

COAA

Construction Owners
Association of Alberta

Scalable Advanced Work Packaging Report

*A Best Practice Tool of the
Construction Owners Association of Alberta*



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1 EXECUTIVE SUMMARY

Advanced Work Packaging (AWP) is a best practice for project delivery in use globally on large projects and has been found to improve safety, schedule, predictability, quality, and labor productivity. Increases of 25% in labor productivity and reductions of 10% in total Installed costs have been confirmed for mature AWP implementations. There is significant opportunity to apply the AWP process for projects under \$100 million. This report provides recommendations based on local industry experience on how to implement AWP on smaller projects but without compromising the principles that result in project performance improvement. This report was developed by 4 working committees and 40 experienced industry professionals as committee members with a 5-member steering committee and is based on the work of the Construction Industry Institute (CII) and COAA.

Scaling AWP first requires identifying key factors that would change the project delivery practices. This report introduces two main factors: familiarity and complexity. If a project is new to the company, then generally the project could be considered unfamiliar. If the project has been done before by the same team, it can be classified as familiar, such as a series of similar projects repeated as part of a program or portfolio. The second main factor is complexity. In reality projects can vary greatly from extremely simple to extremely complex but for the purposes of this report, with projects under \$100M, two levels of complexity are considered; low and high.

These distinctions result in identifying four categories of projects: Unfamiliar – Low Complexity, Familiar – Low Complexity, Unfamiliar – High Complexity and Familiar – High Complexity. To determine if a particular project is one of those four categories a project screening tool was devised. The screening tool asks a series of questions that will help identify if a project is familiar / unfamiliar and low / high complexity.

Once the project category is established, the AWP model can be applied tailored to the needs for that type of project. To arrange the main areas of where practices would change, seven key principles are summarized and aligned with the AWP lifecycle flow chart with stages for the project and key activities. The principles include project scope, project contract strategy, path of construction, work packaging, project resource requirements, confirming requirements are satisfied and monitoring/progressing construction. For each principle general recommendations are made on how the AWP practices would differ depending on the project type.

Four example projects are provided, one for each category, that illustrate the nuances of that project type; such as a first-time project doing a valve-insertion and a program of doing valve-insertions in several project areas. Each example project has a summary of the project scope and includes how AWP would be applied for that project.

As part of the AWP best practice, there are many templates and tools available. However, they may or may not be applicable on smaller projects. This report presents a set of templates and tools that can be used on small projects and provides recommendations on how detailed the planning and framework should be for each type of project. Given the guidance of the different project types, this report aims to help organizations implementing AWP to capture the project delivery excellence and related performance improvements even on smaller projects.

2 INTRODUCTION

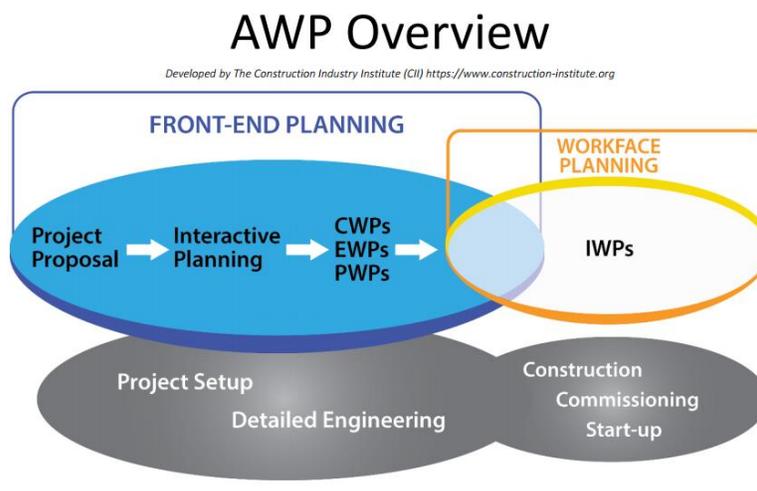
2.1 BACKGROUND

From 2003 to 2006 the Construction Owners Association of Alberta (COAA) developed the “Workface Planning Model” as a draft report which focused on work packaging from the construction contractor’s perspective. It was revised in 2008 and made a COAA best practice but its primary focus was the construction contractor in the oil and gas industry working on megaprojects.

CII reviewed the COAA Workface Planning Model from 2009 to 2011 and developed “Enhanced Work Packaging: Design through Workface Execution - RR272-11” later renamed “Advanced Work Packaging: Design through Workface Execution - Version 2.1 - RS272-1”. It was based on the COAA work but was adapted to apply to a variety of industries and larger project sizes. The model outlined the need to increase the focus on the front-end portions of the project. At the same time a companion document “IR 272-2, Volume II, Advanced Work Packaging: Implementation Case Studies and Expert Interviews” was developed.

In 2013 CII and COAA released “Advanced Work Packaging: Implementation Guidance, IR 272-2, Volume III” and both earlier documents were updated. In September 2015 CII made Advanced Work Packaging a Best Practice based on the validation work done in “RR319-11 - Transforming the Industry: Advanced Work Packaging as a Standard (Best) Practice”.

Figure 1 Representation of the AWP model as presented in IR 272-2



To recap, AWP is a systematic approach to planning and executing construction projects, it has been under development for 15 years and been developed by more than 100 industry professionals with the support of academic researchers at multiple universities. AWP is in use globally and has been found to improve safety,

¹Construction Industry Institute "Advanced Work Packaging: Design through Workface Execution." Implementation Resource 272-2, Version 3.0 Volume I. 2013. PDF.

schedule, predictability, quality, and labor productivity. Increases of 25% in labor productivity and reductions of 10% in total Installed costs have been confirmed for mature AWP systems.²

Companies that started implementing AWP typically used it on large projects and saw significant benefits. These companies were interested in how to apply AWP to smaller projects. COAA received additional requests to develop a "Scalable AWP Guideline" to implement on projects under \$100 million without compromising the principles that result in improved project performance.

Therefore, in 2016 a small team was created to explore developing a scalable AWP model. In 2017 the team was formally chartered with 4 working committees with 40 experienced industry professionals as committee members and a 5-member steering committee. This report is the product of their work and is based on the work of CII and COAA.

The original AWP model was based on the WFP model which was developed based on megaprojects in the oil and gas industry in Alberta. These large Capital projects require more detailed planning and when the RT 272 team developed the Advanced Work Packaging Model, they adapted the model to apply to a variety of industries. The model was not originally developed for smaller sustainable projects.

Over the past few years the COAA AWP committee have been asked what adaptations would be required to implement AWP on smaller sustainable projects. The AWP committee at COAA struck a committee to develop a Scalable AWP model for projects under \$100 million which quickly grew to a steering committee and 4 working teams with a total of over 40 members. There was strong interest for the owner, engineering, supply chain and constructor communities both in Canada and the United States.

The intent was to follow the Advanced Work Packaging Model but identify modifications to adapt the model for smaller projects.

2.2 OBJECTIVES

The objectives of Scalable AWP model and the committees developing it was:

1. Classify projects under \$100 million dollars
2. Apply the Principles of AWP as outlined in the Advanced Work Packaging Model
3. Outline the Practices of AWP appropriate to the project familiarity and complexity
4. Obtain the similar benefits of AWP achieved on larger projects for smaller projects
 - a. Increased Predictability
 - b. Improved Quality
 - c. Improved Safety
 - d. Schedule attainment
 - e. Increased Productivity up to 25%
 - f. Reduced TIC (Total Installed Cost) up to 10%

² Construction Industry Institute "RT319 Transforming the Industry: Making the Case for AWP as a Standard (Best) Practice" <https://www.construction-institute.org/topic-summaries/rt-301-399/rt-319-transforming-the-industry-making-the-ca>

3 CATEGORIZING PROJECTS

3.1 ASSIGNING CATEGORIES FOR PROJECTS

Projects will have two main aspects that will change the approach for project delivery and the AWP practices to be implemented. The two factors introduced here are familiarity and complexity.

Familiarity

Projects can be classified based on their familiarity which can be affected by if it's a first-time project or a repeatable project. This could be an owner who is actively involved in managing projects that are routine to their business or an experienced contractor that engineers and or constructs that type of project on a regular basis.

The Project Management Institute³ defines a project as having a defined start and end point and specific objectives that, when attained, signify completion. A program, on the other hand, is defined as a group of related projects managed in a coordinated way to obtain benefits not available from managing the projects individually. First time projects are unfamiliar whereas repeatable projects become familiar and can be implemented as a program.

Since familiar projects sometimes involve related projects they can benefit from the following:

1. Reuse of project deliverables with only minor modification such as:
 - a. Path of Construction (POC)
 - b. Schedule
 - c. Project Execution Plan (PEP)
 - d. Engineering
 - e. Work Packages
 - f. Progressing and Reporting Structure
2. Economies of Scale for items such as:
 - a. Materials
 - b. Equipment
 - c. Human Resources

Low Complexity vs High Complexity

Projects can also be classified as Low or High Complexity based on issues such as:

1. Number of Work Areas
2. Physical separation of Work Areas (distributed versus one site)
3. Number of Disciplines
4. Number of Shifts
5. Time of year and prevailing weather conditions
6. New Construction (Greenfield) versus expansion of existing facility (Brownfield)
7. Number of different general contractors or integrators

³ Project Management Institute, Sixth Edition PMBOK Page 715

8. Regulatory agencies or involvement of special interest groups, etc.

The level of project complexity is related to the required levels of project rigor. More complex projects require greater oversight, more frequent progress reporting, and greater risk analysis. In other words, Complexity relates to Constructability – how easy or difficult this project will be to build.

3.2 PROJECT RISK MATRIX

By combining familiarity and complexity projects can be assessed for what their risk is, at a very high-level.

Project Risk Complexity Rating Matrix		
	Unfamiliar	Familiar
LOW Complexity	Medium	Low
HIGH Complexity	High	Medium

Low Ranked Projects constitute the lowest risk to the organization

Medium Ranked Projects constitute moderate risk to the organization

High Ranked Projects constitute significant risk to the organization

Based on this classification scheme the four project categories are:

1. Category A - Unfamiliar Low Complexity (Project)
2. Category B - Familiar Low Complexity (Program)
3. Category C - Unfamiliar High Complexity (Project)
4. Category D - Familiar High Complexity (Program)

In this report each project Category is described, and an example is provided with templates and sample documents. It should be noted that in some cases, these distinctions are not detailed enough and should be taken to the level of detail needed for the project to be successful. For example, a program of high complexity projects could potentially represent an even higher risk than a single unfamiliar project however they may come out with the same Medium risk rating. Included in the model are ways to increase the efficiency and effectiveness of different sized projects and address the project category.

4 PROJECT SCREENING TOOL

The project screening tool is an excel document used to decide on the level of familiarity and complexity for the project by answering a series of questions. Typically, this process should be done in the AWP stage 1 – preliminary planning stage of the project. The excel document tracks the answers and helps bring clarity by placing the project into 1 of 4 categories and shows the rank matrix appropriate for your project. The screening tool has been developed with examples and is intended to be tailored for use. For example, the user can change the questions to better suit their specific project requirements and characteristics such as weather conditions for construction.

First determine level of familiarity for certain aspects of the project by answering each of the questions for the 6 main aspects of the project by selecting the *drop-down options*. If your project has responses for 3 or more questions as ‘unfamiliar’ it will be assigned as Unfamiliar.

Table 1 Project Screening Tool - Familiarity Questions

		Familiarity	
		Unfamiliar	Familiar
1	Scope of Work Familiarity	One-off project or a duplicate of a previously executed project and the scope of work had changed by >50%.	Duplicate project with scope of work similar to previously executed projects and has <50% scope change
2	Portfolio, Program or Project	Managed as a Project	Managed as a Portfolio/Program
3	Project Information & Documentation	Customized engineering or <50% engineering and construction work package recycled from previous projects	Standardized design or >50% engineering and construction work packages are recycled from previous projects.
4	Permitting	Although capable, the execution team is not experienced in project-specific regulatory permitting requirements.	Execution team has successfully completed project-specific regulatory permitting requirements.
5	Construction Contract Strategy*	Owner or EPC SCM formally request project-specific proposals, evaluates and awards.	Owner or EPC has partnered with select general contractors and assigns construction on a highest value basis
6	Equipment/ Procurement Strategy	Owner or EPC SCM formally request project-specific proposals, evaluates and awards.	Owner or EPC purchase equipment and material from an approved vendors list

*Where the term Contract Strategy is used, it also refers to the broader term Acquisition Process.

Continue the process to decide on Complexity for certain aspects of the project by continuing to answer the drop-down menu questions.

Table 2: Project Screening Tool - Complexity Questions

		Complexity	
		Low	High
1	Greenfield, Brownfield	Greenfield - No previous facilities existed above or below ground, new development will have minimum impact on operating facilities. New development is separated from the existing facility by a minimum of 30 m (100 Ft.)	Brownfield - New development will be constructed where previous above or below ground facilities or within 30 m (100 Ft.) of existing above or below ground facilities exist. New development interface with existing operation
2	Construction Area	1 or 2 adjacent areas; Shared resources can be utilized	3 or more adjacent or non-adjacent areas. Shared resources need to be coordinated and planned
3	Multi - Disciplines	6 or fewer of any of discipline: earthwork, foundations, structural, buildings, mechanical equipment, piping, insulation, painting/coating/lining, electrical, instrumentation and controls.	7 or more of any of discipline: earthwork, foundations, structural, buildings, mechanical equipment, piping, insulation, painting/coating/lining, electrical, instrumentation and controls.
4	Tie-Ins	Electrical, Instrumentation and Controls Only (EI & C), Hot Work with no loss of production	Mechanical and EI & C or Plant/System Shutdown and loss of production
5	Critical Crane lifts	All crane lifts are standard	Critical crane lifts required
6	Geotechnical Conditions	Dewatering and rock excavation are not required	Dewatering and/or rock excavation are required
7	Excavation	2 m (6.5 Ft) or less depth excavation with trench box and/or OSHA Type 1 or 2 Soils and/or , < 10% Hydro-Vac	> 2 m (6.5 ft.) depth of excavation and/or OSHA Type 3 soil and/or requires shoring and/or >10% Hydro-Vac
8	Working at heights	< 25% scope requires working above 2 m (6.5 ft.) height	> 25% scope requires working above 2 m (6.5 ft.) height
9	Construction Season	Expected weather conditions, no impact on productivity	Occasional extreme weather - Reduced worker productivity, freezing and icy conditions, construction may require hoarding and heating, road weight restrictions, etc.
10	Schedule Compression	Construction is planned on day shift only and/or All EWP/CWP will be issued IFC prior to commencing construction. EPC phases are sequential	Construction planned on day and night shifts and/or all EWP/CWP will not issue IFC prior to commencing construction. EPC phases may overlap.
11	Project Site Remote	Workers drive daily between project and place of residence, no subsistence	Workers commute between project and place of residence between shifts, Projects accommodations or subsistence and de-Bottleneck costs required. Seasonal Roads and bridges may impact transportation plan.

After the questions have been answered the Project Screening Tool will provide the risk matrix for your project.

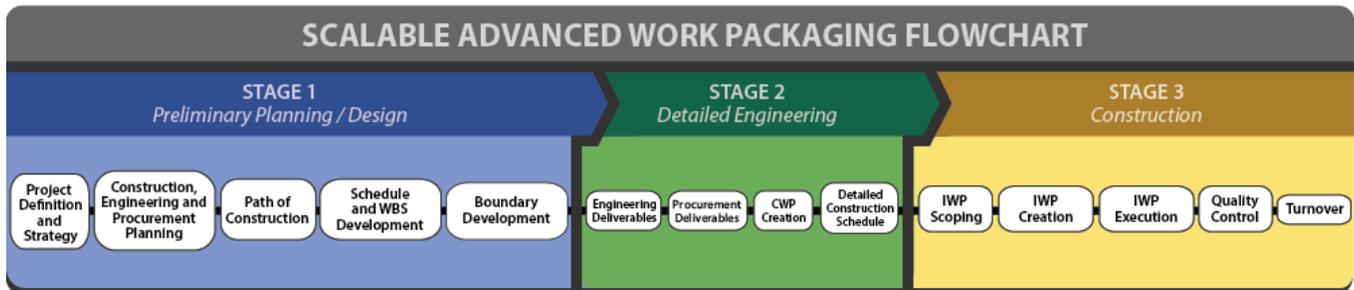
Once this step is completed the category of project has been established and the following AWP Model will have recommendations for each category of project.

It is important to note the difference between a risk matrix typically used during the risk management process and this ranking matrix. The typical risk matrix provides a standard color scheme for individual risks to a project. However, this ranking metric combines project complexity and familiarity to decide on a single ranking for the entire project, which does have an impact on risk but is not the primary focus of this tool.

5 SCALABLE AWP MODEL

The scalable AWP model utilizes the integrated life cycle flow chart from the AWP best practice. The model has been formatted slightly so that it can be scaled up and down for project familiarity and complexity. To see the original model, please refer to the CII website.⁴

Figure 2: AWP Lifecycle Flowchart - Scalable



The three stages have generic terms that are applicable to various industries and are therefore intentionally inclusive. Execution of each element can also change depending on the contracting strategy established.

Stage 1 – Preliminary Planning and Design⁵

During Stage 1 the project concept is established and relevant details are prepared to qualify an investment decision. Also during this stage, work breakdown structure and Path of Construction planning will help define engineering, procurement and construction strategies as well as projects planning and scheduling and package boundary development. The secondary benefit highlighted by the AWP best practice is to reduce engineering, procurement and construction rework.

Project Definition and Strategy

- Define overall scope of work for the project
- Define contracting and procurement plan
- Technical deliverable requirements, data attributes and requirements
- Levels of design
- Regulatory / permitting requirements

⁴ Construction Industry Institute "Advanced Work Packaging: Design through Workface Execution." Implementation Resource 272-2, Version 3.0 Volume I. 2013. PDF.

⁵ Refer to the full AWP Best Practice as in footnote 2 for details on each Stage tasks and subtasks.

- Identify key stakeholders, including special interest groups

Construction, Engineering and Procurement Planning

- Plan for work packaging
- Refine contracting plan
- Plan for procurement and logistics
- Identify size/project constraints and mitigations
- Consider weather risks
- Deliver construction plan
- Consider temporary structures, utilities requirements
- Consider options for construction equipment
- System turnover sequence
- Plan for work packaging
- Review contracting plan
- Review project definition deliverables
- Review procurement plan
- General arrangement/plot plan
- Technology plan

Path of Construction

- Define construction sequencing during project definition, including identification of site preparation activities
- Refine sequence during construction planning
- Review sequence of construction during engineering planning
- Look at sequence of installation during boundary development

Schedule and WBS Development

- Level 2 schedules for engineering by discipline, procurement by commodity and construction by discipline
- Preliminary IWP release plan

Boundary Development

- Plot plan or general arrangement drawings
- Construction plan
- Contracting/procurement execution plan
- Crafts workers available
- Work breakdown schedule
- Geographical layout of systems/areas
- Materials of construction
- Client/contractor contract milestones
- System turnover sequence
- Consideration for modular construction
- Consider construction feedback
- Define EWP standard
- Conflicting work fronts or potential synergies with other projects / operations

Stage 2 – Detailed Engineering

This stage involves detailed Engineering after the financial/investment decision is made and the detailed project work can begin. This stage continues the work done in stage 1, adding considerable value to the work packaging needs defined in stage 1.

Engineering Deliverables

- Level 3 schedule for engineering by discipline
- Execute EWP standard

Procurement Deliverables

- Level 3 schedule by commodity

CWP Creation

- Create CWPS
- Level 3 schedule for construction by CWP

Detailed Construction Schedule

- Develop final schedule for construction
- Review and assess changes to constraints since Stage 1

Stage 3 - Construction

It is during this stage in the AWP best practice that construction organizations perform detailed planning with the option of a specific position called a workforce planner and create the Installation Work Packages or IWPs. The process flowchart for this stage is the most detailed despite having a similar number of sub-tasks.

IWP Scoping

- Regular Superintendent meetings

IWP creation

- Identify WFP role and ensure this is communicated to construction leadership
- Identify IWP content, limits and boundaries
- Identify risks and completely define physical response to all high consequence or likelihood risks
- Identify supplementary equipment, labour, logistics and/or materials
- Manage IWP log
- Develop IWP schedule
- Regular superintendent meetings
- Monitor IWP constraints based on look-ahead schedule
- Check that IWP meets schedule

Document Control

- IWP review by superintendent and remaining parties (HSE, QC)
- Document control holds IWP for issuance

IWP Execution

- Planner reviews IWP, confirms constraint free, confirms everything is ready prior to start
- Superintendent reviews and released IWP
- Field executes work

Quality Control

- WFP Review if IWP is complete within scheduled time frame
- Decision process to complete / repack / hold IWP (this follows same decision process in Lifecycle 1)

Turnover

- Confirm completion of each IWP
- Field engineer performs required updates to drawings

- Document Control updates and archives completed IWP

6 THE AWP PRINCIPLES

The team reviewed the CII Advanced Work Packaging Best Practice and identified the core AWP principles that always apply to any size and category of project.

1. Determine the Project Scope (Stage 1) *“What will the project include and what is excluded?”*
2. Determine the Project Contract Strategy (Stage 1) *“Who will design, procure, engineer, and construct the project and what contract strategy will be used?”*
3. Determine the Path of Construction (POC) for the Project (Stage 1) *“How will the project be built?”*
4. Determine how to Work Package the Project (Stage 1) *“How will the project be work packaged and managed?”*
5. Determine the Project Resource Requirements (Stage 2)
 - a) Identify and supply the necessary information/engineering requirements
 - b) Identify and supply the necessary permanent material requirements
 - c) Identify and supply the necessary construction equipment requirements
 - d) Identify and supply the necessary construction execution labor requirements
6. Confirm the Project Resource Requirements are satisfied or mitigated prior to execution (Stage 3) *“How will resource readiness be determined?”*
7. Monitor Progress and Manage Construction (Stage 3) *“How will construction be progressed and managed including turnover, commissioning and start-up?”*

7 SCALING AWP PRACTICES FOR EACH PRINCIPLE

While principles never change our practices, how we respond must be adapted to the project being undertaken. The following sections describe how the practices will differ for each project category for the seven AWP principles.

Stage 1 – Project Definition

Principle 1: Determine the Project Scope

Principle 2: Determine the Project Contract Strategy

Principle 3: Determine the Path of Construction

Principle 4: Determine how to Work Package the Project

Stage 2 – Detailed Engineering

Principle 5: Determine the Project Resource Requirements

Stage 3 – Project Execution

Principle 6: Confirm the Project Resource Requirements are satisfied prior to execution

Principle 7: Monitor Progress and Manage Construction

7.1 PRINCIPLE 1 DETERMINE THE PROJECT SCOPE

Project scope management, according to the PMI PMBOK (Project Management Institute)⁶, includes developing the scope management plan, collecting requirements including stakeholder needs, defining the scope, creating a work breakdown structure, validating the scope and controlling the scope as changes occur during this first stage of the project. Specifically, when it comes to defining the scope, the project charter, project management plan, requirements, risk register, and organizational process and structure will need to be developed and utilized. This applies to all projects, however within the different types of projects, this step can be scaled up and down in levels of formality and detail. Because there are several elements involved, a quick chart can summarize the main differences.

⁶ Project Management Institute, Inc. *A Guide to the Project Management Body of Knowledge 6th Edition*. PMI member licensed to Lloyd Rankin. Pennsylvania: Project Management Institute, Inc. 2017. PDF. Bottom-up Estimating section 6.4.2.5, Analogous Estimating 6.4.2.2, Parametric Estimating 6.4.2.3, Three-point Estimating 6.4.2.4 and Data Analysis 6.4.2.6

Table 3: Project Scope Definition - Scaling for different projects

Project Element	Category A – Unfamiliar, Low Complexity	Category B – Familiar, Low Complexity	Category C – Unfamiliar, High Complexity	Category D – Familiar, High Complexity
Project Charter	Simple elements; what are we building, when, where. Gives authority to one project manager	Simple elements; what are we building, when, where; listing program areas. Gives authority to one or two project managers	More detailed, must address business outcomes. Gives authority to one project manager	More detailed, must address business outcomes and will include program elements. Gives authority to project management team
Project Management Plan	Simple description of how to execute, monitor and close the project	Simple description of how to execute, monitor and close an example project, includes elements of how the program is coordinated	Detailed plan on how to execute, monitor and close the project.	Detailed plan on how to execute, monitor and close the project. Details may vary for sub-groups within the program
Requirements	Simple data collection Simple decision making. Include experts if needed.	Simple data collection Simple decision making	Include experts, more meetings with integrated teams Full data analysis Designed decision-making criteria	Include experts, more meetings with integrated teams Full data analysis Designed decision-making criteria
Risk Register	Simple, must still include \$ impacts. Include experts if needed.	Simple, site-specific only, must still include \$ impacts. Risks may already be known with control plans.	Detailed, include input from stakeholders	Detailed, include input from stakeholders, multiple contractors
Organizational Process	Simple summary of roles and responsibilities, authorities etc.	Simple summary of roles and responsibilities, authorities etc.	Detailed summary of roles and responsibilities, authorities and more detailed governance process	Detailed summary of roles and responsibilities, authorities and more detailed governance process. Include details for program and any variances among projects
Organizational Structure	Simple, must still be communicated	Simple, must still be communicated	Complicated, must be detailed and communicated	Complicated, must be detailed and communicated
Work Breakdown Structure	Simple, high-level and precedes estimating, scheduling and Path of Construction	Simple, high-level and precedes estimating, scheduling and Path of Construction; standardized across projects	Moderately detailed, still high-level and precedes estimating, scheduling and Path of Construction	Moderately detailed, still high-level and precedes estimating, scheduling and Path of Construction; standardized across projects

7.2 PRINCIPLE 2 DETERMINE THE PROJECT CONTRACT STRATEGY

Each owner company will have their own organizational approaches however this report offers recommendations for each project category based on typical projects done in that type.

