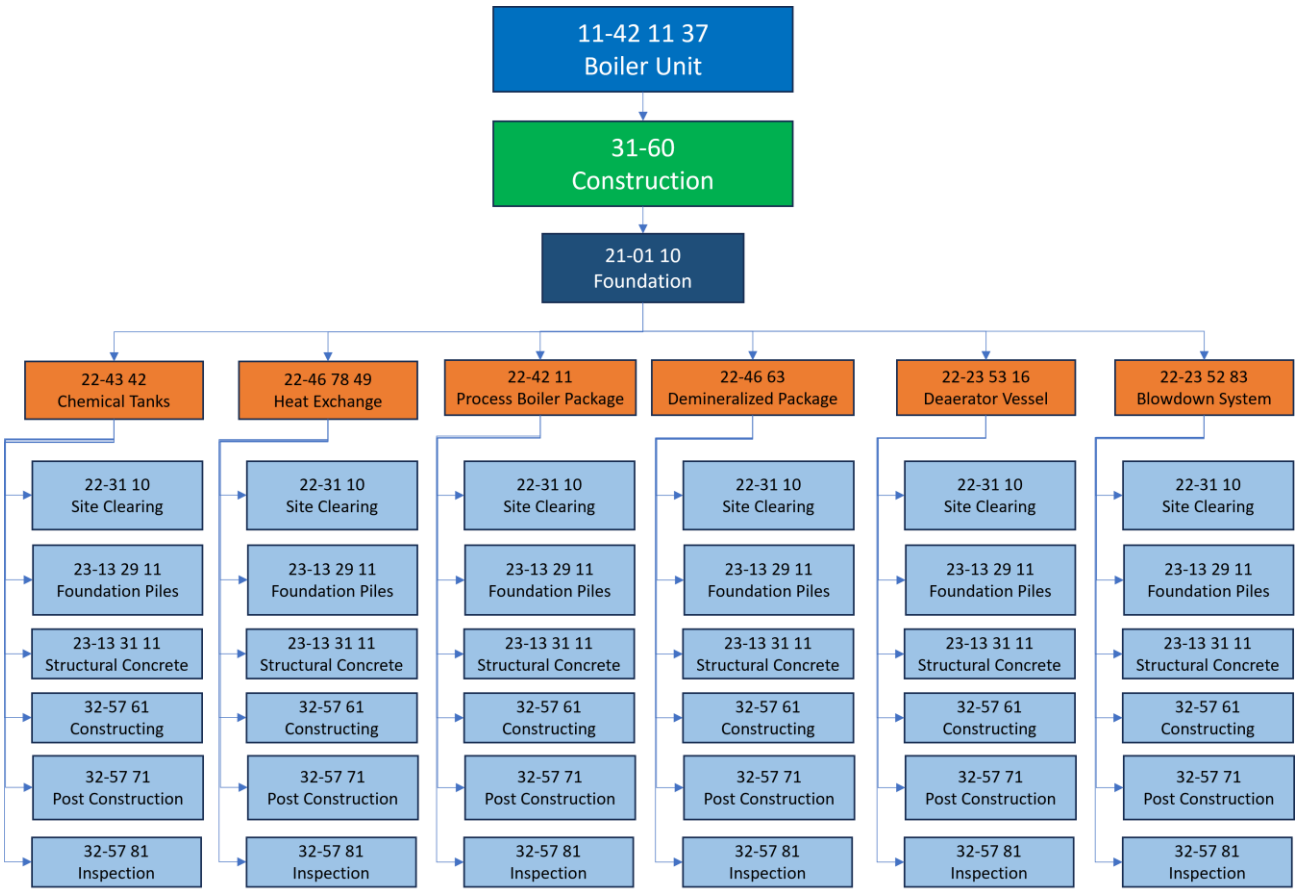
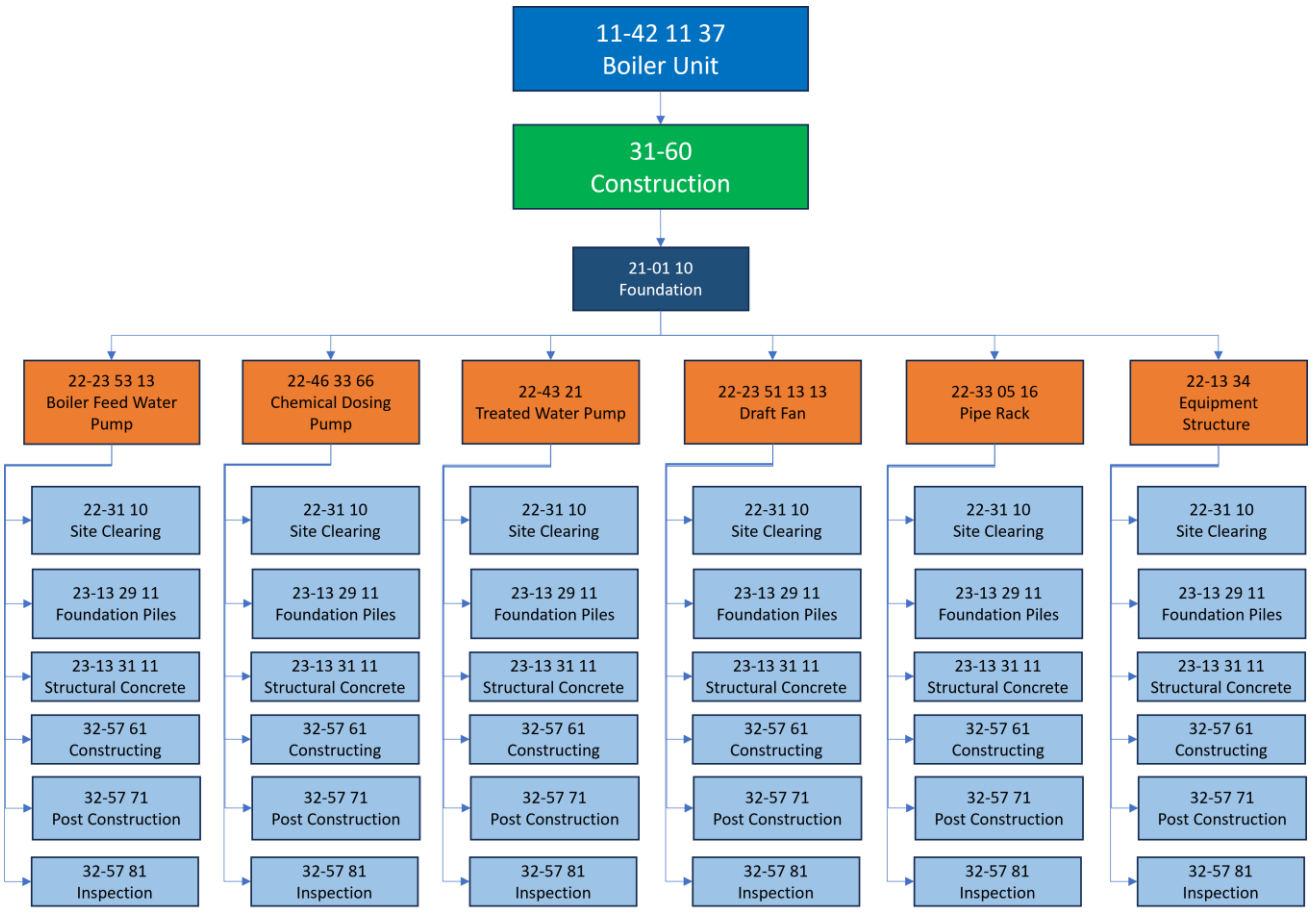
Umar Heru Setiadi is a project management professional with fifteen years of professional experience in the oil and gas sectors. Currently, he works as a Project Interface & Integration Manager at the national oil company of Indonesia. Several projects have been completed, such as Open Access project of Refinery Unit (RU) II Dumai, RDMP RU V Balikpapan Revamping project, Site Development & New Construction Jetty project, and other downstream projects. He holds a bachelor's degree in chemical engineering from Gadjah Mada University (UGM) and an MBA from SBM Bandung Institute of Technology (ITB). He is attending a distance learning mentoring course, under the tutorage of Dr. Paul D. Giammalvo, CDT, CCE, MScPM, MRICS, GPM-m Senior Technical Advisor, PT Mitrata Citragraha, to attain Certified Cost Professional certification from AACE International. Umar lives in Balikpapan, Indonesia and can be contacted at umarheru@gmail.com

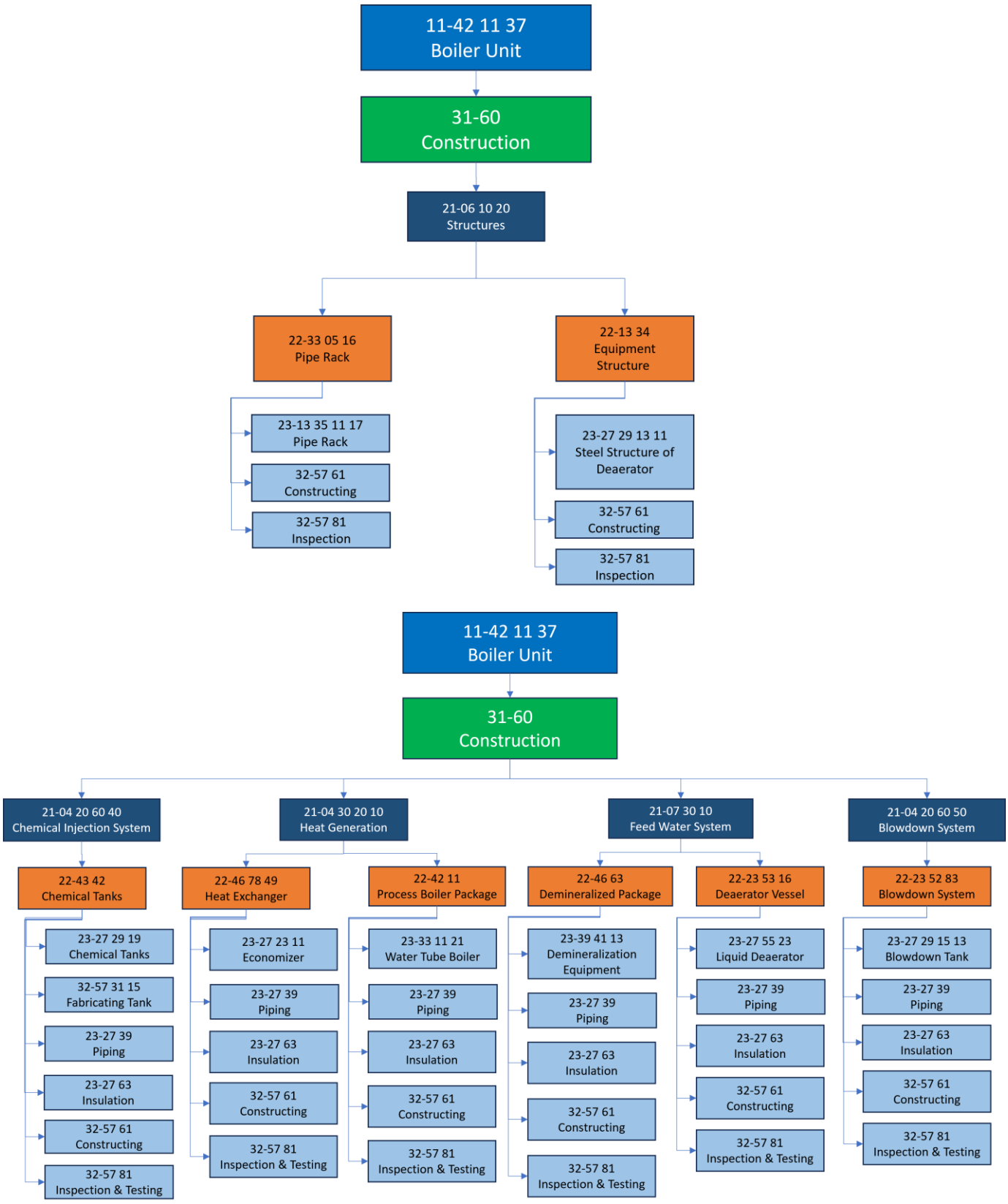
APPENDICES

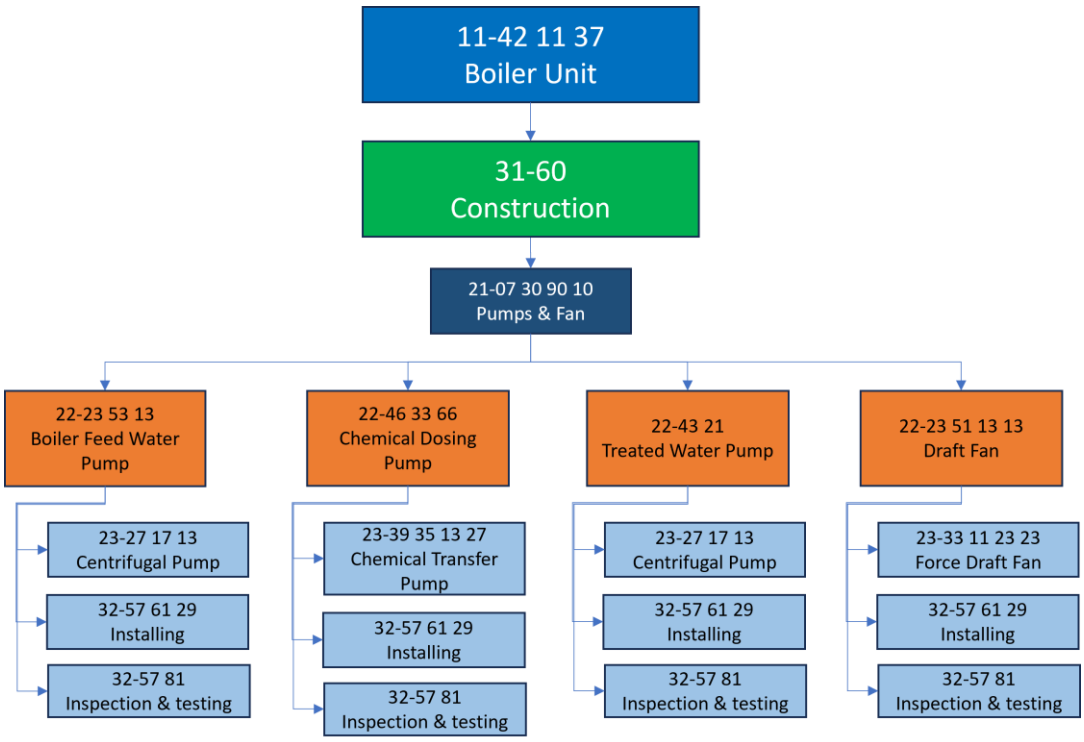
APPENDIX 1 - The Omniclass WBS Organization for New Boiler Unit