The contract strategy can be defined as the selection of organizations and contractual policies required for the effective and efficient execution of a specific project or series of projects. This task is identified under Stage 1 of the project life cycle flow chart for AWP. An effective contract strategy should identify the best way of achieving the project objectives and accommodating identified project constraints, funding requirements, risk profile and asset ownership. The different contract structures and relevant guidance can be found in section 15, which is a reproduction of a chapter within the AWP best practice documents ⁷.

For any type of project, there are various options on how to approach the contracting element. Table 3 indicates some examples of what it could look like for the different types of projects with the understanding that other options are available for any project.

Table 3 Contract Strategy - Scaling for different projects

Project Element	Category A – Unfamiliar, Low Complexity	Category B – Familiar, Low Complexity	Category C – Unfamiliar, High Complexity	Category D – Familiar, High Complexity
Engineering Procurement	Engineering Firm	Engineering Firm	(various options) EPC Firm	(various options) EPC Firm
Construction Management	Owner	Owner		
Construction Execution	Local General Contractor	Local General Contractor or Owner	DFL and or Multiple Contractors	DFL and or Multiple Contractors– multiple locations
Tendering Process	Pre-approved contractors, no bid	Pre-approved contractors, no bid	Formal Bid Process - Program-wide contracts Standardized RFQ	Formal Bid Process
Payment Structure	Cost-reimbursable	Mixed: cost-reimbursable / Lump-sum	Cost-reimbursable	Mixed: cost-reimbursable / Lump-sum

For small projects, the owner would typically take on supply chain functions including purchasing all material and delivering it to site prior to start of project as well as ordering equipment, project controls and

⁷ Construction Industry Institute. "Advanced Work Packaging - Implementation Guidance." Implementation Resource 272-2, Version 3.0 Volume II. 2013. PDF.

establishing the work breakdown and naming conventions. Lastly, the owner may even take over commissioning and start-up for the project.

For medium-sized projects, the engineering firm could take on more responsibility such as procurement and equipment purchasing. The area between small and medium sized projects would become blurry as to what arrangement works best, but typically either owner or engineering firm will take on project controls, work breakdown and naming conventions as well as commissioning and start-up.

Category A - Type 1 Unfamiliar Low Complexity (Project)

Category A projects are typically low in complexity and unfamiliar, such as installing a new pump for the first time. There is typically no previous history to draw on and at least initially these projects will not be managed as a program. Due to the low complexity for these types of projects a simple contracting strategy is engaged. For example, using a local general contractor, or a specialty contractor, hired for the project and a separate engineering firm, with construction management normally done by the owner or in some cases a separate construction management firm would be used.

For smaller projects owners often use pre-existing approved contractors (if available and appropriate) rather than undertaking a formal tendering process. The lack of project familiarity typically favors a Cost Reimbursable however owners tend to prefer lump-sum if all the engineering can be done before construction on a simple project like this. If the engineering cannot be done completely before construction than a cost-reimbursable arrangement is appropriate.

Category B - Type 2 Familiar Low Complexity (Program)

These projects can be repeatable and if there are a number of them, managed as a program. Smaller projects are often brownfield or a revamp whereas larger projects could be either brownfield or greenfield. An example of a familiar, low complexity project would be installing a series of 20 pumps and pipe over 12 months.

Normally a simple contracting strategy is engaged such as using local general contractors hired for each project within the program and a separate engineering firm that develops engineering and procurement across the program with construction management done by the owner. Re-use of deliverables and contract documents or even having contracts that cover multiple installations or parties with a defined partner can be very beneficial. For these programs, companies also would often use pre-existing approved contractors rather than undertaking a formal tendering process. The project familiarity typically allows for either a lump sum or cost reimbursable approach. We strongly recommend that a common data location be established and maintained so that a virtual library can be created for all the AWP elements of the projects within the program.

Category C - Type 1 Unfamiliar High Complexity (Project)

Category C project is typically high in complexity and unfamiliar, such as a debottlenecking project within an operating facility. There is no previous history to draw on and this category of project would typically be managed on a stand-alone basis. Due to the high complexity the project would normally follow a formal tender process prior to contractor and engineer selection. Strategies could include EPC, EP-C, E-PC, E-P-C or other variants and once the strategy was determined request for quote documents would be developed with AWP identified as a key element used in the proposal assessment process. The project category would normally require a cost reimbursable approach. If the contractor is very familiar with this type of project, they may be willing to offer up lump sum pricing. Refer to **Section 15 Contract Structures** for a full description of the different contracting arrangements and recommendations with regards to AWP.

Category D - Type 2 Familiar High Complexity (Program)

While we will provide a more detailed example later a Category D project is typically high in complexity and familiar, such as building a series of \$35 million operating facilities. With previous history to draw upon, this category of project could be managed as a program.

Due to high complexity, the project would normally follow a formal tender process prior to contractor and engineer selection. It is also possible to consider a strategic alliance. Strategies could include EPC, EP-C, E-PC, E-P-C, or other variants. The project category would normally allow for either a cost reimbursable or lump sum approach.

The familiarity of projects should accelerate the tender process and allow for proposals including multiple projects as part of a larger program. The Request for Quote (RFQ) should be largely reusable requiring only small modifications prior to reuse.

We strongly recommend that for familiar projects databases be maintained so that a virtual library can be created for the AWP elements of the project.

7.3 PRINCIPLE 3 DETERMINE THE PATH OF CONSTRUCTION (POC)

Path of Construction, as included in Stage 1 of the project lifecycle, involves integrating the estimate, schedule and work breakdown into a plan of what will be constructed in what sequence. The areas of the entire scope of work are separated into Construction Work Areas and a necessary sequence is established. For more detail please see the POC flow chart diagram page 74.

In general, Path of Construction will tend to be simple e.g. north/south, east/west etc. for small projects and more complicated e.g. multidirectional for larger projects but is generally standardized and reused within a program with minor modifications. The following recommendations include estimation tactics as defined by the Project Management Institute – Project Management Body of Knowledge.

Category A - Unfamiliar Low Complexity (Project)

For this type of project, the path of construction will likely be more informal, however determining the course of construction will be an important step and may involve input from stakeholders. Few meetings will be required and there will be limited opportunity to reuse a previous project's path of construction. This process will utilize the project scope developed and will be project specific – developed for the first time and likely simple. These projects will typically require a bottom-up estimating approach for duration and cost which typically requires more time to develop and can be less accurate than estimates based on other similar projects.

Category B - Familiar Low Complexity (Program)

Again, the path of construction process will be informal with a limited number of stakeholders. The focus is on adapting a previously developed POC and validating the new POC prior to finalization. It will be important to identify installation specific factors and constraints. These projects will typically require an analogous or parametric estimating approach for duration and cost. Analogous estimating tends to be used where there is greater variability in the project parameters and tends to be less accurate than parametric estimating. Parametric estimating is more effective where the project parameters are more consistent from

project to project. Both methods tend to require less time to develop and have greater accuracy than the bottom-up estimating approach.

Category C - Unfamiliar High Complexity (Project)

For this type of project, a formal process will be needed with all relevant stakeholders involved typically including project and construction management, engineering, procurement, and operations. The path of construction typically requires multiple meetings because more detailed schedule and cost estimates

Category D - Familiar High Complexity (Program)

Again, for this type of project a formal process will be needed with all relevant stakeholders involved typically including project and construction management, engineering, procurement, and operations. The focus is on adapting previously developed POC and validating the new POC prior to finalization. Validation of POC typically requires multiple meetings and estimates are normally developed using a Parametric Estimating Approach if the projects are more consistent or an analogous or three-point estimating approach if there is increased variability between project parameters.

7.4 PRINCIPLE 4 DETERMINE HOW TO PACKAGE THE PROJECT

Advanced Work Packaging involves more specific practices starting with this principle. Work packaging must be approached with a plan on how to divide up the work established in the path of construction. For different projects the number of work packages will vary greatly. The work is broken down into construction work packages and checks are done to determine if engineering and procurement can support the schedule and order. It is important to ensure CWPs are structured to account for physical constraints as well as information constraints (such as vendor information).

The engineering work packages are used to develop the construction work packages which are converted into installation work packages

The number of work packages varies depending on the size of project. For example, a project with 1 to 4 weeks of work may have 1-20 installation work packages. Or a project with 8 to 10 months of work might have 30 to 70 IWPs. It is advised to establish guiding criteria for IWP generation. For example, IWPs should be progressable and logical based on the work sequence and include guidance like “Per crew, per shift”.

The planning and execution functions should be sized appropriately. It is important not to over-build the planning and execution functions. Processes that are typical for large projects may not apply to small projects and vice-versa. Therefore, it is important to review the levels of detail needed for the project and decide what practices will be followed. The key guiding principle may be “does the deliverable add value” or in other words, does the level of detail result in each individual package adding value, getting materials and resources into the hands of the worker.

Category A - Unfamiliar Low Complexity (Project)

For these types of projects, CWAs would not normally be required. This would typically be a less formal process with engineering drawings and procurement information used to support simplified CWPs and IWPs typically developed by Superintendents or General Foremen. While this work is low in complexity and associated risk is moderate there is limited historical experience to draw on and limited ability to reuse existing packaging. With regards to work packaging for Category A projects, since there are only a few work

packages it can be expected that the superintendents and general foreman are responsible for workforce planning process. EWP/CWP/PWPs are combined into 1 or 2 packages and IWPs are done by the contractor adding safety, quality and work practices. Also, due to having only a few work packages, a simple technology like Microsoft Excel can be used for tracking and monitoring.

Category B - Familiar Low Complexity (Program)

CWAs would not normally be required as well for these projects and this would also be a less formal process. Engineering drawings and procurement information used to support simplified CWPs, and IWPs are typically modified by Superintendents or General Foremen from a library of pre-existing deliverables. Even though there are many projects because there are also few work packages in each, a simple technology for tracking and monitoring. Developing an internal library of templates and work samples will be beneficial for familiar projects.

Category C - Unfamiliar High Complexity (Project)

The process would be formal with CWA, CWP, EWP, IWP developed and possibly PWP would be used on an as required basis. Typically, the engineering, procurement front-end and field construction functions would each have standard processes and dedicated planners. As these projects are unfamiliar traditional project management approaches would be used to define, the required packages, templates, release plans and develop and execute the identified packages. For more complex projects a more robust technology may be needed for tracking and progressing work packages, and possibly integrate with other software's such as the 3D model, inventory management, timesheets, safety tracking etc.

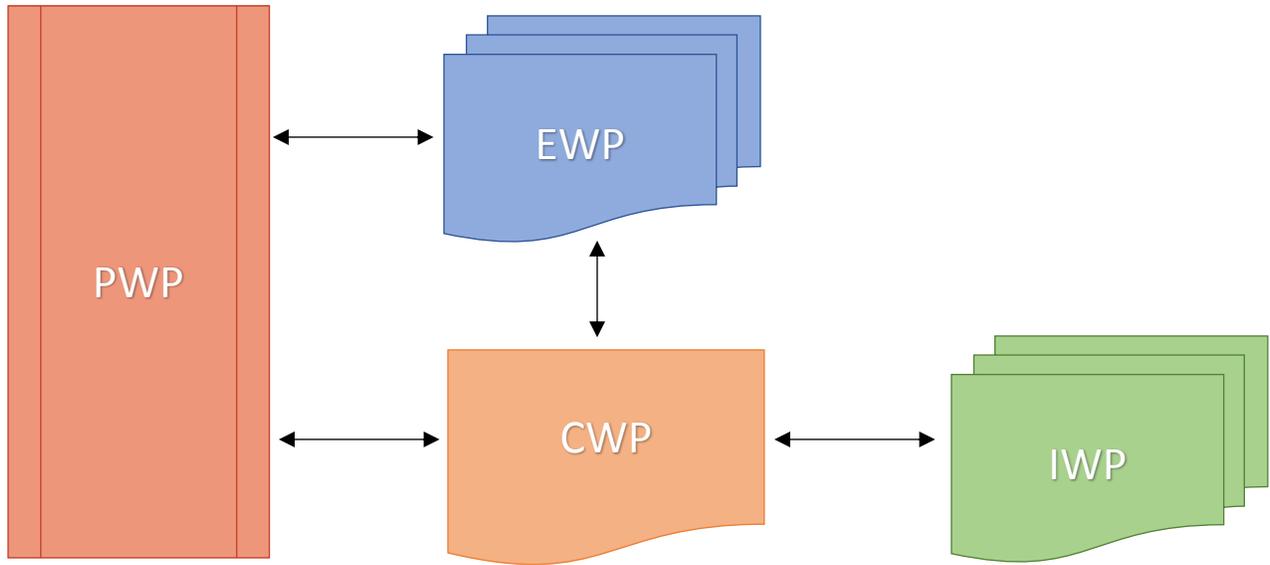
Category D - Familiar High Complexity (Program)

The process would be formal with CWA, CWP, EWP, IWPs and possibly PWPs would be used on an as-needed basis. Typically, the engineering, procurement front-end and field construction functions would each have standard processes and planners. The stakeholders would have libraries of required packages, templates, release plans and develop and execute the identified packages. The modification of existing packages may allow superintendents and general foremen to develop IWPs in addition to Workforce Planners. Again, for more complex projects, and even more so for a program of them, a more robust technology may be needed for tracking and progressing work packages, and possibly integrate with other software. Developing an internal library of templates and work samples will be beneficial for familiar projects.

Table 4: Work Packaging - Scaling for different projects

Project Element	Category A – Unfamiliar, Low Complexity	Category B – Familiar, Low Complexity	Category C – Unfamiliar, High Complexity	Category D – Familiar, High Complexity
CWAs	As required	As required	Scope-intensive areas similar to major projects. Non scope-intensive areas likely be a larger area to suit principle discipline construction requirements. Revamp project CWA boundaries to consider site access requirements.	Areas likely be a larger area to suit principal discipline construction requirements. Staged turnover requirements to be considered in defining CWA boundaries.
EWPs	Combine with CWPs	Combine with CWPs	EWP and CWP boundaries aligned. Scope intensive areas plan release of discipline-specific Engineering by EWP. Non-scope intensive areas plan release of discipline-specific scope by CWA.	EWP and CWP boundaries aligned. Release of discipline-specific scope by CWA or for the project is possible.
PWPs	Not Required	Not Required	PWPs used to track Owner and Engineering Contractor supplied material by CWP.	PWPs used to track Owner and Engineering Contractor supplied material by CWP.
CWPs	Relatively few multi discipline CWPs to be split to suit Contracting strategy.	Relatively few multi discipline CWPs to be split to suit Contracting strategy.	EWP boundaries to align with CWPs. Likely multiple discipline CWPs for each scope-intensive CWA. Likely 1 or 2 discipline specific CWPs for each CWA for non-scope intensive areas.	CWP boundaries to align with EWPs. Likely 1 or 2 discipline specific CWPs for each CWA.
IWPs	Split CWP into discipline specific scope. Relatively few discipline IWPs per CWP.	Split CWP into discipline specific scope. Relatively few discipline IWPs per CWP.	Crew allocation dependent IWP subdivision of CWPs in scope intensive areas. Relatively few IWPs for each CWP in non-scope intensive areas.	Crew allocation dependent IWP subdivision of CWPs.

Work Package Relationship Diagram



EWP	CWP	IWP	PWP
<p>Engineering deliverables.</p> <p>Typically, 1-to-1 but in some cases many-to-1 relationship to CWP.</p> <p>In some cases, the engineering will not be packaged as an EWP, but as drawings that will be incorporated into a simplified CWP.</p>	<p>Construction deliverable.</p> <p>Includes engineering, materials, equipment, safety, quality, and a variety of construction-related information.</p>	<p>Crew-level information used to provide a construction crew with all the information they need to install over a tour (normally up to two weeks).</p>	<p>A method for ensuring the material readiness of the EWPs and CWPs.</p>

Figure 3: Work Package Relationship Diagram

7.5 PRINCIPLE 5 IDENTIFY AND SUPPLY THE NECESSARY RESOURCE REQUIREMENTS

Resources for projects broadly fall into four categories; Engineering, Material, Equipment and Labour.

Principle 5a Identify and Supply the necessary Engineering requirements

Supply of the necessary Engineering requirements can generally be described as ensuring Construction is provided with the necessary information to complete the specified work. To ensure the information is provided appropriately in Stage 2 – Detailed Engineering, there are common considerations to account for including:

1. Constructability: How a project will be built is a key influence in the development of the design. Leveraging the input from the Construction team, and those on the project team with insight in how a facility will be constructed, is paramount. This is particularly true when incorporating AWP on a project. Early alignment will ensure deliverables support the AWP plan.
2. Client Reviews: Client reviews during the development of a project are an important tool to ensure the team is aligned and that the incorporation of AWP is maintained. Typical reviews necessary to obtain alignment on a project include:
 - Design Basis review
 - Interactive planning
 - P&ID Design Review
 - Process Hazard Analysis Review
 - Select engineering drawing reviews
 - Select Vendor drawing reviews, if any
 - Deviations from client standards (if required)
 - Model review – if a 3D model exists. Alternatively use a Plot Plan / General Arrangement review. Typically, these are formalized reviews at 1/3 points of a project's design development.
3. Engineering Tools / Deliverable Format: The selection and use of engineering tools will impact the production of the engineering deliverables that will eventually feed the Work Packages. Selection of tools should align with what information and drawings will be required by construction in either electronic, hard copy, or database format. The selection of engineering tools should be agreed upon in the Preliminary Planning and Design phase and should be incorporated into the Project Execution Plan. A list of anticipated engineering deliverables is typically developed in a Deliverables List which is a beneficial tool to ensure alignment of expectations of project stakeholders. Also important are the list of industry codes and company standards to be followed as inputs to the design and construction planning.
4. Material Requirements: This content must define how the engineering team will generate the Material Requirements for the project, and what format will be used to issue them. These documents / data can include such things as: RFQ, RFP, MTOs, Tagged Item Lists (Equipment, Electrical, Instrument, Specialty Item, etc.), Bulk Material summaries, vendor data etc.
5. Work Package Production: The timing, format, and sequence of issuing of engineering deliverables to support Construction Execution needs to be such that it supports and aligns with the AWP plan for the project. Early definition of the type of deliverables needed to support construction is critical. Most

projects will issue engineering deliverables within Engineering Work Packages (EWP). In all cases, special safety concerns or construction requirements should be properly documented. Common boundaries between CWPs and EWPs are used to ensure engineering scope is aligned to support the path of construction. It is important to note that, for scalable projects, the CWA and CWP geographic boundary definition to support the path of construction may more closely align with the installation of a system of work.

6. **Systems Completion, Turnover and Commissioning Requirements:** Early definition and sequencing of Turnover systems and Commissioning requirements during the detailed engineering phase (or earlier) will ensure a smooth transition to Operations. Unfamiliar projects may require more planning for commissioning and start-up – it is likely this is the time when issues will be discovered. Some clients require the creation of turnover packages that can be defined early in the engineering design process. In all cases, consideration should be given to how the Work Package plan will be sequenced to best support the Commissioning and Start-up phases. Additionally, consideration should be given to activities requiring outages or downtime – these activities may need to accommodate planned downtime.

Table 5: Engineering Requirements - Scaling for different projects

Project Element	Category A – Unfamiliar, Low Complexity	Category B – Familiar, Low Complexity	Category C – Unfamiliar, High Complexity	Category D – Familiar, High Complexity
Constructability	Owner and Eng. input. Prefer early Contractor engagement including joint field walkdowns.	Input from program, informal Owner and Eng. review for each instance. Prefer early Contractor engagement including joint field walkdowns.	Formal, 1 or more design reviews. Formal input from construction contractor including joint field walkdowns.	One formal design review for each instance taking input from program (if applicable). Formal input from construction contractor
Client Reviews	Informal, may not be necessary Single Design Review		Participate in formal design reviews, add informal reviews to maintain alignment with stakeholders	May not be necessary for each instance, but will be set for the program
Engineering Tools / Deliverable Format	Few tools, not normally a 3D model. Determine if new standards are required.	Few tools, not normally a 3D model. Templated for the program	Similar to large project, uses 3D model supporting deliverables generation. Determine if new standards are required.	Few tools, templated for the program, uses 3D model supporting deliverables generation / dashboard
Material Requirements	Reference Eng. Deliverables Limited electronic integration of information. Reference Eng. Deliverables		Electronic generation from 3D model, integrated with procurement and construction work packages.	

	Consider needs for electronic integration of information.		
Work Packages	EWP & CWP combined, multi-discipline. Unique for each contract.	EWP aligned with POC, discipline-specific, unique for each contract.	Ready as part of program prior to construction, discipline-specific, and unique for each contract.
Start-up, Turnover and Commissioning Requirements	May not require extensive planning, unique work packages for this scope of work.	Less detail than large projects, formal plan, not needing unique work packages.	

Principle 5b Identify and supply the necessary permanent material requirements

Supply of the necessary permanent material requirements can generally be described as ensuring construction is provided with the necessary tagged and bulk materials necessary to complete the specified work. To ensure the material is provided appropriately in Stage 2 there are common considerations to account for, including:

1. Purchasing Plan Update: The use of AWP in the development and update of the project Purchasing Plan is critical for the success of AWP on a project. The Purchasing Plan is to be defined in the Preliminary Planning and Design phase of a project and will be updated early in the Detailed Engineering phase.
2. Procurement Work Packages (PWP): The purpose of the PWP is to allocate materials to the EWPs and CWPs by tracking the status of materials. By tagging the equipment/materials with associated EWPs / CWPs the project will ensure that all equipment / materials are available to support the path of construction.
3. Material Sourcing, Logistics, and Material Tracking: The use of AWP on a project will influence how material is sourced and the project must determine how suppliers/vendors will align with the requirements of the procurement plan during the Preliminary Planning and Design phase. Agreement on how and when material will be shipped and tracked is defined in the Preliminary Planning and Design phase of a project and will be updated early in the Detailed Engineering phase.
4. Vendor Data Registry: Define a list of key vendor details including data for installation, dimensions, electrical loads, software compatibility. Determine when this information is necessary for design and installation. Lastly, consider the EWP release schedule.

Table 6: Permanent material requirements - Scaling for different projects

Project Element	Category A – Unfamiliar, Low Complexity	Category B – Familiar, Low Complexity	Category C – Unfamiliar, High Complexity	Category D – Familiar, High Complexity
Purchasing Plan Update	Minor modifications. All material should arrive prior to construction		Align with POC	Limited to minor modification from one project to the next
Procurement Work Packages	Not required		PWP used, aligned with CWPs	Templated from program; PWP used, aligned with CWPs
Material Sourcing, Logistics, tracking	Support material arriving to site before construction		Material must arrive as per POC. Tracking recommended by CWP	Sourcing, delivery and staging by CWA supporting POC

Principle 5c Identify and supply the necessary Equipment requirements

Supply of the necessary construction equipment requirements can generally be described as ensuring the long lead time and specialty construction equipment required to complete the specified work is identified early to ensure availability. To ensure the construction equipment is identified appropriately in Stage 2 there are common considerations to account for, including:

1. Construction Equipment Plan: The development and update of the project construction equipment plan is critical for the success of AWP implementation on a project. The construction equipment plan is to be defined in the Preliminary Planning phase of a project to allow adequate time to source long lead time and specialty construction equipment and lock in on agreements and mobilization/demobilization dates. Once developed, the construction equipment plan will be updated during the planning phase.
2. Construction Equipment Schedule: The development and use of the construction equipment schedule is intended to support the construction equipment plan by tracking the status of the required construction equipment for a given CWA/CWP. The construction equipment schedule must align with a CWA boundary and identify the construction equipment with all associated CWPs, the project will ensure that all construction equipment will be available to support the path of construction.