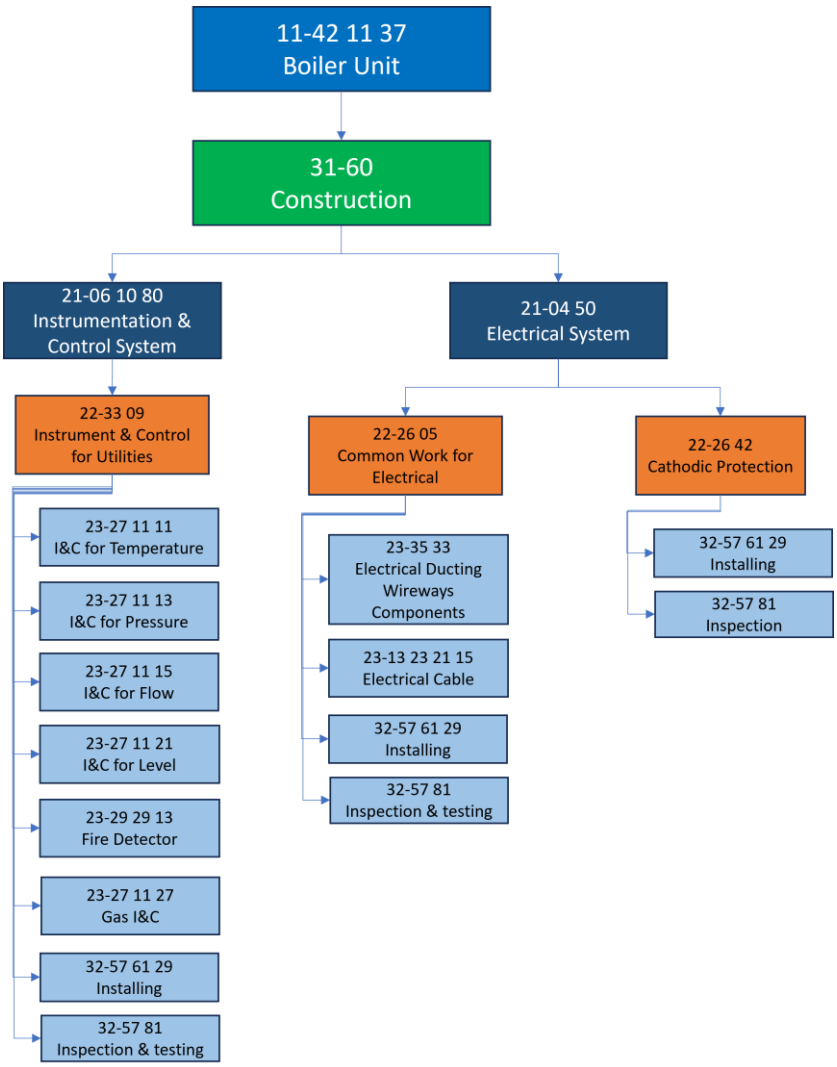


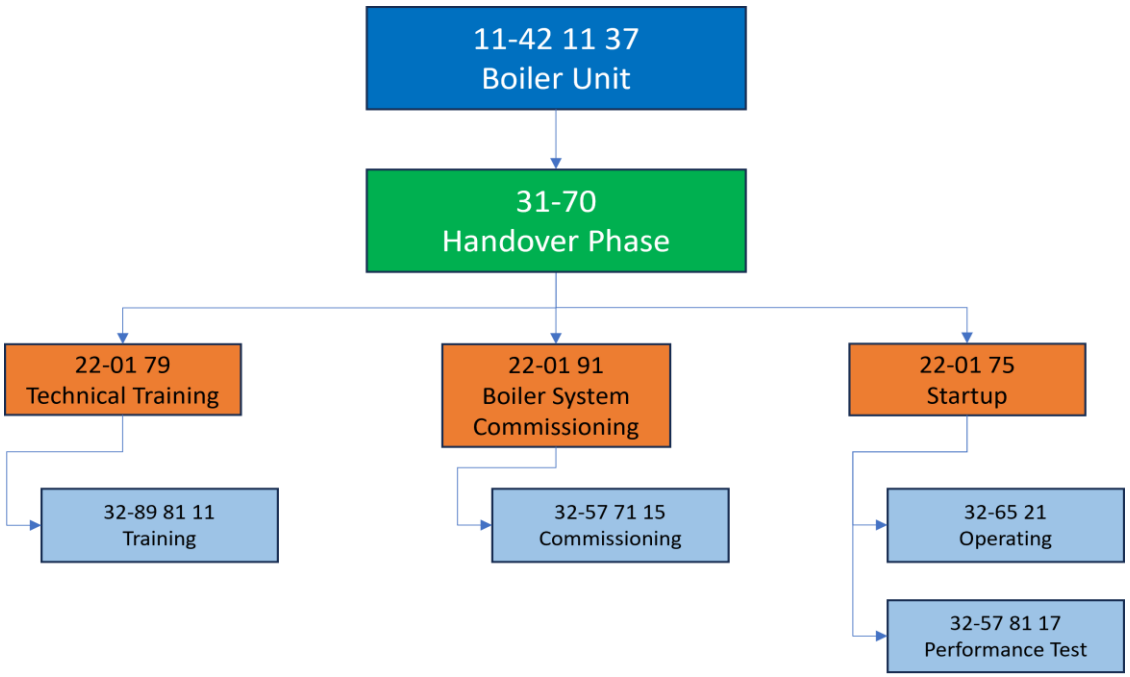












APPENDIX 2 - Proposed Coding for New Boiler Unit Work Breakdown Structure

OmniClass Number	Omniclass Title	Criterion Fullfiled
Table 11 (Construction Entities by Function)		
11-42 11 37	Steam Production Facility	Level 1
Table 31 (Phases)		
31-40 00 00	Design Phase	Engineering Phase
31-60 00 00	Implementation Phase	Construction Phase
31-70 00 00	Handover Phase	Handover Phase
Table 33 (Disiplines)		
33-21 31 24	Process Engineering	Process
33-21 31 14	Structural Engineering	Structural
33-21 31 17	Mechanical Engineering	Mechanical
33-21 31 24 11	Piping Engineering	Piping
33-41 79 00	Control and Communication Services	Instrument & Control
33-21 31 21	Electrical Engineering	Electrical
Table 32 (Service)		
32-35 47 23	Surveying	Surveying
32-35 57 43	Calculating	Calculating
32-35 57 37	Developing	Developing
32-57 61	Constructing	Constructing
32-57 71	Post Construction	Post Construction
32-57 81	Assuring	Inspection
32-57 31 15	Fabricating	Fabricating Tank
32-57 81	Assuring	Inspection & Testing
32-57 61 29	Installing	Installing
32-89 81 11	Training	Training
32-57 71 15	Commissioning	Commissioning
32-65 21	Operating	Operating
32-57 81 17	Testing	Performance Test