Category A - Unfamiliar Low Complexity (Project)

1. Construction Equipment Plan: For the unfamiliar low complexity project, the scope of work and POC is usually simple with a small number of CWAs and CWPs. When the project is a low complexity, unfamiliar project and has not been performed before, it is recommended that a construction equipment plan be developed. It is important to note that all construction equipment is required to be at site prior to the start of the CWP, because seemingly minor delays can have a relatively significant impact. Specifically, ensure that unique or specialty equipment is identified with support of the construction contractor. This is particularly important for unfamiliar scopes.

2. Construction Equipment Schedule: Since this is a low complexity project, a construction equipment schedule is not required. The construction equipment schedule can be incorporated into the construction equipment plan.

Category B - Familiar Low Complexity (Program)

1. Construction Equipment Plan: For the familiar low complexity project, the scope of work and POC is usually simple with a small number of CWAs and CWPs. Since the project is familiar and has been performed before, the construction equipment plan developed for the previous project can be reused. It is recommended to review and verify the plan for any minor modifications that might be required. Rarely are major modifications required. It is important to note that all construction equipment is required to be at site prior to the start of the CWP execution, because seemingly minor delays can have a relatively significant impact.
2. Construction Equipment Schedule: A construction equipment schedule is not required. The construction equipment schedule can be incorporated into the construction equipment plan. If multiple projects will be executed simultaneously or in sequence under the program, a program-specific equipment plan should be developed to identify what equipment can be shared, staged or transferred from work site to work site – particularly for programs with multiple physical locations.

Category C - Unfamiliar High Complexity (Project)

1. Construction Equipment Plan: The scope of work and POC is usually quite complex with a larger number of CWAs and CWPs. The development of the construction equipment plan is crucial for the success of the project and must consider these complexities. Things that must be considered are types of equipment, lead time, availability, logistics of getting the equipment to site, durations and engineering requirements such as ground bearing pressures. It is important to note that all construction equipment is required to be at site prior to the start of the CWP execution. Also of note will be contingency equipment (such as dewatering pumps or shoring) as well as an analysis of when additional equipment may be an advantage during construction. For example, when to procure additional cranes as work fronts become available.
2. Construction Equipment Schedule: Since this is a high complexity project, a construction equipment schedule is required. The construction equipment schedule should be developed to identify the required mobilization and demobilization dates by CWA and CWP. The construction equipment schedule should be used to track the status of the construction equipment to ensure that the construction equipment is on site when required and prior to the start of the CWP execution.

Category D - Familiar High Complexity (Program)

1. Construction Equipment Plan: The scope of work and POC is usually quite complex with a larger number of CWAs and CWPs. Since the project is familiar and has been performed before, the construction equipment plan developed for the previous project can be utilized, but it is recommended that a thorough review be completed to verify the plan for any modifications that might be required. Major modifications can be required due to market conditions, availability and logistics of the equipment required. It is important to note that all construction equipment is required to be at site prior to the start of the CWP execution, because seemingly minor delays can have a relatively significant impact.

2. Construction Equipment Schedule: The construction equipment schedule developed for the previous project can be utilized. It is recommended that a thorough review be completed, and the appropriate modifications made for the required mobilization and demobilization dates. The construction equipment schedule should be used to track the status of the construction equipment to ensure that the construction equipment is on site when required and prior to the start of the CWP execution

Principle 5d Identify and supply the necessary Labour requirements

The identification and supply of labour requirements will be significantly predetermined by the contracting strategy of the project. Factors to initially consider are the requirement of speciality skills (i.e. exotic material welders, heavy riggers, etc.), specialty labour (i.e. inspectors, commissioning, etc.) as well as the complexity of the project which will determine the size of Construction Management Team indirect labour. Additionally, total man-hours estimated for each labour resource classification will be required.

Labour requirements are separated into the following and addressed for each project type:

1. Direct labour: this is the labour that performs the tasks in the field; this labour is generally classified in the discipline trades
2. Indirect labour: this labour classification covers all staff that do not directly install or perform construction activities in the field. Example roles are: Construction Manager, Superintendent, Project Manager, Project Controller, Scheduler, Workface Planner, QC inspector, HS&E Advisor, etc.

The intention of the following recommendations is not to cover all potential roles on a project but the key roles on the majority of projects, and particularly those who interface with the AWP or are critical to its success.

Category A - Unfamiliar Low Complexity (Project)

1. Direct Labour: The Owner will often select a “preferred” or regularly used contractor. Upon receipt of the project scope via the CWP(s) the contractor will estimate the direct field labour required by trade and skill as well as the duration based on estimated hours. These estimates will provide a good indication to the needs of indirect labour. Identification of unique skills will be important for unfamiliar scopes.
2. Indirect Labour: Can be summarized in Table 8

Table 7: Labour Requirements – Category A Project

Labour Type (contractor)	Required	Duration	Tasks and Comments
Project Manager	Yes	Duration of project, likely managing several projects	Project Management
Construction Manager	Project Dependent	If yes, duration of project but likely managing several projects	Construction Management
Craft Supervisor (Superintendent)	Yes	Duration of construction	Supervision of field labour, project progress and schedule updates to Owner
Workface Planner	Project Dependent	If WFPs are employed they will not remain working as WFP for the full duration of the project rather once planning is complete the WFP may move to another project or remain in a different role (coordinator, GF, etc.)	Development of IWPs, management of constraints, updating progress and schedule on behalf of Superintendent
Project Controls and Scheduling	As Required		These functions will likely be completed by the Superintendent of the project and reported to Owner’s Project Controls and Scheduling
HS&E Advisor	Yes	Duration however may be shared with other projects	HS&E advising and support
Quality Control	Yes	Duration however likely supporting multiple projects	QC inspection and turnover functions

Category B - Familiar Low Complexity (Program)

1. Direct Labour: Programs such as these may utilize one contractor or many, depending on contracting strategy and location of work. With scope being similar, or the same, between projects often a high-level review and comparison will suffice against a baseline such as the first one or two projects to be executed. The comparison to baseline will determine if there is enough difference in scope to justify a reanalysis of labour requirements. If multiple projects in the program will be executed simultaneously or in sequence, a strategy specific to direct labor sharing or synergy with the various work areas may be valuable.
2. Indirect Labour: Can be summarized in Table 9

Table 8: Labour Requirements - Category B Project

Labour Type (contractor)	Required	Duration	Tasks and Comments
Project Manager	Yes	Duration of project, likely managing several projects	Project Management
Construction Manager	Project Dependent	If yes, duration of project but likely managing several projects	Construction Management
Craft Supervisor (Superintendent)	Yes	Duration of Project	Supervision of field labour, project progress and schedule updates to Owner
Workface Planner	Project Dependent	WFP is a role, not necessarily a position. WFP may move to another project or remain in a different role (coordinator, GF, superintendent etc.). WFP may develop IWPs for multiple trades and projects.	Development of IWPs, management of constraints, updating progress and schedule on behalf of Superintendent. WFP functions may also be supported by the Owner via Owner staff WFP or a Seconded WFP that plans for multiple projects in the portfolio
Project Controls and Scheduling	No, however some resources needed to management and track program		These functions will likely be completed by the Superintendent of the project and reported to Owner's Project Controls and Scheduling
HS&E Advisor	Yes	Duration however may be shared with other projects in the portfolio	HS&E advising and support
Quality Control	Yes	Duration however likely supporting multiple projects in the portfolio	QC inspection and turnover functions

Category C - Unfamiliar High Complexity (Project)

1. Direct Labour: Determining Direct Labour requirements will be no different than any typical construction project using AWP. A formal Path of Construction with multiple CWAs and CWP's will provide greater detail for planning of which craft and skills are required and when. A typical resource loaded schedule will need to be developed for this project by the performing contractor and managed and reviewed regularly.
2. Indirect Labour: Can be summarized in Table 10

Table 9: Labour Requirements - Category C Project

Labour Type (contractor)	Required	Duration	Tasks and Comments
Project Manager	Yes	Duration of project	Project Management
Construction Manager	Yes	Duration of project	Construction Management
Craft Supervisor (Superintendent)	Yes	Duration of Project	Supervision of field labour, may employ more than one Superintendent
Workface Planner	Yes	Pre-execution planning through construction execution. WFP will likely transition to different roles on same project to utilize knowledge (i.e. coordinator, hydro-planning, field supervisor)	There may be more than one WFP. It is important the WFP is known to the construction leaders. Additionally, WFP may be trade specific or have a more focused set of disciplines to plan (i.e. piping/structural and electrical/instrumentation)
Project Controls and Scheduling	Yes	Duration	Progress and cost management and updates Schedule development and management
HS&E Advisor	Yes	Duration	HS&E advising and support
Quality Control	Yes	Duration	QC inspection and turnover functions

Category D - Familiar High Complexity (Program)

1. Direct Labour: Determining Direct Labour requirements will be no different than any typical construction project using AWP. A formal Path of Construction with multiple CWAs and CWP's will provide greater detail for planning of which craft and skills are required and when. A typical resource loaded schedule will need to be developed for this project by the performing contractor and managed and reviewed regularly.
2. Indirect Labour: Can be summarized in Table 11

Table 10: Labour Requirements - Category D Project

Labour Type (contractor)	Required	Duration	Tasks and Comments
Project Manager	Yes	Duration of project, potentially supporting several projects in portfolio	Project Management
Construction Manager	Yes	Duration of project, potentially supporting several projects in portfolio	Construction Management
Craft Supervisor (Superintendent)	Yes	Duration of Project	Supervision of field labour, may employ more than one Superintendent
Workface Planner	Yes	Pre-execution planning through construction execution. WFP will likely transition to different roles on same project to utilize knowledge (i.e. coordinator, hydro-planning, field supervisor)	If project is highly similar to others in program, IWP planning has potential to be lessened or even just require a review by the Superintendent with agreement from project leadership team. However, it is more likely there may be more than one WFP. Additionally, WFP may be trade specific or have a more focused set of disciplines to plan (i.e. piping/structural and electrical/instrumentation)
Project Controls and Scheduling	Yes	Duration	Progress and cost management and updates Schedule development and management
HS&E Advisor	Yes	Duration	HS&E advising and support
Quality Control	Yes	Duration	QC inspection and turnover functions

7.6 PRINCIPLE 6 CONFIRM THE PROJECT RESOURCE REQUIREMENTS ARE SATISFIED

Confirmation of satisfied resource requirements is typically performed by a readiness checklist or equivalent process.

Category A - Unfamiliar Low Complexity (Project)

All Engineering and Material is to be available prior to Construction Start for the project. The assessment of Construction readiness should be incorporated as part of the preparation of the IWPs prior to mobilization of the Construction team to site.

Category B - Familiar Low Complexity (Program)

All Engineering and Material is to be available prior to Construction Start for the project. The assessment of Construction readiness should be incorporated as part of the preparation of the IWPs prior to mobilization of the Construction team to site. A standardized checklist should be developed for the program and updated to incorporate lessons learned from completed scopes.

Category C - Unfamiliar High Complexity (Project)

For scope intensive areas, Engineering is to be available prior to Construction start for a given CWP. The assessment of Construction readiness should be incorporated as part of the preparation of the IWPs generated from the applicable scope. For all areas, a pre-planned allocated lead time for each EWP to be issued prior to construction start is recommended. This time lag allows for Construction to review and become familiar with the Engineering requirements prior to Construction start for each package. The use of PWPs, aligning with CWPs, provide the assurance that all necessary material is available for each package prior to the start of work.

Category D - Familiar High Complexity (Program)

For repetitive scope, Engineering can likely be complete prior to Construction start for the project. The assessment of Construction readiness should be incorporated as part of the preparation of the IWPs. A pre-planned allocated lead time for the completion of engineering prior to construction start is recommended. This time lag allows for the development of IWPs and provides the opportunity for Construction to review and become familiar with the Engineering requirements prior to Construction start. The use of PWPs, aligning with CWPs, provide the assurance that all necessary material is available for each package prior to the start of work.

7.7 PRINCIPLE 7 MONITOR PROGRESS AND MANAGE CONSTRUCTION PRACTICES

Monitoring progress and managing constructing activities are critical, regardless of project size, familiarity, or complexity. Monitoring progress entails both Project Controls activities (monitoring of installation activities to date) and Quality Control (monitoring quality of activities completed and transitioning to completions). Where the practices differ by project are on staff responsibility (RASCI) and when the monitoring activities take place – such as immediately following activity completion straight to completion rather than a progressive completion.

Management of construction activities, effectively the work packaging process via the IWP, is significantly determined by Principle 4 (Determine How to Package the Project and Manage the Packages) and Principle 5 (Identify and Supply the Necessary Resource Requirements); however, work packaging detail and

management remain very similar regardless of project size, familiarity, or complexity. The practices will differ primarily in staff responsibility (shared resourcing) and when these activities begin.

Category A - Unfamiliar Low Complexity (Project)

Due to the generally smaller nature of these projects, the overall scheduling of the project will be the responsibility of the Owner. With only a few CWPs and potentially specific coordinating dates with the Owner's maintenance crews for isolations and shutdowns, the Contractor will have limited schedule flexibility. As there are an expected small quantity of IWPs and activities tracking of progress may be a simple affair by spreadsheet with manual schedule updates to the Owner by the project Superintendent. With a limited quantity of IWPs and scope, the packages may be built to follow the Inspection and Test Plan (ITP) and the Inspection and Test Report (ITR) requirements. As IWPs are being executed and completed, QC will monitor and inspect the completed tasks and upon completion of an IWP transition immediately into a turnover function.

On these projects the planning and development of IWPs will fall on the contractor's Superintendent or General Foreman if only a minimal amount of IWPs are required (under 10) if greater than 10 a dedicated WFP that *transitions* into a coordinator or GF role after planning is complete is recommended. This planning activity will take place in advance of crew deployment. In addition to development of IWPs, the construction activities will be set up regarding materials responsibility matrix, equipment needs and craft crew requirements.

Category B - Familiar Low Complexity (Program)

Run as a program, and with each project being smaller in scope, the overall scheduling activities will be the responsibility of the owner. However, depending on how many projects are in the program (and how many will be executed simultaneously) the overall quantity of IWPs, as well as coordinating activities among field crews (maintenance crew and construction crews), will be greater and as such require more input from the performing contractors.

With a limited quantity of IWPs and scope, the packages may be built to follow ITP and ITR requirements. As such, as IWPs are being executed and completed QC will monitor and inspect the completed tasks and upon completion of IWP transition immediately into a turnover function.

Depending on the size of the program and the contracting strategy (i.e. few vs. many contractors) the planning and construction management may be similar to **Category A** or the Owner may elect to second a dedicated WFP to plan all IWPs for the program as a whole and issue the IWPs to each project individually. In this second case, and if multiple contractors are employed, each contractor will be required to apply their QC procedures to each IWP as per the Owner's requirements. In either circumstance, on-site superintendent or designee will be responsible for ensuring all on-site activities such as materials, equipment, and crew resourcing align with the IWPs.

Category C - Unfamiliar High Complexity (Project)

Projects such as these will be very similar in AWP implementation to that determined by CII RT 272. As there will be a formal Path of Construction, CWA(s), and multiple CWPs, the development of IWPs is expected to be larger in scope. The key differentiator will be the amount of WFPs employed and the *duration* that they are employed as WFPs for the project. Dedicated WFPs will be employed; however, some WFPs may plan for multiple disciplines (i.e. one WFP may plan piping, mechanical, and structural work). Tracking of progress will follow typical project management guidelines utilizing a project controls group to track both progress and schedule.

As these projects may be larger, and certainly more complex, in scope than **Category A or B** the QC tracking and transition to systems completions and turnover will follow standard project methodologies as CWAs begin to reach completion.

Category D - Familiar High Complexity (Program)

Programs such as these will be very similar in AWP implementation to that determined by CII RT 272. As there will be a formal Path of Construction, CWA(s), and multiple CWPs the development of IWPs are expected to be larger in scope. The key differentiator will be exactly how similar each project within the program is. If the projects are similar enough to allow for duplication of IWPs the utilization of Superintendents and GFs to modify each IWP may suffice. However, if project similarity is such that IWPs cannot be duplicated dedicated WFP will be employed. The key distinction will be the amount of WFP employed and the *duration* that they are employed as a WFP for the project. If dedicated WFP are employed some WFP may plan for multiple disciplines (i.e. Piping, mechanical, and structural by one WFP). Tracking of progress will follow typical project management guidelines utilizing a project controls group to track both progress and schedule.

As these projects may be larger, and certainly more complex, in scope than **Category A or B** the QC tracking and transition to systems completions and turnover will follow standard project methodologies as CWAs begin to reach completion.

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9 DEFINITIONS

The definitions below explain the building blocks of work packaging. Currently, the understanding of these terms varies throughout the construction industry. The objective of defining them here is to standardize the language surrounding work packaging and to provide a coherent basis for industry discussions of the practice. The definitions have been adapted from documents produced by the Construction Owners Association of Alberta (COAA), the Construction Industry Institute (CII), and other sources. The definitions are intended for use with the workflow diagrams provided below.

It is important to note the significant contribution of COAA to this report. The work of the COAA Workface Planning Committee to document the process and the organization's efforts in the field have together laid the foundation for the model presented in this report. The COAA term Workface Planning has been used as an all-inclusive term for techniques to improve field performance. However, workface planning as defined in this report refers specifically to field activities and is a subset of the overall process of Advanced Work Packaging. COAA and CII jointly endorse the definitions presented below.

Advanced Work Packaging

Advanced Work Packaging is the overall process flow of all the detailed work packages (CWPs, EWPs, and IWPs). It is a planned, executable process that encompasses the work on an engineering, procurement, and construction (EPC) project, beginning with initial planning and continuing through detailed design and construction execution. Advanced work packaging provides the framework for productive and progressive construction and presumes the existence of a construction execution plan.

Workface Planning

Workface Planning is the process of organizing and delivering all the elements necessary for an Installation Work Package, before the work is started. This proactive process enables craft workers to perform their work safely, effectively, and efficiently. This is accomplished by breaking down construction work (by trade) into discrete installation work packages that completely describe/cover the scope of work for a given project. This process promotes the efficient use of available resources and permits the tracking of progress.

Workface Planning Lead

A workface planning lead is a person knowledgeable about EPC projects who is chosen to participate in a project's front end planning, and who will later transition to the jobsite. On the jobsite, this workface planning lead will provide essential coordination among engineering, procurement, and construction personnel. This coordination ultimately results in the timely issuance of a complete and constructible installation work package (IWP), a comprehensive document that supports the construction schedule. The workface planning lead will head a staff of workface planners that is sized to match the scope and complexity of the project.

Workface Planner

The Workface Planner is a critical position for the success of the AWP implementation process. The Workface Planner manages the handoff from the Front-End Planning efforts completed in the office to the Workface Planning efforts done in the field.

The Workface Planner receives and organizes all the information placed in the CWP's and EWP's coming from multiple sources such as the Engineering, Procurement, Equipment Suppliers (OEM's) and Owner's. They then identify the required IWP's and ensure that a comprehensive IWP release plan is developed. The Work Face Planner works with the construction team and insures that IWP's are developed to provide constraint free executable work packages to the construction crews.

When looking for a Workface Planner, you must find an individual that has a strong background in construction, a good understanding of construction sequencing as well as having planning experience and competencies. This is a critical attribute to the successful outcome of the Workface Planning efforts.

Work Breakdown Structure

The Work Breakdown Structure (WBS) is a hierarchical representation of a complete project or program. The components of a WBS are arrayed in ever-increasing detail, as is appropriate for any given project (CII, 1988).

Engineering Work Package

An Engineering Work Package (EWP) is an engineering and procurement deliverable that is used to create Construction Work Packages (CWPs). The EWP should be aligned with the construction sequence and priorities. A typical EWP for a CWP includes the following:

- scope of work with document list
- drawings (e.g., general arrangement and equipment installation)
- installation and materials specifications
- vendor data (e.g., equipment O&M manuals)
- Bill of Materials
- lists (e.g., line lists and equipment lists)
- additional pertinent information to support (e.g., permitting studies).

Construction representation during the planning of an EWP is critical. CWPs can contain more than one EWP. EWP completion should be supportive of efficient engineering, but EWP deliverables should be subordinate to the project execution plan and to the sequence and timing of CWPs.

Construction Work Package

A Construction Work Package (CWP) defines a logical and manageable division of work within the construction scope. CWPs are aligned with the project execution plan (which includes the construction execution plan) and the WBS. The division of work is defined such that CWPs do not overlap within a discipline. CWPs are to be measurable and in alignment with project controls. CWPs are the basis for the development of detailed Installation Work Packages. Also, they can contain more than one EWP. A CWP is typically aligned with a bid package. A typical CWP includes the following:

- safety requirements
- at least one EWP

- schedule
- budget (work hours/cost/productivity)
- environmental requirements
- quality requirements
- special resource requirements

A CWP may be divided by area, system, or as otherwise determined by the project (construction) execution plan. In general, it is better to develop CWPs by discipline. A large project will likely contain multiple CWPs. CWPs can be the basis of contractual scopes of work, and are typically aligned with a bid package; a contractual scope may contain more than one CWP. CWPs are developed over time, from contract initiation through construction execution. Complete specifications of CWPs grow over time to include productivity factors, detailed cost reports, and other considerations.

Installation Work Package

An Installation Work Package (IWP) is the deliverable that enables a construction work crew to perform work in a safe, predictable, measurable, and efficient manner. An IWP is scoped to be manageable and "progressable"; it is typically of limited size such that a crew can complete the work in about a week. An IWP contains the necessary documentation supporting workforce execution. IWPs should be approved by the responsible stakeholders, and any constraints should be mitigated before issuance to the field. A typical IWP includes the following:

- work package summary- inclusive of description of work, location, system or facility code, originator, contact information, sequenced work steps, reference documents, estimate of work hours and quantities, cost codes, witness or hold points, and special comments
- quantity work sheet
- safety hazard analysis, specific to tasks in work package
- Material Safety Data Sheet
- drawings (engineering and vendor design)
- specifications (engineering and vendor design)
- change documents (i.e., field change request, deficiency report/non-conformance report, and design change notice)
- manufacturer's installation instructions
- model shots
- Bills of Materials
- required tools
- installation test results forms
- as-built documentation
- inspection checklists
- completion verification signatures

All elements necessary to complete the scope of the IWP should be organized and delivered before work is started. The originator should cover the work with the responsible safety, quality, superintendent, and craft personnel in a preparatory meeting, with special focus on anticipated constraints. Generally, the scope of work associated with the IWP should be small enough that it could be completed by a single foreman and crew within a pre-defined block of work hours.

An IWP contains all applicable and pertinent documents in support of safe and efficient installation of a specific portion of a system by a given trade. These documents are written specifically for the crew performing the activity. It should include a scope for the work, work constraints, design documents, materials, quality records, construction equipment requirements and budget for the work. Even though IWPs are generally developed by area and do not cross CWP boundaries, they may be broken down by commissioning system later in a project. In such instances, an IWP may cross CWP boundaries.

Table 11 Acronyms

AFE	<i>Authorization for Expenditure</i>	A budgetary document for estimating expenses that is provided to partners for approval prior to commencement of construction or design.
CEP	<i>Construction Execution Plan</i>	A guidance document that outlines how the project will be undertaken. The CEP typically includes: Contract Strategy, Project Controls, Project Wide Integration Plan, Change Management, Risk Management, Reporting, Human Resource Plan, Communication Plan, Environmental, Health & Safety Plan, QA/QC Plan, On Site and Offsite Items, Equipment, and Materials.
CWA	<i>Construction Work Area</i>	A portion (square) of the plot plan that has been defined by construction as being a logical area of work. The CWA includes all of the disciplines.
CWP	<i>Construction Work Package</i>	An executable construction deliverable that defines in detail a specific scope of work and should include a budget and schedule that can be compared with actual performance. The scope of work is such that it does not overlap another CWP. The CWP can be used as a scoping document for Requests for Proposal and Contracts.
DBM	<i>Design Basis Memorandum</i>	A “Controlled Document” produced during the front-end engineering study phase that defines the basic design parameters for the intended project. Generation, review, and approval of the DBM are prerequisites to AFE approval and release for development of the Engineering Design Specification (EDS).
DEP	<i>Detailed Engineering Phase</i>	The phase of engineering following EDS, after approval has been given for the project. The DEP provides the specifications and construction drawings that detail all engineering aspects for the construction of a project.
EDS	<i>Engineering Design Specification</i>	The product of front-end engineering development (basic engineering) that defines all elements of project scope and is the Control Document for commencement of detail engineering and procurement activities on the project. A companion document to the EDS is the Project Execution Plan that sets forth the program for project implementation.
EPC	<i>Engineering Procurement Construction</i>	An acronym for Engineering, Procurement, and Construction. EPC describes an organization type that manages the engineering, procurement, and construction aspects of a project.
EWP	<i>Engineering Work Package</i>	An engineering deliverable that is used to develop CWPs and that defines a scope of work to support construction in the form of drawings, procurement deliverables, specifications, and vendor support. The EWP is released in an approved sequence that is consistent with the CWP schedule. The scope of work is typically both by discipline and by area.
IWP	<i>Installation Work Package</i>	A detailed execution plan that ensures all elements necessary to complete the scope of the IWP are organized and delivered before work is started. This detailed planning enables craft persons to perform quality work in a safe, effective, and efficient manner. Generally, the scope of work associated with the IWP is small enough that it could be completed by a single-foreman team, typically in a one- or two-week time frame.

IFC	<i>Issued for Construction</i>	Status given to drawings that have been provided for information purposes only and that cannot be used for construction purposes.
IFI	<i>Issued for Information</i>	Status given to drawings that have been provided for information purposes only and that cannot be used for construction purposes.
IFL	<i>Indirect Field Labor</i>	Labour that supervises or supports the direct field labour but that is not responsible for constructing the final project.
IFR	<i>Issued for Review</i>	Status given to drawings that have been issued for review and that have not been approved to be used for construction purposes.
RFI	<i>Request for Information</i>	A standard business process whose purpose is to collect written clarification that will enable the initiator to determine how to proceed.
RFR	<i>Ready for Release</i>	Status given to an IWP that is complete. All required materials, equipment, tools, labour, and predecessor work must be confirmed prior to release of the package.
VPM	<i>Virtual Plant Model</i>	A three-dimensional virtual environment that replicates the design and layout of the actual facility.
WBI	<i>Work Breakdown Index</i>	A hierarchical summary of a specific Work Breakdown Structure.
WBS	<i>Work Breakdown Structure</i>	A project management tool used for defining and organizing the total scope of a project. The WBS is used to develop a hierarchical tree structure.
WFP	<i>Workface Planning</i>	The process of organizing and delivering all the elements necessary, before work is started, to enable craft persons to perform quality work in a safe, effective, and efficient manner.

Estimating Terms, as defined in the Workface Packaging / Advanced Work Package Best Practice - COAA

Type 1 Estimate	Preliminary estimate based on planned throughput, schedule, and process approach. The Type 1 estimate is often a top down estimate based on similar projects.
Type 2 Estimate	At this stage, the design has been fully optimized, and a basis of design has been finalized (15% to 30% engineering completed) so the estimate will be prepared on a “bottom up” basis. This estimate becomes the Master Control Estimate used for the remainder of the project.
Type 3 Estimate	Typically, the contracting strategy has been developed and engineering work has been performed (2% to 10%). Typically, budget quotes have been received on all long lead equipment. Bulks should be based either on cost estimating software (like Kbase modeling) or factored off equipment pricing.
Type 4 Estimate	Typically, engineering work (1% to 5%) has been performed to help define the project. At this stage, a major equipment list has been prepared with rough sizing. Equipment pricing is typically based on historical data or budgetary quotes and installation/bulk costs are factored off equipment pricing.
Type 5 Estimate	Project early estimates are usually based on very broad objectives and limited technical information. Estimates are prepared on the basis of key assumptions with very little upfront project definition or engineering effort.

Schedule Terms, as defined in the Workface Packaging / Advanced Work Package Best Practice - COAA

Level 1 Schedule	Project Master Schedule (PMS). A major milestone type schedule that highlights major project activities and milestones, with reference to key deliverables throughout the Project.
Level 2 Schedule	Summary Master Schedule (SMS). Generated as a summary of the Level 3 Project Coordination Schedule(s). Depicts the overall schedule broken down into EPC components by area.
Level 3 Schedule	Project Coordination Schedule (PCS). Consists of a set of EPC integrated schedules based on Critical Path Methodology (CPM) and developed by Engineering with Construction input regarding key milestones and applicable deliverables across the design areas.
Level 4 Schedule	Project Control Level Schedule. Represents an expansion of the level 3 schedules and will be established within the integrated project schedule. The established WBS will be used as a basis for the development of the schedule's structure and will be used to manage construction activities throughout the Project to completion.
Level 5 Schedule	Represents a further breakdown of the activities of a Level 4 Schedule, including the detailed tasks within an IWP.

EXAMPLE PROJECTS

EXAMPLE PROJECTS SUMMARY

This report introduces four example projects that follow the categories introduced previously:

Category A: Unfamiliar and Low Complexity: This will be a valve-insertion project, the first time it is undertaken, and therefore the complexity is low but the project is unfamiliar.

Category B: Familiar and Low Complexity: This will be the same valve-insertion project but now implemented in a program to insert the valves across Canada.

Category C: Unfamiliar and High Complexity: This project will be a de-bottlenecking project which is high complexity, unfamiliar, and the closest to the original intent of the AWP best practice, but still could be a small project.

Category D: Familiar and High Complexity: This will be a solar farm which becomes familiar because the components internally are repeated but the complexity is still high.

For the purpose of illustrating how the AWP best practice can be scaled to different project categories, this report will include a single set of example reports and templates which can be utilized in any size of project along with a narrative on how to implement AWP for that type of project.

A set of templates and tools has been developed for the Category D Solar Farm project. The documents have been arranged in order of what stage of the project they would be created or used. In each of the other project examples, recommendations will be included on how to apply AWP principles for that project category. Many of the elements below reflect the COAA committee's experience and recommendations at the time this report was written. Please refer to the most current best practices for any additional learning and templates.

The templates and tools can be found in the appendices or external documents and are listed below:

Stage 1 – Project Definition

- General Arrangement
- Path of Construction (POC) Report Template
- POC Checklist
- POC Inputs Tools and Outputs

Stage 2 – Detailed Engineering

- Construction, Engineering, and Procurement Planning Template
- Engineering Deliverables List
- Purchasing Guideline
- Procurement Purchasing Matrix Template
- Naming Convention
- CWP List

Stage 3 – Construction

- Work package Development Plan
- Equipment List
- WFP Drawing Revision Log associated to IWPs
- WFP Issues Log
- IWP Release Plan
- RFI Log
- Commissioning Execution Plan

EXAMPLE A - UNFAMILIAR / LOW COMPLEXITY: VALVE INSERTION FIRST TIME

EXAMPLE A VALVE INSERTION FIRST TIME – SUMMARY

Overview



Due to changes in regulations in the Canada and the US, with respect to water crossings, liquid pipeline operators have to review the location and response time to close water crossing isolation valves (WCIVs). The review concluded that additional WCIVs need to be installed across North America and affected liquid pipeline operators have committed to multi-year programs to bring their pipeline systems to current regulation.

Acme Pipeline Company is adding water crossing isolation valves at multiple locations throughout Canada in support of the regulatory change. The first time this project is conducted it will be ‘unfamiliar.’

This project will include the installation of a remote 36” main line valve upstream of a river crossing. Project scope will include new electrical distribution to the area, substation, and instrumentation and controls. A planned outage for the tie-in will be scheduled for a maximum of 24 hours. Project capital cost \$2.5 million.

Primary Scope Items

- Single engineering company who has completed similar work before will be engaged.
- Owners SCM organization will order and supply: Substation; E-House; 36” valve with actuator; 36” pipe; and all tagged instruments.
- General- Industrial contractor will be engaged and will supply all other material and will self-perform all construction including site access, fencing, excavation, backfill compaction, piling, foundations, pipe fabrication, field piping (excluding tie-in), all electrical including building setting, instrumentation and controls, controls.
- A separate contract with a utility contractor will be executed for O/H electrical distribution power lines to the site.
- Owner’s maintenance crew will perform mainline isolation, drain-down and safeing, dry commissioning, line fill and wet commissioning and start-up.

Contract Type

Engineering and Construction contracts will be on a cost reimbursable plus fixed management fee.

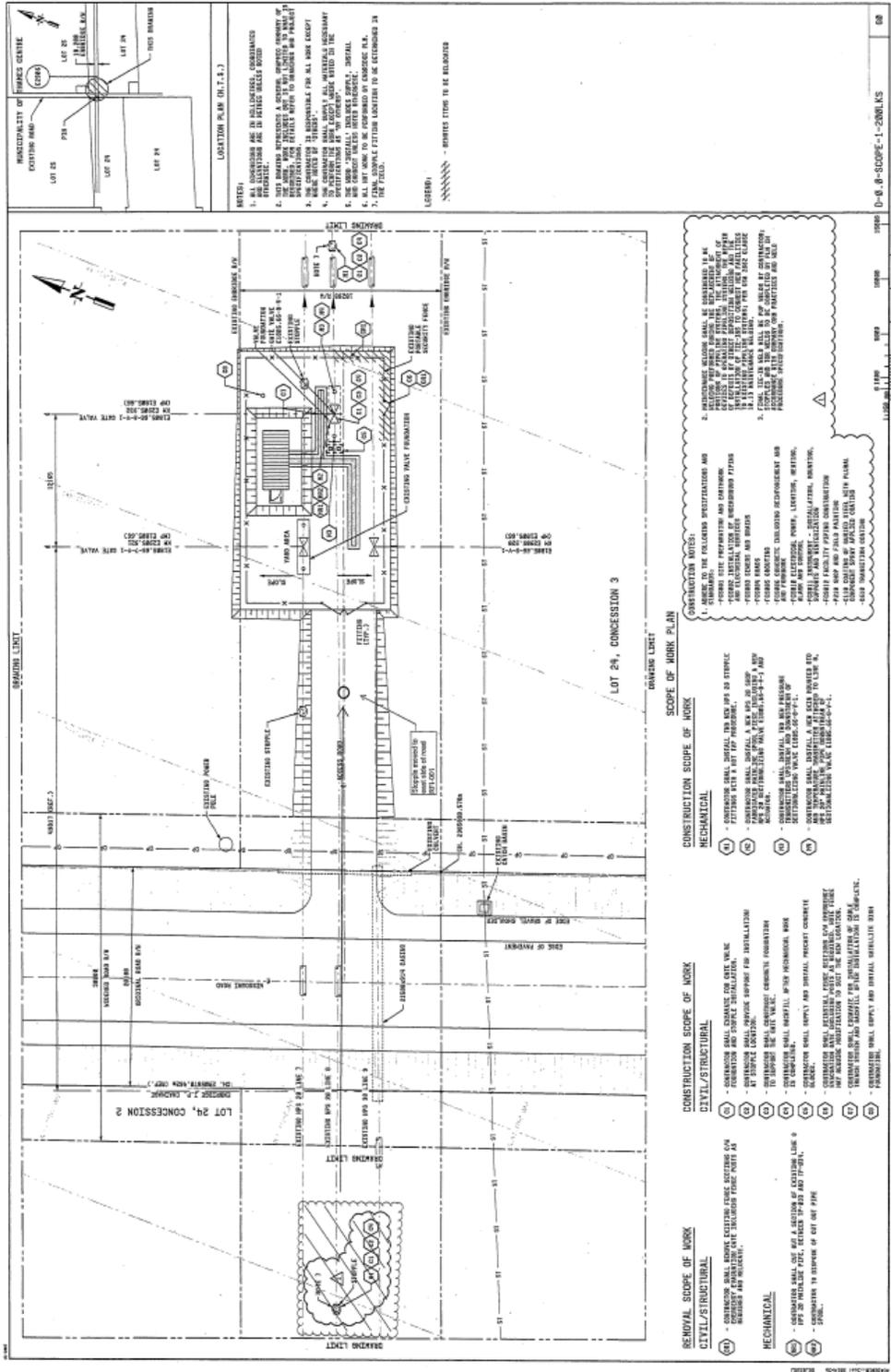
AWP-specific project delivery elements

- Contract Strategy: Local maintenance contractors are hired for a one-time project, overall construction management is coordinated by the owner. It is recommended to solicit construction for input in design since this is a first-time project
- Path of Construction (POC): A project-specific POC is developed for first time use by the owner;
- EPC Approach: Engineering and Procurement may be either external or executed internally by the owner;
- Planning: Superintendents and General Foremen are responsible for Workface Planning
- EWP: Not specifically developed;
- CWP EWP/CWP/PWP: are combined in 1 or 2 packages; first time developed – review with Constructor prior to release
- PWP: Not specifically developed;
- EWP: Not specifically developed;
- IWP: Maintenance contractor adds safety, quality and work practices; first time developed – review with Owner prior to release
- Reporting: Standard level 1 reporting;
- Schedule: Project specific developed for first use by the owner; review with Engr and Constructor
- Project Management: Managed as a traditional single project; and
- Materials: Long Lead Items by owner, materials by EP, Contractor buys shorts

EXAMPLE A VALVE INSERTION FIRST TIME – SUPPORTING DOCUMENTATION

General Arrangement:

Figure 4: Valve Insertion - General Arrangement Drawing 1 of 2



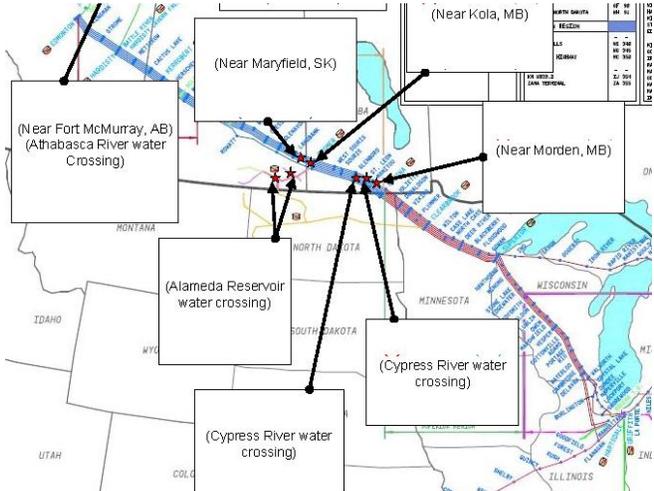
EXAMPLE B - FAMILIAR / LOW COMPLEXITY: VALVE INSERTION PROGRAM

EXAMPLE B VALVE INSERTION PROGRAM – SUMMARY

Overview

Due to changes in regulations in the Canada and the US with respect to water crossings, liquid pipeline operators have to review the location and response time to close WCIVs. The review concluded that additional WCIVs need to be installed across North America and affected liquid pipeline operators have committed to multi-year programs to bring their pipeline systems to current regulation.

Acme Pipeline Company is adding water crossing isolation valves at multiple locations throughout Canada in support of the regulatory change. Each project will include the installation of a remote 36” main line valve upstream of a river crossing. Project scope will include new electrical distribution to the area, substation, and instrumentation and controls. A planned outage for the tie-in will be scheduled for a maximum of 24 hours. Project capital cost \$2.5 million for each location, it is a **repeatable program** executed 4 X per year. The owner has excellent benchmarking data and manages risk on a portfolio basis so will execute engineering and construction on a cost reimbursable plus fixed management fee.



Primary Scope Items

- Single engineering company who has completed this scope of work several times before will be engaged.
- Owners SCM organization will order and supply: Substation; E-House; 36” valve with actuator; 36” pipe; and all tagged instruments.
- General- Industrial contractor who has completed this scope of work several times before will be engaged and will supply all other material and will self-perform all construction including site access, fencing, excavation, backfill compaction, piling, foundations, pipe fabrication, field piping (excluding tie-in), all electrical including building setting, instrumentation and controls, controls.
- A separate contract with a utility contractor will be executed for O/H electrical distribution power lines to the site.
- Owner’s maintenance crew will perform mainline isolation, drain-down and safeing, dry commissioning, line fill and wet commissioning and start-up.

Contract Type

Engineering and Construction contracts will be on a cost reimbursable plus fixed management fee.

AWP-specific project delivery practices

- Contract Strategy: Local maintenance contractors are hired by region to execute multiple sites, overall construction management is coordinated by the owner
- Path of Construction (POC): Standardized and reused for each location with minor modifications by the owner
- EPC Approach: Engineering and Procurement may be either external or executed internally by the owner
- Planning: Superintendents and General Foremen are responsible for Workface Planning
- EWP: Not specifically developed
- CWP/ EWP/CWP/PWP: are combined and standardized and reused for each location with minor modifications combined in 1 or 2 packages
- PWP: Not specifically developed
- IWP: is templated across the program with maintenance contractor adding safety, quality and work practices
- Reporting: Simplified program dashboard with a summary per location
- Schedule: Templated schedules across the program with minor modifications per location
- Project Management: Program - Similar, repeatable scopes of work across multiple regions

See General Arrangement from Example A

Construction, Engineering, and Procurement Planning Template

Construction

1.1. Construction Work Area (CWA) Plan

- no change

1.2. Preliminary Construction Work Package (CWP) Plan

- Owner's Role: N/A
- Construction's Role: Participate in collaborative sessions to establish contract-specific multi-discipline combined EWPs/CWPs which align with the project's Construction Execution Strategy and facilitate development of the Path of Construction.
- Engineering's Role: Participate in collaborative sessions to align deliverables with the combined EWP/CWP structure. Typically, the CWPs would be issued prior to construction start.
- Procurement's Role: Participate in collaborative sessions to align the Procurement plan, including planned supplier data, will support the generation of CWPs and the Path of Construction. As all material is to be available prior to construction start, PWP's would not be utilized.

1.3. Path of Construction Plan

- no change

1.4. Site Constraint Plan

- no change

- 1.5. Labor & Subcontracting Plan
 - no change
- 1.6. Temporary Construction Facility Plan
 - no change
- 1.7. Major Construction Equipment Plan
 - no change
- 1.8. Preliminary System Turnover Sequence
 - Owner's Role: N/A
 - Construction's Role: Map CWP completions to Systems and develop criteria for System Turnover.
 - Engineering's Role: Plan for engineering deliverables to be available to issue CWPs prior to construction start and to suit criteria for System Turnover.
 - Procurement's Role: Ensure the Procurement plan, including supplier data and material delivery support the System Turnover requirements.
- 1.9. Preliminary Technology Plan
 - no change
- 1.10. Preliminary Material Management Plan
 - no change
- 2. Engineering
 - 2.1. Preliminary Engineering Work Package (EWP) Plan
 - Owner's Role: N/A – EWPs combined with CWPs
 - Construction's Role: N/A
 - Engineering's Role: N/A
 - Procurement's Role: N/A
 - 2.2. Site Arrangement with Construction Work Areas (CWAs)
 - Owner's Role: The Owner is responsible for review of the Site Arrangement with Construction Work Areas to ensure Owner required constraints are met.
 - Construction's Role: Construction is responsible for generating the Construction Work Areas to be applied to the Project Site Arrangement. The Construction Work Areas are documented in the Construction Work Area Plan generated by Construction during the preliminary planning and design stage.
 - Engineering's Role: Engineering is responsible for reviewing and documenting the Construction Work Areas on the project Site Arrangement for inclusion in to the Construction Work Area Plan generated by Construction during the preliminary planning and design stage.

The Familiar/Low complexity AWP Project has simple multi-discipline and/or procurement complexities that result in a small number of CWAs. The Site Arrangement with Construction Work Areas (CWAs) can often be tailored from a similar previous project. Knowledge should be leveraged from the previous project with modifications for current project requirements. During the application of the CWAs on the project Site Arrangement, it is typical for CWA boundaries to be adjusted as they are visually applied to the Site Arrangement. These adjustments should be documented in the Construction Work Area Plan generated by Construction during the preliminary planning and design stage.

 - Procurement's Role: Procurement is responsible for reviewing the Site Arrangement with Construction Work Areas and presenting constraints for project team consideration. Constraints considered are items such as laydown/storage space.
 - 2.3. Preliminary Technology Plan

The Familiar / Low Complexity AWP Project has simple multi-discipline and/or procurement complexities that result in a small number of CWAs. The Preliminary Technology Plan can often be tailored from a similar previous project. Knowledge should be leveraged from the previous project with modifications for current project requirements. A mapped project database with agreed upon data and/or 3D model software and agreed upon attribute list should be a consideration for this type of project. It should be determined early in the project what is required so that all the CWPs and deliverables are setup correctly. Defining these technologies too late will minimize the benefit to the schedule or efficiency that could be achieved.

2.4. Preliminary Major Vendor Submittal Requirements and Timing

The Familiar / Low Complexity AWP Project has simple multi-discipline and/or procurement complexities that result in a small number of CWAs. The Preliminary Major Vendor Submittal Requirements and Timing can often be tailored from a similar previous project. Knowledge should be leveraged from the previous project with modifications for current project requirements. For this type of project, preliminary vendor data should be required for any information that could affect the Site Arrangement at the beginning of the preliminary planning stage or has long fabrication times. The vendor data should be checked to align with the needs of the CWAs to support the path of construction. Vendor drawing submittals and reviews are one of the most critical steps during engineering and can often take longer than anticipated.

3. Procurement

3.1. Preliminary Procurement Work Package (PWP) Plan

- Owner's Role: N/A – PWPs not utilized for Familiar / Low Complexity projects
- Construction's Role:
- Engineering's Role:
- Procurement's Role:
 - Ensure that all material is supplied to prior to start of construction

3.2. Preliminary Sourcing, Logistics, and Material Tracking Plan

- no change

3.3. Preliminary Technology Plan

- no change

EXAMPLE C – UNFAMILIAR / HIGH COMPLEXITY: DE-BOTTLENECK PROJECT

EXAMPLE C DE-BOTTLENECK PROJECT – SUMMARY

Project Objective

- Purify intermediate hydrocarbon for sale to rail and pipeline customers

Project Cost

- \$10MM - \$100MM

Scope Summary

- Process low purity feedstock through two new distillation tower systems installed ISBL, in an existing operating area.
- High purity product is routed to an existing pipeline and/or a new storage sphere through existing pipe racks and some existing piping.
- The new storage sphere is installed in an existing tank farm in an OSBL area.
- Product in the new storage sphere will be loaded into rail cars via upgrades to an existing rail car loading rack, within the complex but remote to the sphere.
- Increase rail car volume requires 6,000 feet of storage track to be added to an existing storage yard adjacent to the loading rack.

Schedule Constraints

- Tie-ins will be installed during two unit outages for catalyst changes. The first outage is a catalyst change 6 months after the start of detail design. Unit specific tie-ins can be executed during this outage.
- The second outage is a major debottleneck on the subject unit and other units in this area. Area wide utility tie-ins that require an outage of the entire area must be installed during this outage. Unit specific outages should be executed during the first outage above, if possible, to reduce the workforce density during the ongoing T/A. This outage will be executed 12 months after the start of detail design.
- ISBL construction will be executed inside an existing operating area. The unit will be brought on line during normal operation without a unit shutdown, 15 months after the start of detail design.
- OSBL Sphere Construction, Rail Car Loading Modifications, and Rail Car Storage expansion will be brought on line 24 months after the start of detail design.

Equipment List

- Preliminary Packaging Plan
- Project Images
- Block Flow Diagram
- Estimate

AWP-specific project delivery practices

- **Contract Strategy:** Traditional request for proposal (RFP) from pre-approved industrial contractors. Due to the revamp nature of scope the pay items would be a combination of lump-sum, cost reimbursable and unit rate. Early construction management input in front-end design is recommended. The owner may favor an industrial contractor that self performs the highest number of craft labour, minimizing sub-contractor management and interfaces.
- **EPC Approach:** Front end and detailed engineering by engineering house specializing in hydrocarbon processing.

- Planning: Superintendents and General Foremen are responsible for Workface Planning
- EWP: Developed by discipline and construction area
- CWP and PWP: Developed by area
- IWP: By contractor adding s safety, quality and work practices to CWP's
- Reporting: Will tend to be similar to large projects at a level 3 minimum
- Schedule: Project specific schedules developed to level 3 minimum
- Project Management: Managed as a traditional single project; and
- Materials: Long Lead Items by owner, materials by EP, Contractor buys shorts.