Table 21 (Element)		
21-01 10	Foundation	Foundation
21-06 10 20	Special Structures	Structures
21-04 20 60 40	Chemical waste system	Chemical Injection System
21-04 30 20 10	Heat Generation	Heat Generation
21-07 30 10	Water Utilities	Feed Water System
21-04 20 60 50	Process Water System	Blowdown System
21-07 30 90 10	Supplementary Components	Pumps & Fan
21-06 10 80	Special Instrumentation	Instrumentation & Control System
21-04 50	Electrical	Electrical System
Table 22 (Work Result)		
22-02 21 00	Surveys	Survey
22-43 42	Pressurized Tank	Chemical Tanks
22-46 78 49	Waste Heat Recovery Heat Exchangers	Heat Exchanger
22-42 11	Process Boilers	Process Boiler Package
22-46 63	Demineralization Equipment	Demineralized Package
22-23 53 16	Deaerators	Deaerator Vessel
22-23 52 83	Boiler Blowdown Systems	Blowdown System
22-31 10	Site Clearing	Site Clearing
22-23 53 13	Boiler Feedwater Pumps	Boiler Feedwater Pumps
22-46 33 66	Liquid Chemical Transfer Pumps	Chemical Dosing Pump
22-43 21	Liquid Pumps	Treated Water Pump
22-23 51 13 13	Draft-Induction Fans	Draft Fan
22-33 05 16	Utility Structures	Pipe Rack
22-13 34	Fabricated Engineered Structures	Equipment Structure
22-33 09	Instrumentation and Control for Utilities	Instrument & Control for Utilities
22-26 05	Common Work Results for Electrical	Common Work for Electrical
22-26 42	Cathodic Protection	Cathodic Protection
22-01 79	Demonstration and Training	Technical Training
22-01 91	Commissioning	Boiler System Commissioning
22-01 75	Starting and Adjusting	Startup

Table 23 (Products)		
23-13 29 11	Foundation Piles	Foundation Piles
23-13 31 11	Structural Concrete	Structural Concrete
23-13 35 11 17	Structural Racking	Pipe Rack
23-27 29 13 11	Tank Support Structures	Steel Structure of Deaerator
23-27 29 19	Tanks	Chemical Tanks
23-27 39	Piping	Piping
23-27 63	Mechanical Insulation and Linings	Insulation
23-27 23 13	Plate and Frame Heat Exchangers	Economizer
23-33 11 21	Water Tube Boilers	Water Tube Boiler
23-39 41 13	Demineralization Equipment	Demineralization Equipment
23-27 55 23	Liquid Deaerators	Liquid Deaerator
23-27 29 15 13	Flash Tanks	Blowdown Tank
23-27 17 13	Centrifugal Pump	Centrifugal Pump
23-39 35 13 27	Liquid Chemical Transfer Pumps	Chemical Transfer Pump
23-27 17 13	Centrifugal Pump	Centrifugal Pump
23-33 11 23 23	Boiler Draft Fans	Force Draft Fan
23-27 11 11	Temperature Measuring Instrument And Controls	I&C for Temperature
23-27 11 13	Pressure Measuring Instrument And Controls	I&C for Pressure
23-27 11 15	Flow Measuring Instrument And Controls	I&C for Flow
23-27 11 21	Level Measuring Instrument And Controls	I&C for Level
23-29 29 13	Fire Detectors	Fire Detector
23-27 11 27	Gas Instrument And Controls	Gas I&C
23-35 33	Electrical Ducting Wireways Components	Electrical Ducting Wireways Components
23-13 23 21 15	Cables	Electrical Cable
Table 36 (Information)		
36-71 81 16 29	Existing Condition Reports	Existing Condition Report
36-71 91 12 19	Design Drawings	PFD, P&ID Drawing
36-71 91 12 25 13	Code Analyses	Line Designation Table
36-71 91 12 21	Design Drawing Document Sets	Process Datasheet
36-71 91 11 25	Reports / Studies	Structural Calculation Report
36-71 91 12 19	Design Drawings	Structural Drawing
36-71 91 11 25	Reports / Studies	Mech. Calculation Report
36-71 91 12 21	Design Drawing Document Sets	Mech. Datasheet
36-71 91 12 19	Design Drawings	Mech. Drawing
36-71 91 12 19	Design Drawings	Piping Arrangement & Iso Drawing
36-71 91 11 25	Reports / Studies	Inst. Calculation Report
36-71 91 12 21	Design Drawing Document Sets	Inst. Datasheet
36-71 91 12 19	Design Drawings	Safety Sequence Diagram
36-71 91 11 25	Reports / Studies	Elect. Calculation Report
36-71 91 12 21	Design Drawing Document Sets	Elect. Datasheet
36-71 91 12 19	Design Drawings	Elect. Drawing

APPENDIX 3.a. Detail of Bid Item 1 (Engineering) for New Boiler Unit

Bid Item Number	Asset / Project Element	Size/Count	Units
BID ITEM 1	ENGINEERING	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	22-02 21	Survey	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	33-21 31 24	Process Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	33-21 31 14	Structural Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4	33-21 31 17	Mechanical Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5	33-21 31 24 11	Piping Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6	33-41 79 00	Instrument & Control Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
7	33-21 31 21	Electrical Engineering	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$0**