EXAMPLE C DE-BOTTLENECK PROJECT – SUPPORTING DOCUMENTATION

General Arrangement Images:

- List of CWAs Construction Work Areas
- Layout of CWAs
- 3D Model CWA 1
- 3D Model CWA 8
- Images from CWA 9
- Hydro purification drawings (2)
- Hydro purification list of potential costs areas

Figure 6: Debottleneck Project - List of CWAs

Hydrocarbon Purification Project

Equipment Tag	Description	CWA	CWP Discipline Packages						
			Civil (C)	Concrete (K)	Steel (S)	Piping (P)	Mechanical (M)	Electrical (E)	Instrumentation (J)
N/A	General IBL Scope	CWA 01	CWP 01AC	CWP 01AK	CWP 01AS	CWP 01AP		CWP 01AE*	CWP 01AJ
N/A	IBL First Stage Area	CWA 01		CWP 01BK	CWP 01BS	CWP 01BP		CWP 01BE	CWP 01BJ
N/A	IBL Second Stage Area	CWA 01		CWP 01CK	CWP 01CS	CWP 01CP		CWP 01CE	CWP 01CJ
N/A	New Pipe Rack	CWA 01		CWP 01DK	CWP 01DS	CWP 01DP		CWP 01DE	CWP 01DJ
N/A	Cooler Platform on Existing Pipe Rack	CWA 01			CWP 01ES	CWP 01EP		CWP 01EE	CWP 01EJ
N/A	Unit Tie Ins	CWA 01				CWP 01FP		CWP 01FE	CWP 01FJ
D-7408	First Stage Tower Condensate Drum	CWA 01					CWP 01BM		
D-7409	First Stage Tower Accumulator	CWA 01					CWP 01BM		
D-7411	Second Stage Tower Condensate Drum	CWA 01					CWP 01CM		
D-7413	Second Stage Tower Accumulator	CWA 01					CWP 01CM		
E-7408	First Stage Tower Reboiler	CWA 01					CWP 01BM		
E-7409 A/B	First Stage Tower OVHD Condenser	CWA 01					CWP 01EM		
E-7410	First Stage Tower Overhead Cooler	CWA 01					CWP 01EM		
E-7411	First Stage Tower Reboiler	CWA 01					CWP 01BM		
E-7412	First Stage Tower Overhead Cooler	CWA 01					CWP 01DM		
E-7413 A-F	First Stage Tower OVHD Condenser	CWA 01					CWP 01DM		
E-7427	Cooler	CWA 01					CWP 01AM		
E-7433	Bottoms Cooler	CWA 01					CWP 01AM		
P-7338 A/B	Reflux Pump	CWA 01					CWP 01DM		
P-62334 A/B	Pipeline Pumps	CWA 01					CWP 01DM		
P-7404 A/B	Scrubber Feed Pumps	CWA 01					CWP 01DM		
P-7408 A/B	First Stage Tower Condensate Pumps	CWA 01					CWP 01BM		
P-7409 A/B	First Stage Tower Reflux Pumps	CWA 01					CWP 01BM		
P-7411 A/B	Second Stage Tower Condensate Pumps	CWA 01					CWP 01CM		
P-7412 A/B	Second Stage Tower Bottoms Pumps	CWA 01					CWP 01CM		
P-7413 A/B	Second Stage Tower Reflux Pumps	CWA 01					CWP 01CM		
P-7420 A/B	IBL Vent Scrubber Bottoms Pumps	CWA 01					CWP 01DM		
T-7408	First Stage Tower	CWA 01					CWP 01BM		
T-7411	Second Stage Tower	CWA 01					CWP 01CM		
T-7420	IBL Vent Scrubber	CWA 01					CWP 01AM		
N/A	Tie In TP-OSBL-9	CWA 02				CWP 02AP			
N/A	Tie In TP-OSBL-10	CWA 02				CWP 02BP			
N/A	Tie In TP-OSBL-11	CWA 02				CWP 02CP			
N/A	Tie In TP-OSBL-12	CWA 02				CWP 02DP			
N/A	Tie In TP-6011	CWA 02				CWP 02EP			
N/A	Piping / Electrical Through Existing Rack Area A	CWA 03			CWP 03AS	CWP 03AP		CWP 03AE	CWP 03AJ
N/A	E-House Modifications	CWA 04						CWP 04AE	CWP 04AJ
N/A	Piping / Electrical Through Existing Rack Area B	CWA 05			CWP 05AS	CWP 05AP		CWP 05AE	CWP 05AJ
N/A	Piping / Electrical Through Existing Rack Area D	CWA 06			CWP 06AS	CWP 06AP		CWP 06AE	CWP 06AJ
N/A	Piping Through Existing Rack Area E	CWA 07			CWP 07AS	CWP 07AP			CWP 07AE
N/A	General Product Sphere Area Scope	CWA 08	CWP 08AC	CWP 08AK	CWP 08AS	CWP 08AP		CWP 08AE**	CWP 08AJ
D-61455	Vapor Balance K.O. Pot	CWA 08					CWP 08AM		
P-7312	Railcar Loading Pump	CWA 08					CWP 08AM		
P-7421 A/B	OBL Vent Scrubber Bottoms Pumps	CWA 08					CWP 08AM		
T-7421	OBL Vent Scrubber	CWA 08					CWP 08AM		
TK-7311	Product Sphere	CWA 08		CWP 08BK	CWP 08BS	CWP 08BP	CWP 08BM	CWP 08BE	CWP 08BJ
N/A	Railcar Loading Area General Scope	CWA 09	CWP 09AC	CWP 09AK	CWP 09AS	CWP 09AP		CWP 09AE	CWP 09AJ
D-61685	Railcar Loadout K.O. Pot	CWA 09					CWP 09AM		
Rack A-D	Loading Rack	CWA 09		CWP 09BK	CWP 09BS	CWP 09BP	CWP 09BM	CWP 09BE	CWP 09BJ
South Yard	New Storage Track	CWA 09	CWP 09CC						

* Includes Home Run Cables to IBL Area

** Includes Home Run Cables to Product Sphere Area

Figure 7: Debottleneck Project - CWAs Layout

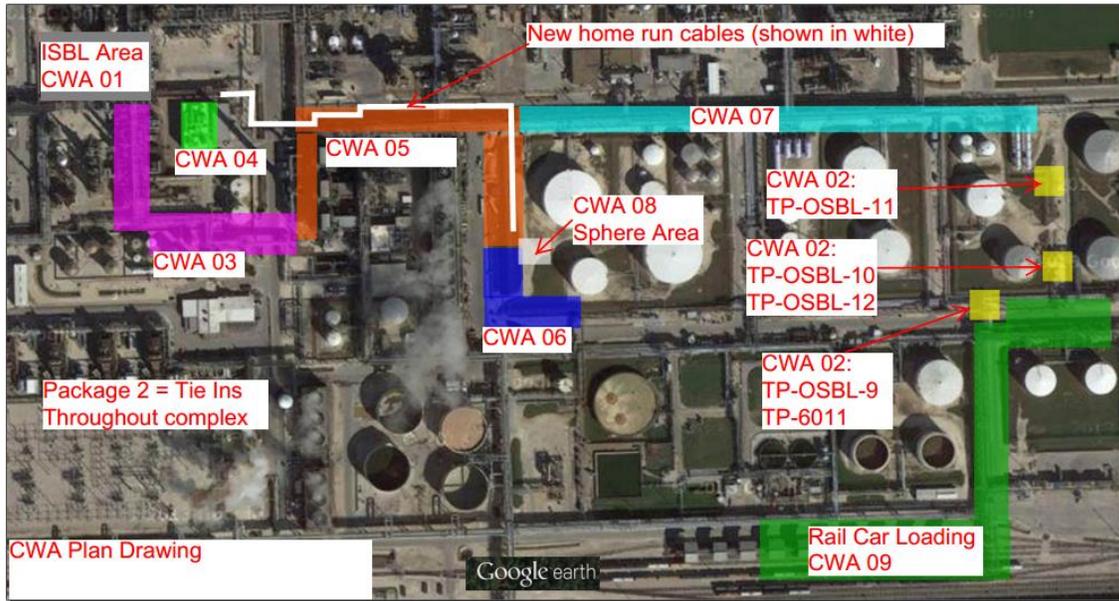
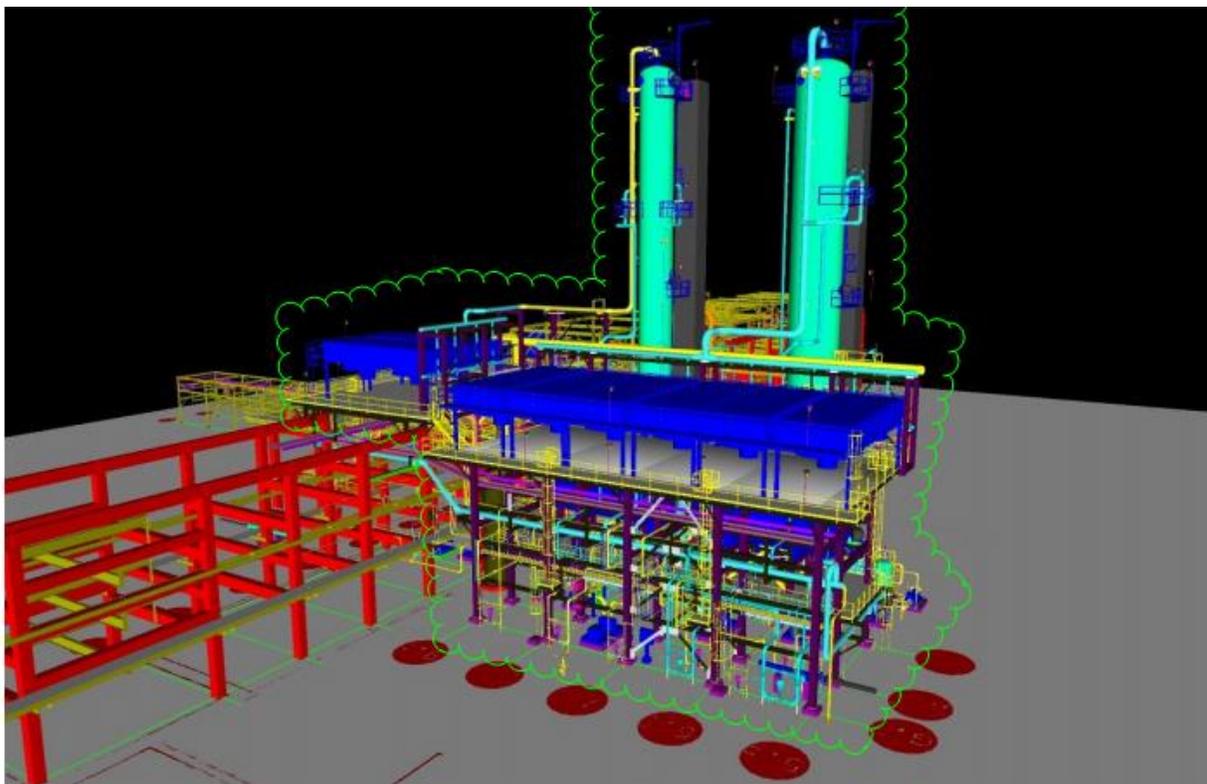


Figure 8: Debottleneck Project - CWA 1: 3D Model



CWA 1
ISBL HYDROCARBON PURIFICATION UNIT
AREA IN CLOUD IS NEW, BALANCE IS EXISTING

Figure 9: Debottleneck Project - CWA 8: 3D Model

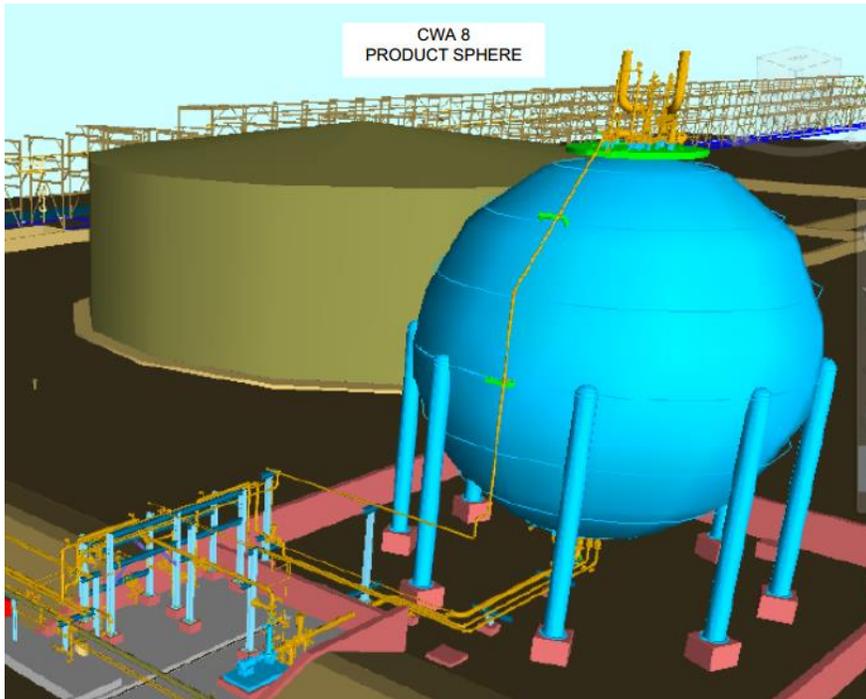


Figure 10: Debottleneck Project - CWA 9 Image

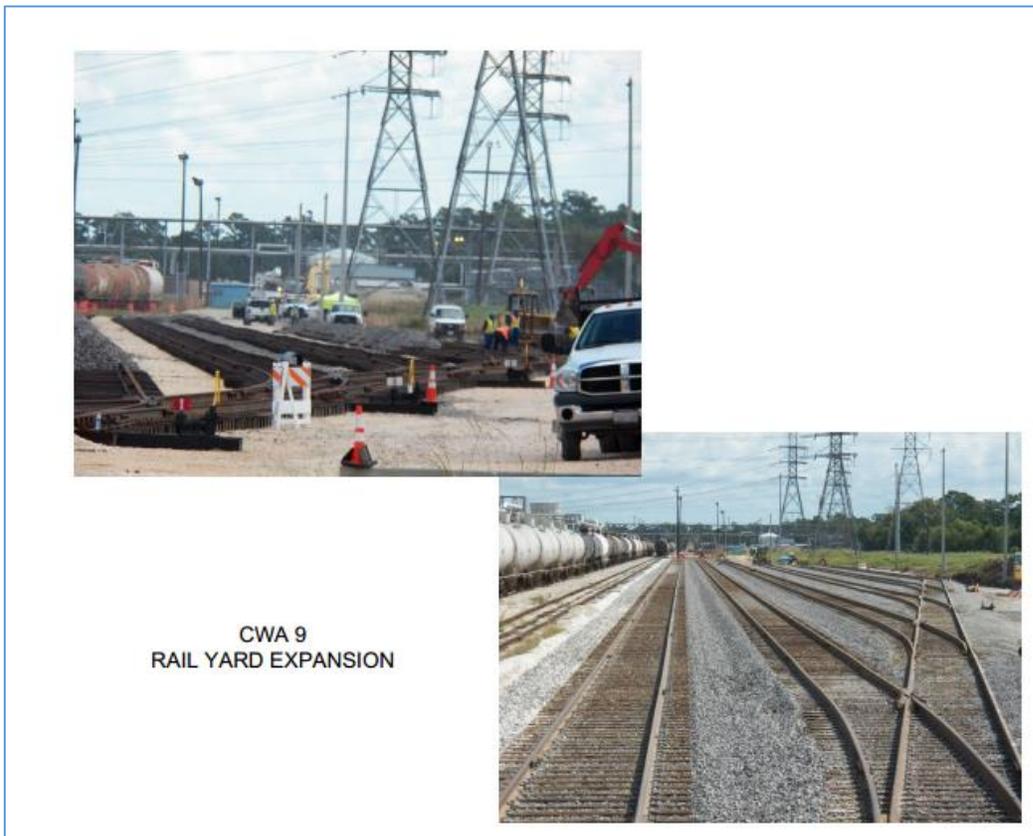


Figure 11: Debottleneck Project - Hydrocarbon Purification Layout 1 of 2

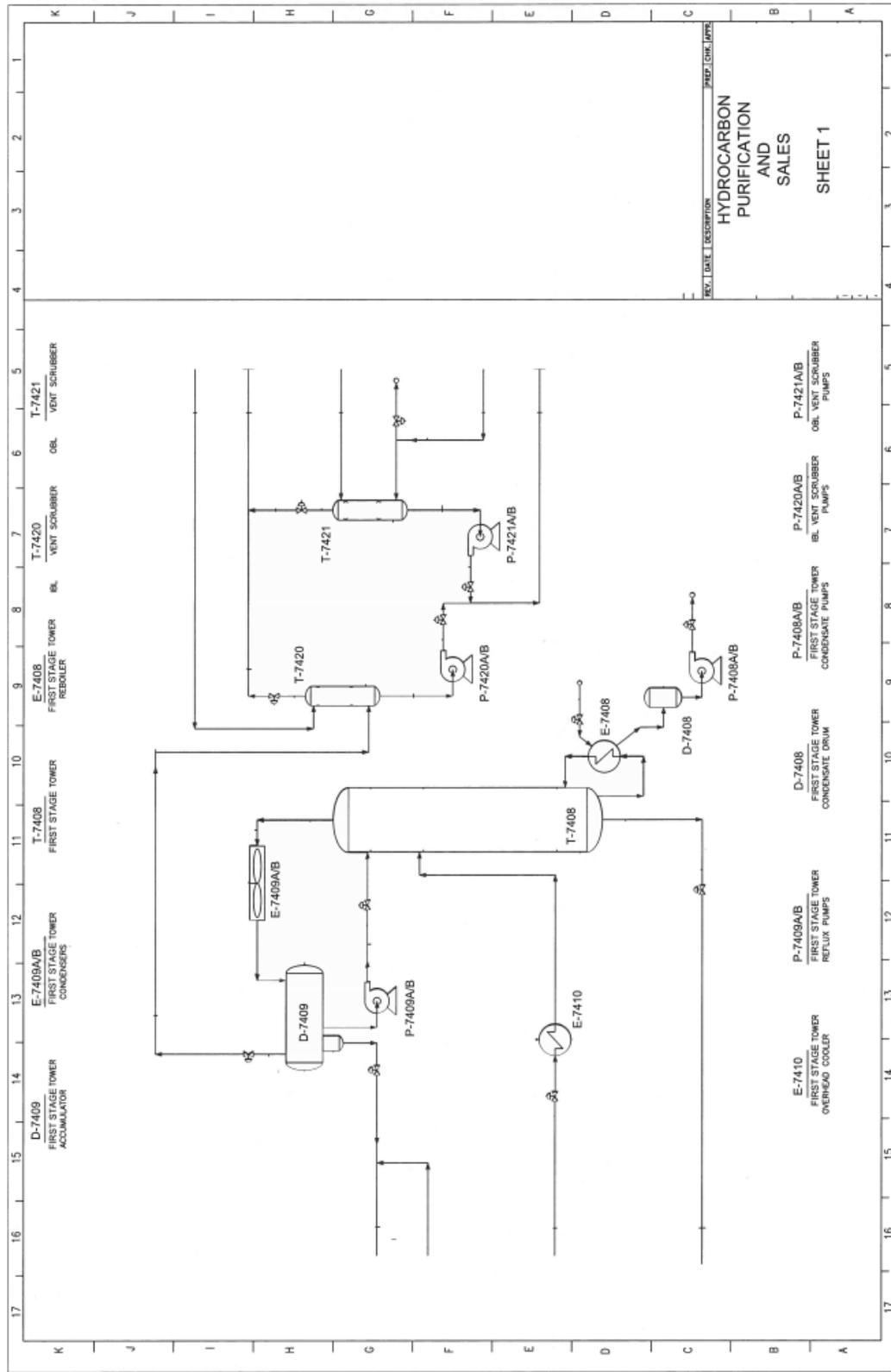


Figure 12: Debottleneck Project - Hydrocarbon Purification Layout 2 of 2

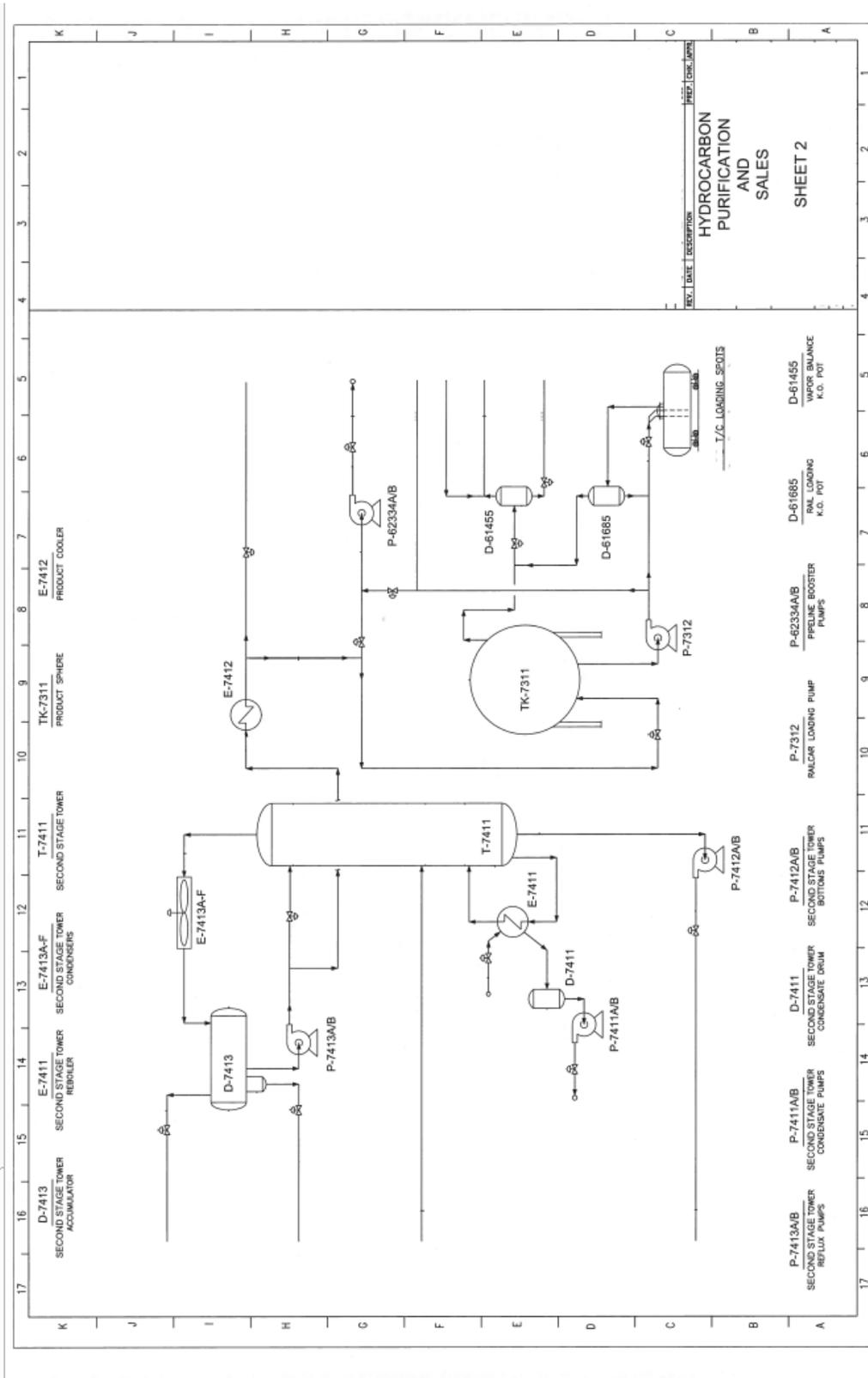


Figure 13: Debottleneck Project - Cost Areas

Project ID: Project Manager: Prepared By: Date Prepared: Run Date: Location: Estimate Type: Control (+/-10%)						
OVERALL SUMMARY Project Title: HYDROCARBON PURIFICATION AND SALES						
CATEGORY	DIRECT CRAFT (Hrs)	LABOR (L \$)	MATERIAL COST (DM \$)	SUB-CONTRACT (SC \$)	TOTAL COST	SPENT TO DATE
DIRECT COSTS:						
PROCESS EQUIPMENT	7,833					
PIPING	76,850					
CONCRETE	20,834					
BUILDINGS	220					
SITWORK	3,764					
PILING	7,087					
STRUCTURAL	10,677					
INSTRUMENTATION	12,411					
ELECTRICAL	34,882					
INSULATION	12,629					
FIREPROOFING	3,895					
PAINTING	5,284					
DEMOLITION	6,112					
SUBTOTAL - TOTAL DIRECT COSTS (TDC)		202,460				
Scaffolding <input type="text"/> Average All-In Wage Rate <input type="text"/>						
Rental Equipment <input type="text"/>						
Shared Turnaround Cost <input type="text"/>						
Construction Management <input type="text"/>						
Other Construction Indirects <input type="text"/>						
SUBTOTAL - TOTAL CONSTRUCTION COST (TCC)						

EXAMPLE D – FAMILIAR / HIGH COMPLEXITY: SOLAR FARM PROGRAM

EXAMPLE D SOLAR FARM PROGRAM –SUMMARY

Overview

Acme Solar Co. is building a new zero-emissions solar facility in Anytown, Canada which will provide power directly to the existing grid. The solar panels will be installed on fixed-tilt racks and rest roughly 3 to 5 feet off the ground. The steel racks are built on steel pilings that direct bury into the soil and do not require concrete or grout. Post-construction, the facility operates independent of fuel, water, waste mitigation, or on-site personnel.

The project is an Engineering, Procurement, and Construction (EPC) contract for the design, construction, and commissioning of a 300MW photovoltaic solar facility for Acme Solar Company at the Anytown Power Plant.

Primary Scope Items

- Project Management of full EPC scope, including permitting and licensing.
- All engineering work required to design the solar facility.
- Procurement of all needed materials, except for:
 - o Photovoltaic modules (supplied by Acme)
 - o Inverters (supplied by Acme)
 - o GSU Transformer (supplied by Acme)
 - o Site clearing, grading, excavation, roads, and fencing.
- All environmental systems (new and existing) and improvements.
- Construction of the solar facility, including but not limited to:
 - o Install Acme fixed-tilt solar racks (9,016).
 - o Install 320w Acme panels (468,832).
 - o Install combiner boxes (2,254).
 - o Install Inverters (80).
 - o Install underground utilities and route to existing substation.
- Site security and fencing.
- Start-up and commissioning support.
- SCADA system installation and commissioning support.
- Performance testing support.

Contract Type

The project will be governed by a firm lump sum EPC agreement. Sequential turnover of the project will occur in segments of 37.5MW blocks. Turnover must occur in the stipulated, pre-determined block order (1 – 8) per the attached General Arrangement. Block turnover will be regarded as the project’s primary milestones, and are:

- Block 1 Mechanical completion (all racks and panels)
- Block 1 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 1 Final completion
- Block 2 Mechanical completion (all racks and panels)
- Block 2 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 2 Final completion

- Block 3 Mechanical completion (all racks and panels)
- Block 3 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 3 Final completion
- Block 4 Mechanical completion (all racks and panels)
- Block 4 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 4 Final completion
- Block 5 Mechanical completion (all racks and panels)
- Block 5 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 5 Final completion
- Block 6 Mechanical completion (all racks and panels)
- Block 6 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 6 Final completion
- Block 7 Mechanical completion (all racks and panels)
- Block 7 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 7 Final completion
- Block 8 Mechanical completion (all racks and panels)
- Block 8 Substantial completion (all inverters, combiner boxes, and utilities)
- Block 8 Final completion

Note: Each block contains 1,127 racks, 58,604 panels, and 10 inverters.

AWP Practices

Contract Strategy would include an EPC arrangement with Owner providing OEM equipment. The blocks/projects would be managed by EPC with limited oversight by owner.

Path of Construction would be standardized for each block and refined with minor modifications if needed.

Project Schedule: Prepare preliminary Path of Construction so that a Level 2 Schedule can be developed with milestone dates established for completion of Basis of Design (BoD), Final Investment Decision (FID), start/finish of Detailed Engineering and Design, required on site dates for critical path equipment/material, start/finish of Construction and expected on-line date.

Project Work Breakdown Structure (WBS): Project Team to follow WBS Guidance document to support the organization and scheduling of the Work.

Project Cost Estimate: Sufficient Engineering effort and Procurement effort should be performed in order to develop a Class 3 cost estimate and assist in the preparation of the Project Proposal for final investment decisions.

Design Basis

Primary Engineering Requirements: Review Project definition to determine the primary engineering discipline and develop a block diagram to illustrate the principle elements and key design characteristics.

Basic Engineering Requirements: Review Engineering deliverables list and select those that will be required and to what level of detail or status.

Key Design Decisions and Assumptions: Provide a log of all key decisions and assumptions to assist Engineering Team during the Detailed Engineering Phase.

Risk Management: Provide a log of all project risks and mitigation identified during the development of the design basis and engineering plan with the intent that it be maintained throughout the Project.

Permitting Requirements: Review Project Scope, Project location, Project design criteria (Codes, Standards, Specifications and Regulations) and consult with both local groups and local authorities to determine project approvals and permitting requirements. (Could be within Owner scope).

Design Criteria

Review Engineering Deliverables List and identify the design deliverables that will be required for the Basis of Design and set the level of development (IFI, IFD, IFR, etc.).

Work Breakdown Guidelines

This guideline is to be used support the development of a project WBS, generate a Construction Work Package (CWP) naming structure and provide a basis for developing CWPs for a project.

The Work Breakdown Structure (WBS) is a framework, typically used for Engineering, Procurement, Construction and Start-up project phases, which progressively and logically subdivides the entire work content in a hierarchical manner. The development of a WBS must consider:

- Alignment with Cost Breakdown Structure
- Alignment with any existing WBS system for a facility
- Flexibility to develop work packages that define work by location, contractor and type of scope.

The sample naming convention provided in attachment XX provides for the identification of necessary CWPs.

CWP Guidelines

For projects the size and complexity of the Anytown Solar Project, it is recommended that CWPs be issued without the need for a complimentary Engineering Work Package. Development of CWPs must consider:

- CWPs are not to be divided between intended Contractors that will be performing work.
- CWP scope alignment with Construction of work:
 - o Typical breakdown is strictly by area to support bulk construction.
 - o Smaller projects tend to be comprised of retrofit scope which does not include significant bulk construction requirements.
 - o Scope boundaries used for different 'Discipline Codes' to be aligned for a given 'Activity Code'.
 - o A sample CWP naming convention is attached.

Geographic boundary definition

The use of geographic boundaries to define scope is a critical component of a CWP. Geographic boundaries to be defined by following order of priority:

- Boundaries to align to suit WBS criteria.
- Boundaries to align to suit contractor scope.
- Area boundaries to be determined to suit installation of work. (e.g. minor scope that crosses multiple existing Construction Work Areas may be combined in a single area boundary)
- Area boundaries to be aligned for all Disciplines for each Activity Code.
- Boundaries to align to suit WBS details if applicable.
- Number of fields making up Geographic Definition can vary to suit work.

Construction activity definition

Primary construction activities are grouped together using an Activity Code. These primary construction activity categories define principle boundaries for stages of construction or define unique construction scope. The following are Activity Code examples:

- Demolition,
- Tie In,
- Underground,
- Module Assembly, and
- Field Installation

Discipline definition

Within primary construction activities, a Discipline Code is used to define different types of work required. A Discipline Code must consider the Engineering and Construction disciplines required to complete the work. The following are Discipline Code examples:

- Architectural,
- Civil,
- Piling,
- Concrete Foundations,
- Structural Steel,
- Mechanical,
- HVAC,
- Equipment Ladders and Platforms,
- Piping,
- Electrical,
- Electric Heat Tracing,
- Control Systems,
- Insulation, and
- Fireproofing

Work package content

A sample CWP Report is provided in attachment 3. The content of a CWP can vary for a given project; however, the content reflected in the sample CWP Report includes the following:

Scope of work: A general description of the work to be completed, including applicable details unique to the CWP, is provided.

Required documents:

Specifications and Standards: A list of applicable Specifications and Standards provided in the Contract is included.

Engineering Drawings: A list of documents provided by Engineering required for the CWP is provided.

Vendor Drawings: A list of documents provided by applicable vendors required for the CWP is provided. Applicable vendor data is included for any material and equipment purchased by the Owner or the Engineering / Procurement Company.

Reference Drawings: A list of documents provided by Engineering, or applicable vendors, necessary for reference for the CWP is provided (e.g. Structural Steel CWP may reference relevant Piling CWP).

Material Summary: Each CWP is to include a summary of material required and will be provided in a format to suit the applicable discipline (e.g. Piping material is listed in detail on each isometric. In addition, a detailed bill of material (BOM) is included in the applicable PWP.)

Procurement work packages

A Procurement Work Package (PWP) is to be generated by Engineering for each CWP. The PWP will include the following content:

- a BOM for all necessary material supplied by the Owner or Engineering / Procurement Company
- a status for all material that will be kept up to date until such time that all material is available for Construction.

As the status of material is continuously being updated, a given PWP will be issued in a manner agreed upon by the Owner, Engineering / Procurement Company and the Construction Contractor.

The naming structure for a PWP is noted on the attached Sample CWP Naming Convention.

A sample PWP Report is included in attachment 4.

Figure 14: Solar Project - CWP Naming Convention

ACME SOLAR COMPANY

Date: 29-Aug-17

Anytown Solar Project

Sample CWP Naming Convention:

Geographic Definition				Scope Definition	
Project	Unit	CWA	SubArea	Activity Code	Discipline Code
A	01	02	C	D	E

- A Project: If required, refers to Owner project code
- 01 Unit: Refers to Owner unit code
- 02 Construction Work Area: Refers to a partition of scope within a Unit
- C SubArea: Refers to a specific portion within and Area (if required)
- D Activity Code: Construction activity definition
- E Discipline Code: Specific work for construction activity.

PWP Naming Convention: CWP - P

Activity Code	Activity Code Description	Discipline Code	Discipline Code Description
D	Demolition	C	Mechanical
F	Field Installation	H	HVAC
M	Module Assembly	J	Control Systems
R	Retrofit	L	Piping
T	Tie In	M	Structural Steel
U	Underground	N	Insulation
		P	Electrical
		Q	Piling
		R	Architectural
		S	Civil – Earthwork
		U	Concrete Foundations
		V	Equipment Ladders and Platforms
		X	Fireproofing
		Z	EHT

General schedule considerations for the generation of a WBS / CWP structure include the following:

Engineering to provide input to, and generate, a Construction Work Area layout drawing to support the identification of long lead material.

Engineering to generate a EWP List (sample provided in attachment 2) at the end of Stage 1: Preliminary Planning to support the generation of the Level 3 Construction schedule.

Engineering/Procurement Company to generate EWPs and PWPs to support construction generating IWPs.

Work Packaging:

- EWPs would be discipline specific. All deliverables complete prior to construction work starting for the Construction Work Area (CWA) in this project termed "Block."
- This repeatable program can template the deliverables and have standard installation details.
- CWPs are developed for one block and reusable for each subsequent block. Boundaries for AWP will be discipline specific, matching block boundary per contract scope. Planning will be CWA-driven.
- PWPs are not required as material is bulk and interchangeable across blocks
- All supplier data required to support EWPs
- IWP scope subdivides CWPs based on estimated effort
- IWPs are developed for one block and reusable for each subsequent block
- Limited IWP count per CWP (likely 1 or 2 per discipline)

Execution

- Reporting will include a dashboard for each block in the project.
- Schedule will be standardized and reused for each block
- Project management will be program-style; one manager for all
- EPC/Owner shared responsibility for material and equipment purchases across the program

EXAMPLE D SOLAR FARM PROGRAM – SUPPORTING DOCUMENTS

Stage 1 – Definition

- General Arrangement
- POC Report Template
- POC Checklist
- POC Inputs Tools and Outputs

Stage 2 – Detailed Engineering

- Construction, Engineering and Procurement planning template
- Purchasing Guideline
- Procurement Purchasing Matrix Template
- Naming Convention
- CWP List
- CWP Report template
- PWP Report Template

Stage 3 – Construction

- Work package Development Plan
- Equipment List
- WFP Drawing Revision Log associated to IWPs
- WFP Issues Log
- IWP Release Plan
- RFI Log
- Commissioning Execution Plan (16 pages)

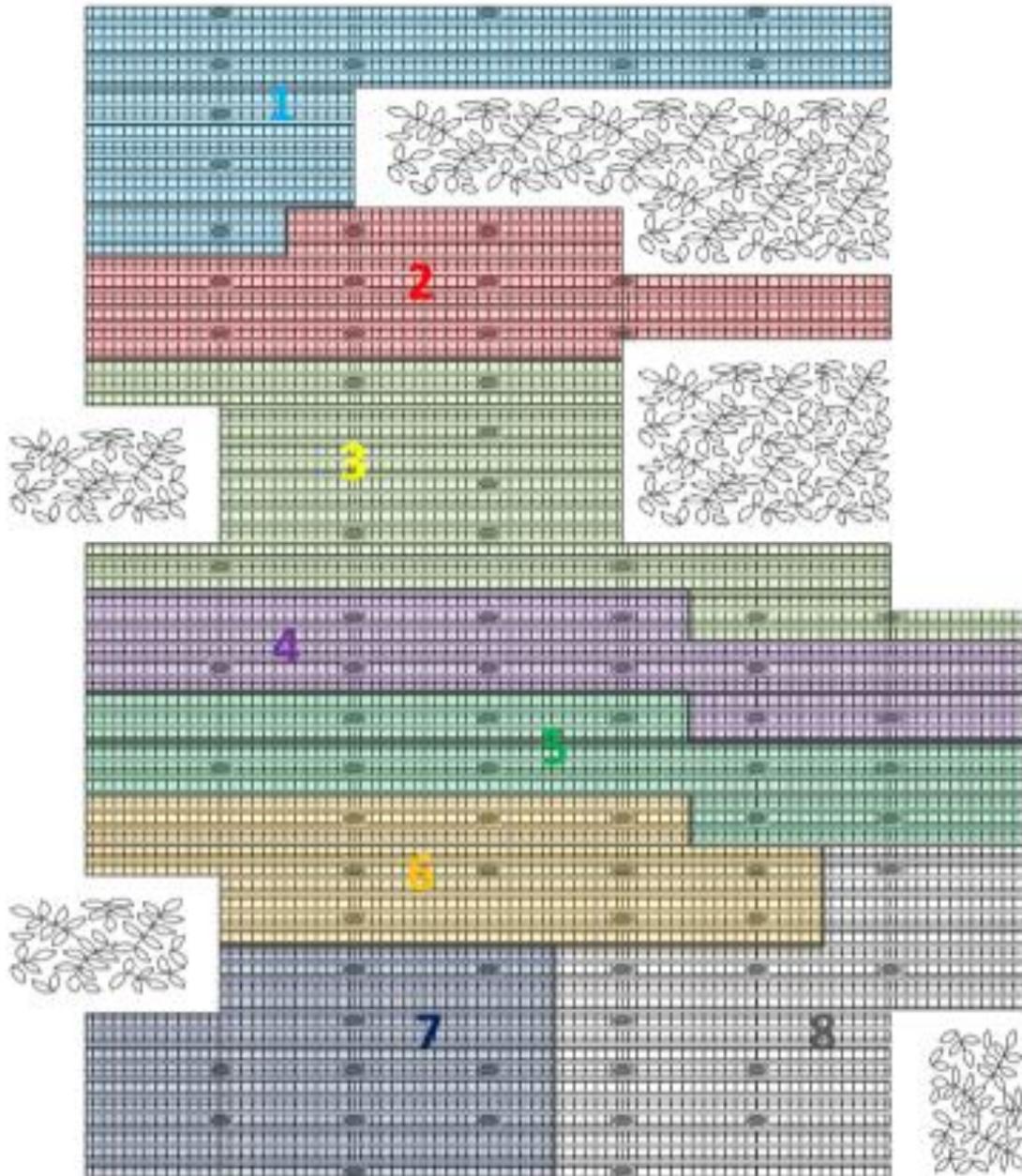
General Arrangement

ACME SOLAR COMPANY



For demonstration purposes only.

-  Solar panels
-  Protected land
- 1** Block Number
-  Inverter



Path of Construction Report Template

Purpose

The purpose of this procedure is to outline the methodology for developing the path of construction for a familiar, high complexity project such as a Solar Farm.

Scope

This document contains detailed information about conducting multiple sessions that follow a process flow diagram by project stage versus roles outlining the inputs, activities, and outputs necessary to develop a path of construction.

Responsibilities

The Project Manager is responsible for the document and executing its contents; find definitions for RASCI in the definitions section.

Project Manager

Accountable to ensure the path of construction procedure is followed in the development of the projects path of construction. Participates in path of construction activities as a Subject Matter Expert.

Note: Should the project not have an assigned Construction Manager during the initial phases of project development and engineering the Project Manager/Engineer will assume those responsibilities as it relates to this POC procedure.

Construction Manager

Responsible for using the path of construction procedure as a guideline for the process. The Construction Manager will facilitate the path of construction development sessions and have the appropriate level of experience to perform the path of construction activities.

The Construction Manager on these types of projects will typically provide input on;

- Constructability,
- CWP Coordination,
- Contract Management

Additional resources to support the Construction Manager in the development of the POC are:

- Project Engineer: Participates in path of construction activities and represents Engineering's interests.
- Scheduler: Depending on a program or portfolio, resources can be shared across multiple projects. Represents the path of construction in the project schedule in the form of CWPs.
- C&SU or Operations Manager: Participates in path of construction activities as a Subject Matter Expert.
- Estimator: Participates in path of construction activities as a Subject Matter Expert.

Definitions

- Responsible - these people are the "doers" of the work. They must complete the task or objective or make the decision. Several people can be jointly responsible.
- Accountable - this person is the "owner" of the work. He or she must sign off or approve when the task, objective or decision is complete. This person must make sure that responsibilities are assigned in the matrix for all related activities. There is only one person accountable, which means that "the buck stops there."

- Supporting - can provide resources or can play a supporting role in implementation
- Consulted - these are the people who need to give input before the work can be done and signed-off on. These people are “in the loop” and active participants.
- Informed - these people need to be kept “in the picture.” They need updates on progress or decision, but they do not need to be formally consulted, nor do they contribute directly to the task or decision.
- Construction Work Package (CWP) - An executable construction deliverable that defines in detail a specific scope of work and should include a budget and schedule that can be compared with actual performance. The scope of work is such that it does not overlap another CWP. The CWP can be used as a scoping document for Requests for Proposal and Contracts.
- Engineering Work Package (EWP) - An engineering deliverable that is used to develop CWPs and that defines a scope of work to support construction in the form of drawings, procurement deliverables, specifications, and vendor support. The EWP is released in an approved sequence that is consistent with the CWP schedule. The scope of work is typically both by discipline and by area.
- Installation Work Package (IWP) - A detailed execution plan that ensures all elements necessary to complete the scope of the IWP are organized and delivered before work is started. This detailed planning enables craft persons to perform quality work in a safe, effective, and efficient manner. Generally, the scope of work associated with the IWP is small enough that it could be completed by a single-foreman team, typically in a one- or two-week time frame.
- Workface Planning (WFP) - The process of organizing and delivering all the elements necessary, before work is started, to enable craft persons to perform quality work in a safe, effective, and efficient manner.
- Path of Construction – is the articulation of the optimum building sequence of the physical components of a facility.
- Design Basis Memorandum (DBM) - A “Controlled Document” produced during the front-end engineering study phase that defines the basic design parameters for the intended project. Generation, review, and approval of the DBM are prerequisites to AFE approval and release for development of the Engineering Design Specification (EDS).
- Engineering Design Specification (EDS) - The product of front-end engineering development (basic engineering) that defines all elements of project scope and is the Control Document for commencement of detail engineering and procurement activities on the project. A companion document to the EDS is the Project Execution Plan that sets forth the program for project implementation.
- Detailed Engineering - The phase of engineering following EDS, after approval has been given for the project. The DEP provides the specifications and construction drawings that detail all engineering aspects for the construction of a project.

Procedure

The established method of performing work; WHO does WHAT by WHEN. Procedures present a step-by-step sequenced way to do a task consistently and with maximum efficiency.

Session Preparation

The Project Construction Manager is responsible for the preparation of the path of construction sessions.

He develops the path of construction agenda. The agenda must have a clearly stated objective and list of activities. This should be based on Appendix A Path of Construction Flow Diagram, Appendix – Inputs, Tools and Techniques, Outputs and reflect the stage of the project at the time of the meeting. Appendix B Outputs should guide the list of activities for the session.

The time frame and scope of activities discussed during the path of construction session depends on the current project objectives. If the project's current deliverables are for DBM or EDS purposes, then the activities discussed should only detail that phase of project development. If the current scope of the project is detailed design, it is correct to discuss detailed engineering activities. This approach avoids wasting time in discussing activities that are not relevant at the time of the path of construction meeting.

The Project Construction Manager distributes Appendix D Path of Construction Input Checklist by Functional Area to the participants.

The Project Construction Manager will assemble the data for review by the meeting participants prior to the session. This will ensure all relevant information is available and complete.

He sends out the meeting agenda and data package to attendees. In the meeting request make it clear that attendance is mandatory. If a person is unable to attend they must send a delegate.

Meeting Guidelines

Construction Manager will facilitate the path of construction sessions according to the agenda.

Strong facilitation skills are critical to achieving path of construction outputs in the allotted time.

A path of construction Log should be set up to keep lists of needs, assumptions and parking lot issues, so they can be addressed to list information requirements or assumptions used during the path of construction development.

Post-Meeting Activities

The path of construction session provides the basis for or input to the final project fabrication or off-site assembly strategy, procurement strategy, contracting plan, heavy lift plan, plot plan, work package schedules, and estimate with project team input and buy-in.

Implementation

Overall Project Manager/Leader is responsible to ensure the document is being implemented.

Reference Documents

- CWP Best Practice
- EWP Standards
- IWP Standards
- WFP Implementation Manual

Appendices

- Appendix – Path of Construction Flow Diagram
- Appendix – Path of Construction Inputs, Tools and Techniques, Outputs
- Appendix – Path of Construction RASCI Chart
- Appendix – Path of Construction Input Checklist by Functional Area

Acknowledgements

- COAA WFP Best Practices Committee
- Construction Industry Institute

Interpretation and Updating

Accountable for interpretation and updating to be defined using position titles. Should be one position only.

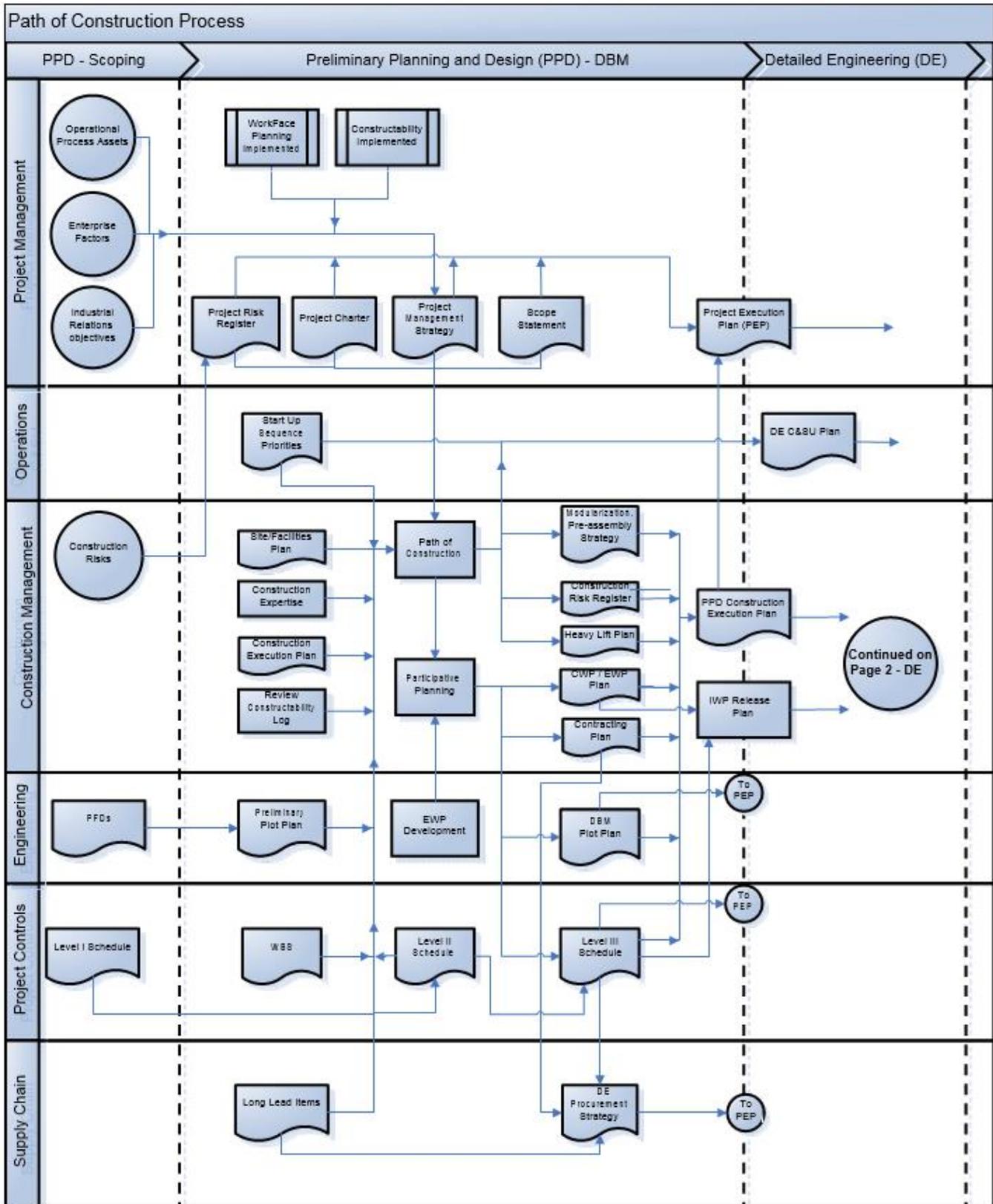
The Project Manager or Project Leader is responsible to interpret and update this procedure.