Summary Item: 22-02 21 Survey — **Total Cost:** $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
22-02 21	Survey										
36-71 81 16 29	Existing Condition Report	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 47 23	Site Surveying	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Survey	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item: 33-21 31 24 Process Engineering — **Total Cost:** $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 Engineering										
36-71 91 12 19	PFD, P&ID Drawing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
36-71 91 12 25 13	Line Designation Table	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
36-71 91 12 21	Process Datasheet	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 43	Calculating the Process Data	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 37	Developing the Process Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Process Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item: 33-21 31 14 Structural Engineering — **Total Cost:** $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 14	Structural Engineering										
36-71 91 11 25	Structural Calculation Report	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
36-71 91 12 19	Structural Drawing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 43	Calculating the structural data	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 37	Developing the Structural Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Structural Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item: 33-21 31 17 Mechanical Engineering — **Total Cost:** $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 Engineering										
36-71 91 11 25	Mechanical Calculation Report	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
36-71 91 12 21	Mechanical Datasheet	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
36-71 91 12 19	Mechanical Drawing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 43	Calculating the Mechanical Data	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-35 57 37	Developing the Mechanical Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Mechanical Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	33-21 31 24 11	Piping Engineering									Total Cost:	$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 11	Piping Engineering											
36-71 91 12 19	Piping Arrangement & Iso Drawing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-35 57 37	Developing the Piping Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Piping Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	

Summary Item:	33-41 79 00	Instrument & Control Engineering									Total Cost:	$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	
33-41 79 00	Instrument & Control Engineering											
36-71 91 11 25	Instrument & Control Calculation Report	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
36-71 91 12 21	Instrument & Control Datasheet	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
36-71 91 12 19	Safety Sequence Diagram	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-35 57 43	Calculating the I&C Data	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-35 57 37	Developing the I&C Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Instrument & Control Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	

Summary Item:	33-21 31 21	Electrical Engineering									Total Cost:	$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 Engineering											
36-71 91 11 25	Electrical Calculation Report	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
36-71 91 12 21	Electrical Datasheet	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
36-71 91 12 19	Electrical Drawing	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-35 57 43	Calculating the Electrical Data	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-35 57 37	Developing Electrical Document Deliverables	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Electrical Engineering	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	

APPENDIX 3.b. Detail of Bid Item 2 (Construction) for New Boiler Unit

		Bid Item Number	Asset / Project Element	Size/Count	Units				
		BID ITEM 2	CONSTRUCTION	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	21-01 10	Foundations	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	21-06 10 20	Structure	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	21-04 20 60 40	Chemical Injection System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4	21-07 30 10	Feed Water System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5	21-04 30 20 10	Heat Generation	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6	21-04 20 60 50	Blowdown System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
7	21-07 30 90 10	Pumps & Fan	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8	21-06 10 80	Instrumentation & Control System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
9	21-04 50	Electrical System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$0**

Summary Item:	21-01 10	Foundations											Total Cost:	$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
22-43 42	Foundation of Chemical Tanks										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Foundation of Chemical Tanks	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
22-46 78 49	Foundation of Heat Exchanger (Economizer)										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	(Economizer)	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
22-42 11	Foundation of Boiler Package										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Foundation of Boiler Package	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
22-46 63	Foundation of Demineralized Package										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Foundation of Demineralized Package	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
22-23 53 16	Foundation of Deaerator Vessel										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Foundation of Deaerator Vessel	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
22-23 52 83	Foundation of Blowdown system										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Foundation of Blowdown system	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
22-23 53 13	**Foundation of BFW Pump**										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Foundation of BFW Pump**	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
22-46 33 66	**Foundation of Chemical Dosing Pump**										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Foundation of Chemical Dosing Pump**	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
22-43 21	**Foundation of Treated Water Pump**										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Foundation of Treated Water Pump**	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
22-23 51 13 13	**Foundation of Draft Fan**										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Foundation of Draft Fan**	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
22-33 05 16	**Foundation of Pipe Rack**										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Foundation of Pipe Rack**	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
22-13 34	**Foundation of Equipment Structure**										
22-31 10	Site Clearing (including soil excavating & backfilling)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 29 11	Foundation Piles	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 31 11	Structural Concrete (including pile cap & slab)	0	m3	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing the foundation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 71	Post Construction (including cleaning & commissioning)	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Foundation of Equipment Structure**	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	21-06 10 20	Structure									Total Cost:	$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	
22-33 05 16	Pipe Rack											
23-13 35 11 17	Pipe Rack Material	0	Kg	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 61	Constructing the Pipe Rack	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Pipe Rack	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	
22-13 34	Equipment Structure											
23-27 29 13 11	Steel Structure of Deaerator	0	Kg	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 61	Constructing the Structure of Deaerator	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Equipment Structure	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	