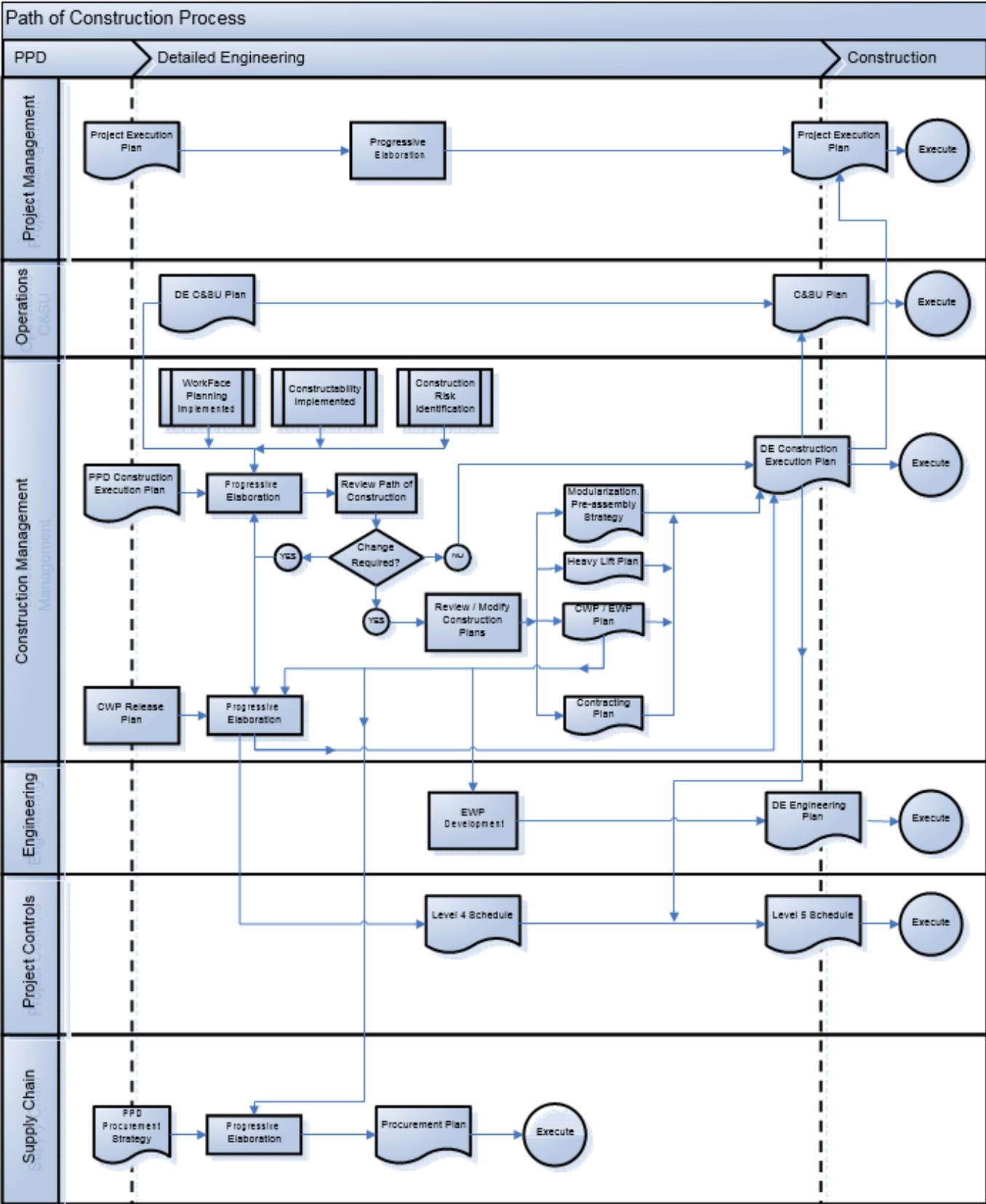
Approved by

- Name
- Title
- Department

NOTE: ORIGINAL SIGNED COPY TO BE RETAINED BY THE DOCUMENT CONTROL FOR THE PROJECT.

Path of Construction – Flow Diagram





Path of Construction – Inputs Tools Outputs

ASSUMPTIONS⁸

Project Charter is approved
 Adequate resources are available and correct
 The proper reviews and authorizations will be applied to support the process
 The appropriate technical tools (Organizational Process Assets) exist
 Constructability studies have been applied
 Scope Management is not a consideration

1 INPUTS

- .1 Project Scope Statement / Scope Baseline
- .2 Project Charter
- .3 Enterprise Environmental Factors
- .4 Enterprise Objectives and Considerations
- .5 Site Plan – High level process areas layout
- .6 C & SU Systems Priorities Defined
- .7 WBS (Equipment and Systems identified)
- .8 Plot Plans
- .9 Project Delivery Model
- .10 Project Management Plan
- .11 Milestone Schedule
- .12 Construction Execution Plan
- .13 Construction Input / Expertise
- .15 Specialty Contractors
- .16 Procurement Constraints (Long Leads)
- .17 Organizational Process Assets (Standards, Procedures, Templates, Measurement Data, Project Files)

2 TOOL AND TECHNIQUES

- .1 Constructability Techniques Applied
- .2 Expert Judgment
- .3 Decomposition
- .4 Alternatives Identification
- .5 Select construction techniques – modularization, prefabrication, Contracting options
- .6 Activity Sequencing
- .7 Activity Duration Estimating
- .8 Work Packaging – defining CWP/EWP/FIWP
- .9 Detailed schedule development
- .10 Risk identification and management
- .11 Management of Change – Scope Control

3 OUTPUTS

- .1 Integrated Project Baseline Schedule with Engineering, Procurement, and Construction deliverables identified
- .2 Contracting Plan
- .3 CWP/EWP/IWP Schedule
- .4 FIWP release plan
- .5 Modularization, Prefabrication and Pre-assembly Plans
- .6 Construction Management Team Resource Requirements
- .7 Project Constraints
- .8 Construction Risk Identification
- .9 Critical Path

⁸ For further information on **Inputs/Tools/Techniques/Outputs** please see PMBOK included in references



Path of Construction - RASCI Chart

PoC RASCI
 Document Number: COP-WFP-SPD-12-2013-v1
 Revision: A

- R = Responsible - The Doers
- A = Accountable - Owner of the Work
- S = Supporting - Provide Resources
- C = Consulted - Give Input
- I = Informed - Require Updates/Progress

INPUTS	Project Manager	Construction Manager	Construction Coordinator	Engineering Manager	Procurement Manager	Scheduler	Contracts Manager	CRSU Manager	Operations Manager	Estimator
Project Scope Statement / Scope Baseline	R	I								
Project Charter										
Enterprise Environmental Factors										
Enterprise Objectives and Considerations										
Site Plan – High level process areas layout	A	C	R							
C & SU Systems Priorities Defined	A	S					R			
WBS (Equipment and Systems identified)	AR	C	S							
Plot Plans		C	R							
Project Delivery Model										
Project Management Plan	AR	C	C							
Milestone Schedule	AR	C	C				C			
Construction Execution Plan	A	R	C							
Construction Input / Expertise										
Heavy-Lift Requirements										
Specialty Contractors	A	C								
Procurement Constraints (Long Leads)	A		C	R						
Organizational Process Assets (Standards, Procedures, Templates, Measurement	A	R		A	R	R				R

CATEGORY D - TEMPLATE - POC RASCI rev A



Path of Construction - RASCI Chart

PoC RASCI
 Document Number: COP-WFP-SPD-12-2013-v1
 Revision: A

- R = Responsible - The Doers
- A = Accountable - Owner of the Work
- S = Supporting - Provide Resources
- C = Consulted - Give Input
- I = Informed - Require Updates/Progress

	Project Manager	Construction Manager	Constructability Coordinator	Construction Coordinator	Engineering Manager	Procurement Manager	Scheduler	Contracts Manager	C&SU Manager	Operations Manager	Estimator
Data, Project Files											
TOOLS AND TECHNIQUES											
Constructability Techniques Applied	I A		C					C			
Expert Judgment	I A		C					C			
Decomposition											
Alternatives Identification											
Select construction techniques – modularization, prefabrication, Contracting options	A R		C C								
Activity Sequencing	I C		R C C R					C			
Activity Duration Estimating	C		R C C R					C			
Work Packaging – defining CWP/EWP/FIWP	I A		R C								
Detailed schedule development	I A		R C C					C			
Risk identification and management	A C										
Management of Change – Scope Control	A R		C								
OUTPUTS											
Integrated Project Baseline Schedule with Engineering, Procurement, and	A C		C C					C			

CATEGORY D - TEMPLATE - POC RASCI rev A



Path of Construction - RASCI Chart

PoC RASCI
 Document Number: COP-WFP-SPD-12-2013-v1
 Revision: A

- R = Responsible - The Doers
- A = Accountable - Owner of the Work
- S = Supporting - Provide Resources
- C = Consulted - Give Input
- I = Informed - Require Updates/Progress

	Project Manager	Construction Manager	Constructability Coordinator	Construction Coordinator	Engineering Manager	Procurement Manager	Scheduler	Contracts Manager	CSU Manager	Operations Manager	Estimator
Construction deliverables identified	A	C									
Contracting Plan	A	C						R			
CWP/EWP/IWP Schedule	A	R	C	R							
FIWP release plan											
Modularization, Prefabrication and Pre-assembly Plans											
Construction Management Team Resource Requirements	I	AR	C						I		
Project Constraints	I	A			R				I		
Construction Risk Identification	I	R	C	R					C		
Critical Path	A	R			R				C		

CATEGORY D - TEMPLATE - POC RASCI rev A

Path of Construction check list

Stakeholder	Input	Type	Pre. Requisite	PREFEED	FEED	Detailed Eng.	Construction	Comments
Owner	Enterprise Objectives	Doc						
	Schedule Milestones	Doc						
Project Management	Project Charter	Doc						Project Charter would need to be partially complete during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be developed during Detailed Engineering.
	Project Objectives/Strategy Summary	Doc						Project Objectives would need to be partially complete during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be developed during Detailed Engineering.
	Project Execution Strategy	Doc						Project Execution strategy would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	AWP / WFP Strategy	Doc						AWP/WFP strategy would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	High-level Scope Summary	Doc						Needs to be completed during the Detailed Engineering & FEP Construction Phase.
	Project Delivery System	Doc						Project Execution strategy
	Project Key Milestone/Deadlines	Schedule						Would need to be started during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	Project Quality Manual	Doc						
	Change Management Strategy	Doc						
	Important Risks/Risk Mgmt plan	Doc						Needs to be considered for lessons learned
	High-level Deliverables List	Doc						Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	Project WBS	Doc						Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Major long lead items	Doc						Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	Modularization Strategy	Doc						Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	Project HSSE Plan	Doc						
	Lessons Learned Register	Doc						Needs to be considered for lessons learned
	Path of Construction Process	Procedure						Would need to be completed during the Detailed Engineering phase and the FEP Construction phase.
	Integrated Planning Sessions	Doc						Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
Data Base - Format & Deliverables	Doc							

Completions, Commissioning & SU	Preliminary System ID	Doc						Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Start up Strategy	Doc						Would need to be partially completed during the FEP Construction phase and completed during the WFP Construction phase.
	Strategy to change from bulk construction to system turnover							Would need to be partially completed during the FEP Construction phase and completed during the WFP Construction phase.
	Start up Schedule	Schedule						Would need to be partially completed during the FEP Construction phase and completed during the WFP Construction phase.
	Preliminary System Turnover Schedule	Schedule						Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Support for Constructability Program	Resources						Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
Construction Management	Construction Execution Plan / Strategy	Doc						Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	CWA Boundary Definition	Doc						Would need to be complete during the Detailed Engineering phase and the FEP Construction phase.
	CWP Boundary Definition	Doc						Would need to be complete during the Detailed Engineering phase and the FEP Construction phase.
	Proposed Construction Schedule	Schedule						POC determines Schedule
	CWP Release Plan	Schedule						
		Spreadsheet						
	Construction Rates							
	Ability to Meet CWP Rules of Credit	Doc						
	Heavy Lift Plan (Need to be identified, but not plan)	Doc						Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	List of Constraints (permits, live areas, hazardous areas, operational constraints, shut down schedule, camp space, other projects, environmental)	Doc						Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Access and Mobility issues	Doc						Would need to be complete during the Detailed Engineering phase and the FEP Construction phase.
	Schedule for needed on site dates for Long Lead Equipment List	Schedule						
Engineering	Plot Plan	Drawing						Would need to be complete during the Detailed Engineering phase and the FEP Construction phase.
	P & I D's	Drawing						Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	P F D's	Drawing						
	Engineering key milestones	Doc						POC will establish the engineering milestones
	Engineering WBS - CWP/EWP Numbering Convention	Doc						POC will establish the engineering milestones

	Long Lead Equipment List	Doc							Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	Engineering Delivery Strategy	Doc							Would need to be complete during the Detailed Engineering phase and the FEP Construction phase.
	3D Modelling Strategy	Doc							
	Engineering Schedule	Schedule							POC will establish the engineering schedule
	Constructability implementation plan	Doc							
	Identified Engineering Constraints	Doc							Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Construction Specs	Doc							
	EWP Release Schedule	Schedule							POC will establish the engineering schedule
	Vendor Data Required Dates by EWP	Schedule							Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Equipment Data Sheets	Schedule							Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Ability to apply Rules of Credit for EWP's	Doc							Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Hazop Study								Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
Supply Chain Management	Long Lead Equipment Lead Times								
	Schedule of Deliveries to site	Schedule							POC will determine Delivery schedule
	Strategy to obtain vendor data on time	Doc							
	Contracting Strategy Engineering	Doc							
	Fabrication / Modular Assembly	Doc							
	Site Construction	Doc							
	Specialty Contractors	Doc							Would need to be partially complete during the Detailed Engineering phase and would need to be complete during the FEP Construction phase.
	Vendor Support	Doc							
	Material Management Strategy								
	Delivery Strategy	Doc							POC will determine the delivery
	Warehousing Strategy	Doc							Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	Distribution Strategy	Doc							POC will determine the Distribution
	Procurement Strategy	Doc							Would need to be partially completed during the FEED phase (if there is a FEED phase for the large runner projects). It would need to be completed during the Detailed Engineering and FEP Construction Phase.
	Project Controls	Quality Control Procedures	Doc						
Project Schedule		Schedule							POC will determine Project Schedule
Rules of Credit (EWP, CWP, PWP)		Doc							

	Total Project Automation Plan	Doc							
Info. Management	Database and Information Management								

Construction, Engineering and Procurement Planning Template

Project Category: Familiar - Complex

Project Description: Solar Project

Project Stage: Preliminary Planning and Design

Activity: Construction, Engineering, and Procurement Planning

Purpose: Early project planning that integrates work packaging with construction, engineering, and procurement.

Content:

1. Construction
 - 1.1. Construction Work Area (CWA) Plan
 - 1.2. Preliminary Construction Work Package (CWP) Plan
 - 1.3. Path of Construction Plan
 - 1.4. Site Constraint Plan
 - 1.5. Labor & Subcontracting Plan
 - 1.6. Temporary Construction Facility Plan
 - 1.7. Major Construction Equipment Plan
 - 1.8. Preliminary System Turnover Sequence
 - 1.9. Preliminary Technology Plan
 - 1.10. Preliminary Material Management Plan
2. Engineering
 - 2.1. Preliminary Engineering Work Package (EWP) Plan
 - 2.2. Site Arrangement with Construction Work Areas (CWAs)
 - 2.3. Preliminary Technology Plan
 - 2.4. Preliminary Major Vendor Submittal Schedule
3. Procurement
 - 3.1. Preliminary Procurement Work Package (PWP) Plan
 - 3.2. Preliminary Sourcing, Logistics, and Material Tracking Plan
 - 3.3. Preliminary Technology Plan

Narrative:

1. Construction

1.1. Construction Work Area (CWA) Plan

- Owner's Role: N/A
- Construction's Role: Provide input to Estimating and Proposal group to establish CWAs which align with the preliminary Construction Execution Strategy. The objective is to package work for the construction crews in an efficient manner. Participate in collaboration sessions.
- Engineering's Role: Produce General Site Arrangement and Equipment Layout. Participate in collaboration sessions.
- Procurement's Role: N/A

1.2. Preliminary Construction Work Package (CWP) Plan

- Owner's Role: N/A
- Construction's Role: Participate in collaborative sessions to establish discipline-specific CWPs which align with the project's Construction Execution Strategy and facilitate development of the Path of Construction.
- Engineering's Role: Participate in collaborative sessions to align the EWP structure and EWP release plan with CWPs and the Path of Construction.
- Procurement's Role: Participate in collaborative sessions to align the PWP structure and Procurement plan with CWPs and the Path of Construction.

1.3. Path of Construction Plan

- Owner's Role: Ensure the requirements for the project's contractual delivery schedule are properly defined and communicated.
- Construction's Role: Participate in collaboration session(s) to ensure CWP structure and release plan support the project's POC.
- Engineering's Role: Participate in collaboration session(s) to ensure EWP structure and release plan support the project's POC.
- Procurement's Role: Participate in collaboration session(s) to ensure PWP structure and release plan support the project's POC.

1.4. Site Constraint Plan

- Owner's Role: N/A
- Construction's Role: TBD
- Engineering's Role: TBD
- Procurement's Role: TBD

1.5. Labor & Subcontracting Plan

- Owner's Role: N/A
- Construction's Role: Review Construction Execution Plan and Path of Construction to determine which work will be subcontracted to a 3rd party. Ensure subcontracted work is governed by contract language which communicates necessary milestones and deadlines.
- Engineering's Role: N/A
- Procurement's Role: N/A

1.6. Temporary Construction Facility Plan

- Owner's Role: Provide any necessary guidance regarding easements or access relative to establishing or moving temporary facilities on to site.
- Construction's Role: TBD
- Engineering's Role: TBD
- Procurement's Role: TBD

1.7. Major Construction Equipment Plan

- Owner's Role: Provide any necessary guidance regarding easements or access relative to getting large equipment on site.
- Construction's Role: Ensure any easements, access, or transportation permits and inspections are complete and/or scheduled prior to and during delivery of large equipment.
- Engineering's Role: N/A
- Procurement's Role: N/A

1.8. Preliminary System Turnover Sequence

- Owner's Role: N/A
- Construction's Role: Map CWP completions to Systems and develop criteria for System Turnover.
- Engineering's Role: Ensure preliminary EWP structure and Release Plan support completion of CWPs in alignment with System Turnover requirements.
- Procurement's Role: Ensure preliminary Procurement Plan and PWP structure support completion of CWPs in alignment with System Turnover requirements.

1.9. Preliminary Technology Plan

- Owner's Role: N/A
- Construction's Role: TBD
- Engineering's Role: TBD
- Procurement's Role: TBD

1.10. Preliminary Material Management Plan

- Owner's Role: Provide detailed delivery details for any owner-provided equipment and/or material. If the owner has designated a specific provider/source for the EPC to use, that provider/source must be included in Front-End Planning and POC activities.
- Construction's Role: Communicate the desired Path of Construction and CWP Release Plan.
- Engineering's Role: Provide IFC drawings with complete material take-off quantities and specifications.
- Procurement's Role: Produce Procurement Work Packages. Develop procurement plan to ensure sourcing, delivery, and receipt of all required components and material align with CWP & EWP plans.

2. Engineering

2.1. Preliminary Engineering Work Package (EWP) Plan

- Owner's Role: The Owner is responsible for being the Champion of the AWP process and reviewing the Preliminary EWP Plan to ensure it meets the overall project AWP strategy requirements.

- **Construction's Role:** Construction is responsible for reviewing the Preliminary EWP Plan content and alignment with the Construction Work Area Plan and Construction Work Package Plan.
- **Engineering's Role:** Engineering is responsible for establishing the Preliminary Engineering Work Package (EWP) Plan. The Plan should contain a preliminary list of EWPs and their association with the project CWAs and CWPs. The Plan should contain the expected content and format of the Engineering Work Package deliverable. Typically a project specific EWP template is included for clarification. Often a project specific preliminary deliverables list or deliverables series list is provided with associated EWPs assigned. These items are important so that expectations are set and resources are planned appropriately to support the timely issue of Engineering Work Packages.

The Familiar/High Complexity AWP Project is often one that is familiar, but has significant multi-discipline and/or procurement complexities that results in a significant number of CWAs and CWPs which directly results in a significant number of EWPs. The EWP template and preliminary deliverables list can often be tailored from a similar previous project. Knowledge should be leveraged from the previous project with modifications for current project requirements. The focus should be on deliverables or content that needs to be modified from the previous example project. Some of the common drivers for differences are project site, environmental conditions, client requirements, supply chain differences, and scope differences.

- **Procurement's Role:** Procurement is responsible for reviewing the Preliminary EWP Plan to ensure it contains the required content by Construction Work Area and Construction Work Package to support the Procurement Work Packages (PWP) Plan.

2.2. Site Arrangement with Construction Work Areas (CWAs)

- **Owner's Role:** The Owner is responsible for review of the Site Arrangement with Construction Work Areas to ensure Owner required constraints are met.
- **Construction's Role:** Construction is responsible for generating the Construction Work Areas to be applied to the Project Site Arrangement. The Construction Work Areas are documented in the Construction Work Area Plan generated by Construction during the preliminary planning and design stage.
- **Engineering's Role:** Engineering is responsible for reviewing and documenting the Construction Work Areas on the project Site Arrangement for inclusion in to the Construction Work Area Plan generated by Construction during the preliminary planning and design stage.

The Familiar/High Complexity AWP Project is often one that is familiar, but has significant multi-discipline and/or procurement complexities that results in a significant number of CWAs. The Site Arrangement with Construction Work Areas (CWAs) can often be tailored from a similar previous project. Knowledge should be leveraged from the previous project with modifications for current project requirements. During the application of the CWAs on the project Site Arrangement, it is typical for CWA boundaries to be adjusted as they are visually applied to the Site Arrangement. These adjustments should be documented in the

Construction Work Area Plan generated by Construction during the preliminary planning and design stage.

- Procurement's Role: Procurement is responsible for reviewing the Site Arrangement with Construction Work Areas and presenting constraints for project team consideration. Constraints considered are items such as laydown/storage space.

2.3. Preliminary Technology Plan

- Owner's Role: The Owner is responsible to define the final turnover requirements for each CWA or the whole project. The Owner should also define any preferred technologies to be used that will interface with their systems.
- Construction's Role: Understand the technologies being used and provide input to what Construction will use during erection. Construction will define the hierarchy level of the CWA to be used and should be supported by the defined technology.
- Engineering's Role: Engineering will create all engineering deliverables to support the inputs as required by the selected technology. For large complex project this should be setup in the early preliminary stage to ensure that all the different technologies are compatible and transfers information correctly.

The Familiar/High Complexity AWP Project is often one that is familiar, but has significant multi-discipline and/or procurement complexities that results in a significant number of CWAs. The Preliminary Technology Plan can often be tailored from a similar previous project. Knowledge should be leveraged from the previous project with modifications for current project requirements. A mapped project database with agreed upon data and/or 3D model software and agreed upon attribute list should be a consideration for this type of project. It should be determined early in the project what is required so that all the engineering packages and deliverables are setup correctly. Defining these technologies too late will minimize the benefit to the schedule or efficiency that could be achieved.

- Procurement's Role: Ensure the procurement systems can track the equipment and commodities by CWA to ensure delivery of vendor data and equipment delivery meet the needs of Engineering and Construction.

2.4. Preliminary Major Vendor Submittal Requirements and Timing

- Owner's Role: The Owner is required to ensure there are sufficient funds available to support the procurement of any early equipment to support early CWAs or long fabrication items. The Owner will also need to determine how much of a role it will have during the Vendor document review cycle. If the Owner has specialized expertise in certain equipment, then the Owner should be included in the review. If not, the Owner should be copied on the drawing back to the vendor or review in parallel with Engineering.
- Construction's Role: Construction is responsible to identify any equipment needed early as defined in the CWAs. Construction will review all vendor data to understand/modify as needed to support the CWAs and package segregation.
- Engineering's Role: Engineering will create packages as defined in the CWAs. Several CWAs can be grouped together in one purchase order but the delivery of each piece of equipment

must support the CWA and path of construction. Generally, projects do not have sufficient funding approval during the preliminary planning stage and the purchase orders may be split between Engineering Only and Fabrication.

The Familiar/High Complexity AWP Project is often one that is familiar, but has significant multi-discipline and/or procurement complexities that results in a significant number of CWAs. The Preliminary Major Vendor Submittal Requirements and Timing can often be tailored from a similar previous project. Knowledge should be leveraged from the previous project with modifications for current project requirements. For this type of project, preliminary vendor data should be required for any information that could affect the Site Arrangement at the beginning of the preliminary planning stage or has long fabrication times. The vendor data should be checked to align with the needs of the CWAs to support the path of construction. Vendor drawing submittals and reviews are one of the most critical steps during engineering and can often take longer than anticipated.

- Procurement's Role: Ensure that the Terms and Conditions in all procurement contracts encourage the supplier/vendors to meet the engineering deliverables schedule set by the path of construction. Support Engineering in splitting Engineering and Fabrication purchase orders as required to meet the CWA schedule.