Summary Item:	21-04 20 60 40	Chemical Injection System									Total Cost:	$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	
22-43 42	Chemical Tanks											
23-27 29 19	Chemical Tank Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 31 15	Fabricating the Chemical Tank	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 61	Constructing the Piping & Installing the Insulation	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Chemical Tanks	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	

Summary Item:	21-07 30 10	Feed Water System									Total Cost:	$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	
22-46 63	Demineralized Package											
23-39 41 13	Demineralization Equipment	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 61	Constructing & Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Demineralized Package	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	
22-23 53 16	Deaerator Vessel											
23-27 55 23	Liquid Deaerator Equipment	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 61	Constructing & Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Deaerator Vessel	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	

Summary Item:	21-04 30 20 10	Heat Generation									Total Cost:	$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	
22-46 78 49	Heat Exchanger											
23-27 23 11	Economizer Package	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 61	Constructing & Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Heat Exchanger	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	
22-42 11	Process Boiler Package											
23-33 11 21	Water Tube Boiler Package (including Chimney)	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 61	Constructing & Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0	
SUBTOTAL	Process Boiler Package	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0	

Summary Item:	21-04 20 60 50	Blowdown System									Total Cost:	$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
22-23 52 83	Blowdown System										
23-27 29 15 13	Blowdown Tank	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-27 39	Piping Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-27 63	Insulation Material	0	Lot	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61	Constructing & Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Blowdown System	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	21-07 30 90 10	Pumps & Fan									Total Cost:	$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
22-23 53 13	Boiler Feed Water Pump										
23-27 17 13	Centrifugal Pump Package	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61 29	Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Boiler Feed Water Pump	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
22-46 33 66	Chemical Dosing Pump										
23-39 35 13 27	Package	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61 29	Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Chemical Dosing Pump	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
22-43 21	Treated Water Pump										
23-27 17 13	Centrifugal Pump Package	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61 29	Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Treated Water Pump	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
22-23 51 13 13	Draft Fan										
23-33 11 23 23	Force Draft Fan Package	0	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61 29	Installing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Draft Fan	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	21-06 10 80	Instrumentation & Control System									Total Cost:	$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
22-33 09	Instrumentation & Control										
23-27 11 11	I&C for Temperature device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-27 11 13	I&C for Pressure device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-27 11 15	I&C for Flow device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-27 11 21	I&C for Level device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-29 29 13	Fire Detector device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-27 11 27	Gas I&C device	0	Set	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61 29	Installing I&C device	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Instrumentation & Control	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

Summary Item:	21-04 50	Electrical System										Total Cost:	$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
22-26 05	Common Work for Electrical										
23-35 33	Electrical Ducting Wireways Components	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
23-13 23 21 15	Electrical Cable material	0	m	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 61 29	Installing Electrical cable & components	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection & Testing	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Common Work for Electrical	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
22-26 42	Cathodic Protection										
32-57 61 29	Installing Cathodic Protection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81	Inspection	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	Cathodic Protection	1	Unit	$ -	$0	$ -	$0	$ -	$0	$ -	$0

APPENDIX 3.c. Detail of Bid Item 3 (Handover Phase) for New Boiler Unit

Bid Item Number	Asset / Project Element	Size/Count	Units
BID ITEM 3	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	22-01 79	Technical Training	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	22-01 91	Commissioning of Boiler System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	22-01 75	Startup of Boiler System	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
		Subtotal Direct Construction Costs	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$0**

Summary Item: 22-01 79 Technical Training — **Total Cost:** $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 79	Technical Training										
32-89 81 11	Training for Operation & Maintenance	0	Manhour	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Technical Training**	**1**	**Unit**	**$ -**	**$0**	**$ -**	**$0**	**$ -**	**$0**	**$ -**	**$0**

Summary Item: 22-01 91 Commissioning of Boiler System — **Total Cost:** $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 91	Commissioning of Boiler System										
32-57 71 15	Commissioning	0	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Commissioning of Boiler System**	**1**	**Lumpsum**	**$ -**	**$0**	**$ -**	**$0**	**$ -**	**$0**	**$ -**	**$0**

Summary Item: 22-01 75 Startup of Boiler System — **Total Cost:** $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 75	Startup of Boiler System										
32-65 21	Operating (preparation & Startup)	0	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0
32-57 81 17	Performance Test	0	Lumpsum	$ -	$0	$ -	$0	$ -	$0	$ -	$0
SUBTOTAL	**Startup of Boiler System**	**1**	**Lumpsum**	**$ -**	**$0**	**$ -**	**$0**	**$ -**	**$0**	**$ -**	**$0**