3. Procurement

3.1. Preliminary Procurement Work Package (PWP) Plan

- Owner's Role: TBD
- Construction's Role: TBD
- Engineering's Role: TBD
- Procurement's Role: TBD
 - Tagging the equipment/materials with associated PWPs, based on the particular MTOs
 - Ensure that all PWP deliverables meet the path of construction

3.2. Preliminary Sourcing, Logistics, and Material Tracking Plan

- Owner's Role: TBD
- Construction's Role: TBD
- Engineering's Role: TBD
- Procurement's Role: TBD
 - Sourcing: Determine suppliers/vendors align with the requirements of the procurement plan.
 - Logistics: Determine where equipment/materials are being shipped from and how they will be delivered.
 - Material Tracking Plan: Determine the method of tracking and receiving methods for material/equipment

3.3. Preliminary Technology Plan

- Owner's Role: TBD
- Construction's Role: TBD
- Engineering's Role: TBD

- Procurement’s Role: Unknown

Attachments:

1. Construction
 - **Add lists, forms, drawings, etc that can be provided as examples to support content above.**
2. Engineering
 - Site Arrangement with Construction Work Areas (CWAs) indicated – See “ACME Solar GA with Blocks”
3. Procurement
 - Procurement Purchasing Matrix Guideline - Rev A
 - Purchasing Plan Guideline - Rev A

Engineering Deliverables List

Discipline	Deliverable	DBM & FEED			Detailed		
		Includ	Status	Comment	Includ	Status	Comment
General	Design Basis	×	IFD				
General	Scope of Work	×	IFD				
General	Work Package List		IFR				
General	Work Packages	×	IFR				
General	Permit /						
General	Contract Scope of Work	×	IFD				
General	Material Requisitions	×	IFR				
General	Technical Bid Evaluation						
General	Standard Drawings (incl. Standard Installation Drawings)	×	IFD				
General	Engineering Specifications	×	IFD				
General	Material Handling Matrix						
Process	Heat and Material Balances (Computer Simulations)	×	IFD				
Process	Hydraulic Calculations						
Process	Process Design Criteria	×	IFD				
Process	Material Selection Design Basis	×	IFD				
Process	Process Flow Diagrams (PFD)	×	IFD				
Process	Block Flow Diagrams	×	IFD				
Process	Process Equipment Datasheets	×	IFR				
Process	Instrument Datasheets	×	IFR				
Process	Battery Limit Interface Table	×	IFR				

Process	Tie-in List	×	IFR				
Process	Catalyst and Chemicals Requirements List	×	IFR				
Process	Piping Design Data/Line List	×	IFD				
Process	Cause and Effects						
Process	Process Control Narrative	×	IFR				
Process	PHA	×	IFD				
Process	Piping & Instrumentation Diagrams	×	IFD				
Process	Startup and Operating Manuals						
Mechanical	Mechanical Equipment List	×	IFD				
Mechanical	Mechanical Equipment Specifications	×	IFD				
Mechanical	Equipment Sizing Verification (including Pump Size)						
Mechanical	Equipment Datasheets	×	IFD				
Mechanical	Equipment Layout Drawings	×	IFD				
Mechanical	Material Selection Diagram	×	IFD				
Mechanical	L&P Drawings						
Mechanical	Material Requisitions	×	IFD				
Mechanical	Technical Bid Evaluation						
Mechanical	Spare Parts List						
Mechanical	Lubrication List						
Piping	Plot Plans	×	IFD				
Piping	Work Package Location Plans	×	IFR				
Piping	Module Location Plans	×	IFR				
Piping	Tie In Location Plans	×	IFR				
Piping	Utility Station Location Plans						
Piping	Piping General Arrangements						
Piping	Piping Material Control Plan	×	IFR				
Piping	Material Take Offs	×	IFR				
Piping	Piping Stress Calculations						
Piping	Equipment Nozzle Loading Calculations						
Piping	Demolition Drawings						
Piping	Line Designation Table	×	IFR				
Piping	Underground Piping Drawings	×	IFD				
Piping	Piping Purchase Specifications (deliverable to Supply Chain)	×	IFD				
Piping	Piping Supports (List, Datasheets)						
Piping	Isometrics						
CSA	Material Take Offs	×	IFD				
CSA	Calculations						
CSA	Soil Report	×	IFC				
CSA	Drainage and Sewer Drawings	×	IFD				
CSA	Pond / Dyke Drawings						
CSA	Roads / Paving Drawings	×	IFD				

CSA	Fencing Drawings	×	IFD				
CSA	Rough / Finish Grading Drawings	×	IFD				
CSA	Piling Drawings						
CSA	Foundation Drawings	×	IFD				
CSA	Structural Steel Drawings						
CSA	Building Matrix						
CSA	Architectural Drawings						
CSA	Demolition Drawings						
HVAC	HVAC Air Flow Diagrams / Sequence of Operation						
HVAC	Heating & Cooling Load Calculations						
HVAC	Ducting and Instrumentation Drawings						
HVAC	HVAC Pressurization Drawing						
HVAC	HVAC Equipment List						
HVAC	HVAC Drawings						
HVAC	HVAC Layout Drawings						
HVAC	LEED Compliance Checklist						
Electrical	Area Classification Drawing	×	IFD				
Electrical	Calculations						
Electrical	Single Line Drawings	×	IFD				
Electrical	Electrical Equipment List	×	IFD				
Electrical	Electrical Datasheets	×	IFD				
Electrical	Electrical Wiring Drawings	×	IFD				
Electrical	Power, Lighting and Grounding Layout Drawings	×	IFD				
Electrical	Cable Schedules	×	IFD				
Electrical	Panel Schedules	×	IFD				
Electrical	EHT Block Diagrams / Zoning Drawings						
Electrical	EHT Tracing Isometrics						
Electrical	EHT Cable Schedules						
Electrical	Cable Tray Layout Drawings						
Electrical	Demolition Drawings						
Electrical	Cathodic Protection Drawings						
Electrical	Underground Drawings	×	IFD				
Electrical	E House Layout Drawings	×	IFD				
Electrical	Temporary Power Drawings						
Electrical	Electrical Studies (e.g. Arc Flash)	×	IFD				
Control Systems	Instrument List	×	IFD				
Control Systems	Instrument Specifications	×	IFD				
Control Systems	Instrument Datasheets	×	IFD				
Control Systems	SIL Report						

Control Systems	LAN Diagrams						
Control Systems	Auxillary P&IDs						
Control Systems	Control Narrative	×	IFR				
Control Systems	Cause and Effect Drawings						
Control Systems	Interlock, Contorl and Instrument Wiring Drawings						
Control Systems	Architecture Block Diagrams	×	IFR				
Control Systems	Interconnection Drawing	×	IFR				
Control Systems	Loop Diagrams						
Control Systems	Fire and Gas Layout Drawings						
Control Systems	Site Communication Network Diagrams	×	IFR				
Control Systems	SCADA Requirements	×	IFR				
Control Systems	Panel Schedules	×	IFR				
Control Systems	Instrument Location Plans	×	IFD				
Control Systems	Cable Tray Layout Drawings						
Control Systems	Control Room Layout Drawings						
Control Systems	Range, Alarm & Trip Setting List	×	IFR				
Control Systems	Demolition Drawings						

Purchasing Plan Guideline

Purpose

This Purchasing Plan Guideline has been prepared for use in connection with the ANYTOWN SOLAR PROJECT. Its purpose is to provide guidance and coordination of the procurement packages. It is to be used as a basis to populate a fit for purpose Purchasing Matrix (see attached) which is intended to supplement the project's procurement process for the purchase of materials and equipment.

Introduction

Content to include:

- Type of project
- Project location
- High level summary of overall project schedule with purchasing milestones
- High level budget summary of purchasing packages
- Reference to purchasing matrix
- Any unique details.

Strategy

This section identifies the package originator and type of purchase. This section should be filled out during Stage I Preliminary Planning and Design and confirmed in the early stages of Stage II Detailed Engineering. This is recorded in the purchasing matrix as listed below.

- Purchasing matrix column designations:
- Purchaser (Owner/EP/C) – Designate what entity is required to purchase the package
- Project Strategy (SS/CB/SCA) – Designate the intended sourcing plan for the package
- Form (S/I/L) – Designate the intended commercial form for the package based on package risk
- Type D=Design, F=Furnish, I=Install – Designate the general type of purpose for the package

Bidders

This section identifies the bidder pool and bidder selection. This section should be filled out during Stage I Preliminary Planning and Design and finalized in the early stages of Stage II Detailed Engineering. This is recorded in the purchasing matrix as listed below.

Purchasing matrix column designations:

- Approved bidders list – List any internal or owner approved bidders for the package
- Selected approved bidder – List the selected approved bidder for the package
- Supplier of choice agreement number – List any pre-negotiated supplier agreements for the package

Shop interface

This section identifies the required interfaces with the shop. This section should be filled out during Stage I Preliminary Planning and Design and finalized in the early stages of Stage II Detailed Engineering. This is recorded in the purchasing matrix as listed below.

Purchasing matrix column designations:

- Shop expediting required (Y/N) – List requirements for shop expediting for the package
- Shop inspection required (Y/N) – List requirements for shop inspections for the package

Delivery

This section identifies the required delivery terms for the package. This section should be filled out during Stage I Preliminary Planning and Design and finalized in the early stages of Stage II Detailed Engineering. This is recorded in the purchasing matrix as listed below.

Purchasing matrix column designations:

- Delivery terms FOB/FCA/DDP/Other – List the project required delivery terms for the package

Schedule

This section identifies the general schedule for the package. This section should be filled out during Stage I Preliminary Planning and Design and finalized in the early stages of Stage II Detailed Engineering. This is recorded in the purchasing matrix as listed below.

Purchasing matrix column designations:

- Lead time from PO acceptance – List the general lead time of delivery from PO acceptance for the package.
- Lead time from drawings acceptance – List the general lead time of delivery from shop drawing approval for the package.
- Lead time from release to manufacture – List the general lead time of delivery from approved to manufacture release for the package.

Field interface

This section identifies the field interface requirements. This section should be filled out during Stage I Preliminary Planning and Design and finalized in the early stages of Stage II Detailed Engineering. This is recorded in the purchasing matrix as listed below.

Purchasing matrix column designations:

- Capital spares required – List the spares required to be turned over to the owner for the package.
- Preservation required – List preservation requirements for field use and upkeep for the package.
- SU vendor support required – List the startup services required from the vendor for the package.

Naming Convention

ACME SOLAR COMPANY

Date: 29-Aug-17

Anytown Solar Project

Sample CWP Naming Convention:

Geographic Definition				Scope Definition	
Project	Unit	CWA	SubArea	Activity Code	Discipline Code
A	01	02	C	D	E

- A Project: If required, refers to Owner project code
- 01 Unit: Refers to Owner unit code
- 02 Construction Work Area: Refers to a partition of scope within a Unit
- C SubArea: Refers to a specific portion within and Area (if required)
- D Activity Code: Construction activity definition
- E Discipline Code: Specific work for construction activity.

PWP Naming Convention: CWP - P

Activity Code	Activity Code Description	Discipline Code	Discipline Code Description
D	Demolition	C	Mechanical
F	Field Installation	H	HVAC
M	Module Assembly	J	Control Systems
R	Retrofit	L	Piping
T	Tie In	M	Structural Steel
U	Underground	N	Insulation
		P	Electrical
		Q	Piling
		R	Architectural
		S	Civil – Earthwork
		U	Concrete Foundations
		V	Equipment Ladders and Platforms
		X	Fireproofing
		Z	EHT

CWP List

ACME SOLAR COMPANY
Anytown Solar Project
CWP List

Geographic Definition				Scope Definition		Work Package	Description	Comment
Project	Unit	CWA	SubArea	Activity Code	Discipline Code			
A	01	00	A	F	S	A0100AFS	General Area: Civil	Includes Fencing
A	01	00	A	F	J	A0100AFJ	General Area: Control Systems	includes CCTV devices and cables
A	01	01	A	U	S	A0101AUS	Block 1: Civil	
A	01	01	A	U	U	A0101AUU	Block 1: Concrete Foundations	
A	01	01	A	U	Q	A0101AUQ	Block 1: Piling	
A	01	01	A	F	M	A0101AFM	Block 1: Structural Steel	includes fixed tilt solar racks
A	01	01	A	F	P	A0101AFP	Block 1: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	01	A	F	J	A0101AFJ	Block 1: Control Systems	Includes SCADA System and Control System cables.
A	01	02	A	U	S	A0102AUS	Block 2: Civil	
A	01	02	A	U	U	A0102AUU	Block 2: Concrete Foundations	
A	01	02	A	U	Q	A0102AUQ	Block 2: Piling	
A	01	02	A	F	M	A0102AFM	Block 2: Structural Steel	includes fixed tilt solar racks
A	01	02	A	F	P	A0102AFP	Block 2: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	02	A	F	J	A0102AFJ	Block 2: Control Systems	Includes SCADA System and Control System cables.
A	01	03	A	U	S	A0103AUS	Block 3: Civil	
A	01	03	A	U	U	A0103AUU	Block 3: Concrete Foundations	
A	01	03	A	U	Q	A0103AUQ	Block 3: Piling	
A	01	03	A	F	M	A0103AFM	Block 3: Structural Steel	includes fixed tilt solar racks
A	01	03	A	F	P	A0103AFP	Block 3: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	03	A	F	J	A0103AFJ	Block 3: Control Systems	Includes SCADA System and Control System cables.
A	01	01	A	U	S	A0101AUS	Block 4: Civil	
A	01	01	A	U	U	A0101AUU	Block 4: Concrete Foundations	
A	01	01	A	U	Q	A0101AUQ	Block 4: Piling	
A	01	01	A	F	M	A0101AFM	Block 4: Structural Steel	includes fixed tilt solar racks
A	01	01	A	F	P	A0101AFP	Block 4: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	01	A	F	J	A0101AFJ	Block 4: Control Systems	Includes SCADA System and Control System cables.
A	01	02	A	U	S	A0102AUS	Block 5: Civil	
A	01	02	A	U	U	A0102AUU	Block 5: Concrete Foundations	
A	01	02	A	U	Q	A0102AUQ	Block 5: Piling	
A	01	02	A	F	M	A0102AFM	Block 5: Structural Steel	includes fixed tilt solar racks
A	01	02	A	F	P	A0102AFP	Block 5: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	02	A	F	J	A0102AFJ	Block 5: Control Systems	Includes SCADA System and Control System cables.
A	01	03	A	U	S	A0103AUS	Block 6: Civil	
A	01	03	A	U	U	A0103AUU	Block 6: Concrete Foundations	
A	01	03	A	U	Q	A0103AUQ	Block 6: Piling	
A	01	03	A	F	M	A0103AFM	Block 6: Structural Steel	includes fixed tilt solar racks
A	01	03	A	F	P	A0103AFP	Block 6: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	03	A	F	J	A0103AFJ	Block 6: Control Systems	Includes SCADA System and Control System cables.
A	01	03	A	U	S	A0103AUS	Block 7: Civil	
A	01	03	A	U	U	A0103AUU	Block 7: Concrete Foundations	
A	01	03	A	U	Q	A0103AUQ	Block 7: Piling	
A	01	03	A	F	M	A0103AFM	Block 7: Structural Steel	includes fixed tilt solar racks
A	01	03	A	F	P	A0103AFP	Block 7: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	03	A	F	J	A0103AFJ	Block 7: Control Systems	Includes SCADA System and Control System cables.
A	01	03	A	U	S	A0103AUS	Block 8: Civil	
A	01	03	A	U	U	A0103AUU	Block 8: Concrete Foundations	
A	01	03	A	U	Q	A0103AUQ	Block 8: Piling	
A	01	03	A	F	M	A0103AFM	Block 8: Structural Steel	includes fixed tilt solar racks
A	01	03	A	F	P	A0103AFP	Block 8: Electrical	Includes cables, conduit, combiner boxes and photovoltaic modules
A	01	03	A	F	J	A0103AFJ	Block 8: Control Systems	Includes SCADA System and Control System cables.

Work package Development Plan

Revision: A
19-Aug-17

ACME Solar Project Work Package Development Schedule	Work Package Development Guidelines	Action By	Package	DBM	FEED			Detailed Design			Deliverable	Document Type and Revision
					Early	Mid	Late	Early	Mid	Late		
1	Project Scope and Objectives	Owner		X	X						Issue Design Basis	
2	Define Construction Work Areas	EP	CWA	X	X						Issue Plot Plan for Review	
3	Define Path of Construction	C	CWP	X	X						Issue Plot Plan for Approval	
4	Define Long Lead Equipment	EP	PWP	X	X						Issue Equipment List for Approval	
5	1) Material and Fabrication Long Lead Items 2) Early Construction Activities											
6	Set Engineering Priority for Scope and Datasheet Development	EP	EWP		X						Issue datasheets for inquiry	
7	Develop Long Lead Procurement Packages	EP	PWP		X	X					Issue Inquiry Packages	
8	Revalidate Construction Work Areas and Path of Construction	C				X					Issue Plot Plan for Design	
9	Purchased Orders Placed	EP				X					Issue Purchase Order Packages	
10	1) Engineering and Fabrication Purchase Order for Long Lead Items 2) Engineering Only Purchase Order for Early Construction Activities (define fabrication Purchase Orders based on early construction activities)											
11	Start Work Package Definition	Owner/FIMP	FIMP								Highlighted set of Issued for Design documents by systems	
12	1) Commissioning System 2) Construction Boundaries i.e. hydro test packages											
13	Start Work Package Development	EP	FIMP			X					FIMP Issued for Review	
14	Received and Review Vendor Data	EP					X				Approved vendor drawings	
15	Issue Drawings and Documents for Construction	EP							X		Drawings Issued for Construction	
16	Issue Work Packages for Construction	EP	FIMP							X	FIMP Issued for Construction	

Equipment List

HEAVY EQUIPMENT AND CIVIL	PUMPS AND HOSES	ADMINISTRATION
36" REMOTE WALK BEHIND SHEEPSFOOT	2" HOSE	Conex, 20ft
56" ROLLER	2" PUMP	Conex, 20ft White
70" ROLLER	2" Trash Pump	Conex, 40ft
72" Carriage Forklift Attachment 6' Forks	3" HOSE	Generator 19-29 KVA
84" ROLLER	3" PUMP	GENERATOR 3.0-3.4 KW
8'X10' Road Plate	4" HOSE	Handwash station
8'X8' Road Plate	4" PUMP	Light Tower Solar Generator
DOZER	6" PUMP	Light Tower Towable
EXCAVATOR	STRAINER 4"	Modular Shield Strut 36" Trench Box
FORKLIFT 10K VARIABLE REACH	STRAINERS ALL SIZES	Office Trailer 3 plex
FORKLIFT 12K EXTENDED REACH		Office Trailer Double Wide
FORKLIFT 6K Rough Terrain 21-29'		Office Trailer Double Wide Stairs
FORKLIFT 6K VARIABLE REACH		Office Trailer Triple Wide Stairs
FORKLIFT 7k VARIABLE REACH	TRANSPORTATION	Porta-John
FORKLIFT 8K VARIABLE REACH	FUEL TANK	Radio
MEGADECK 7x14 MAT Crane Pads	300 Gallon Holding Tank	Tool Room, 48ft covered trailer w/ internet and ToolWatch tech
MINI EXCAVATOR 10000-14000#	4 Reel Trailer	
PLATE COMPACTOR	40' Man Basket	
RT Fork Lift Mast Lift	ATV,2 seater gas or diesel unit	
Skidsteer auger attachment + Extension	ATV,4 seater gas or diesel unit	
Skidsteer Auger Power Unit	FLAT BED TRAILER	MISCELLANEOUS
Skidsteer, Attachment Forks 6ft long	RT Scissor Lift	burndy Pat 750 crimper
Skidsteer, TAK TL12	Trailer, Small Reel	Fiber Optic Sidelwinder
Skidsteer, TAK TL8W	Trailer, Triple Reel Cable Trailer	GMP Fiber Optic Sidelwinder
TRACTOR	TRUCK, WATER 2000-2999 GAL	
TRACTOR FORK ATTACHMENT	TRUCK, WATER 4000-5000 GAL	
	Vehicle, Ford F150	

WFP Drawing Revision Log associated to IWPs

EWP#
JOB #

DRAWING LOG

DRAWING NUMBER	REVISION												IWP							
	REV #	DATE RECEIVED	REV #	DATE RECEIVED	REV #	DATE RECEIVED	REV #	DATE RECEIVED	REV #	DATE RECEIVED	REV #	DATE RECEIVED								
DD93 - P - 8005 - 1	1C	17-Dec-11																		
PL93 - P - 8006 - 1	1D	17-Dec-11																		
PL93 - P - 8203 - 1	1C	17-Dec-11																		
PL93 - P - 8204 - 1	1C	17-Dec-11																		
PL93 - P - 8205 - 1	1B	17-Dec-11																		
PL93 - P - 8206 - 1	1B	17-Dec-11																		
WL93 - P - 8203 - 1	1B	17-Dec-11																		
WL93 - P - 8204 - 1	1A	17-Dec-11																		
KP93 - P - 8000 - 1	1D	17-Dec-11																		
KP93 - P - 8001 - 1	1E	17-Dec-11																		
-																				

WFP Issues Log

PROJECT PLANNING											PROJECT :		
MTO - ISSUES / CONCERN LOG											CLIENT :		
										DATE			
30	#	EWP/CWP	TASK	DRAWING	ISSUE / CONCERN				DATE	ACTION	BY WHOM	RESOLVED	DATE
	01												
	02												
	03												
	04												
	05												
	06												
	07												
	08												

IWP Release Plan

IWP Release Plan

Work Packages				Key Planned Dates				Constraints				Approval Flow (Sign Off's)				Responsibilities				
IWP	CWP	EWP	Discipline	Description	Const. Complete	Const. Start	Field Release	Access	Equipment	Materials	Permits	Other	QC	HSE	Supervision	D/C Print IWP	Foreman Assigned	WFP Assigned	Notes	

RFI Log

EWP#
JOB #

RFI Log

OWNER RFI No	GC RFI No	RFI No	INFORMATION REQUESTED	SUBMITTED		RECEIVED		REQUESTED INFORMATION	IWP No	SYSTEM	DOES THIS RFI CREATE EXTRA	EXTRA WORK No	REDLINE REQUIRE	CONSTRUCTION COMPLETE	QC COMPLETE	RFI SIGNED OFF
				DATE	NAME	DATE	NAME									

Commissioning Execution Plan

1.0 Introduction

Proper Project Start-up and Commissioning provides a documented, safe, timely, orderly, and systematic start-up and commissioning of a facility. The safe and timely commissioning is one of the main objectives of all projects.

The Commissioning phase covers the activities related to pre-operational tests, functional tests, facility tests and other related tests/checks prior to operation of the facility. The plant is divided into functionally operative systems, called Turnover Packages, or TOPs. The Commissioning phase typically starts with turnovers from the Construction Team to the Commissioning Team. Once the above transfer takes place, the Commissioning phase of the project starts. The Commissioning stage may be divided into the following main sub-stages:

- Pre-Commissioning (individual component testing and inspection)
- OEM Cold Commissioning (testing on individual systems)
- OEM Hot Commissioning (integrated system checkout with process)
- Functional and Facility Tests

1.1 Definition

The Start-up and Commissioning Stage of a project will commence when the Commissioning team energizes the facility's electrical distribution system from its "Normal" power source. It continues through to the point of acceptance for operation by the Owner. On the Sample 2 Solar Farm Project the plan is to have the Owner begin energizing the switchyard and the equipment within which includes CCVTs, 238KV Line Breaker and the Step-up Transformer. This work will be performed after the 24-hour soak period on the Step-up Transformer the appropriate 34.5 KV Breakers and Disconnects will be closed once a block is ready for commissioning which will energize the Inverter Skid Transformers up to the AC side of the Inverters. At that time the plan is to begin energizing the inverters from the solar arrays and then synchronizing to the Inverter Transformers for distribution from the facility. The control system is also prepared and placed into service to support control checkout of the facility.

1.1.1 Commissioning Organization

To fulfill the Commissioning objectives, the EPC Contractor's Commissioning Organization will provide a specialized team to ensure the compliance of all equipment and facilities with the contract requirements for the Solar Farm Project. The Commissioning Team structure will include:

- Commissioning Manager
- Discipline Commissioning Engineers (for Electrical, and Control System)
- Discipline Technicians
- OEM supplied Technical Advisors (according to equipment specialties).
- OEM testing personnel for commissioning of Owner supplied inverter skids.
- Owner supplied Operators (these operators will receive overall direction from the Commissioning

Engineers as well as the OEM and other Technical Advisors (TA) until Substantial Completion of each Unit)

The Commissioning Manager has responsibility over all commissioning activities to be performed in relation to the systems transferred from Construction. He will define the turnover packages, coordinate the turnover process with the Construction Teams, and perform Commissioning phase activities and turnover of all start-up and commissioning documents to the Owner. Discipline Commissioning Engineers will be assigned by the Commissioning Operations Manager and will report to the Commissioning Manager. Their basic responsibilities will be the following:

- To verify, certify and accept the completion of the construction phase
- To carry out the operational and functional tests on completed systems including equipment and instruments.
- To document the whole commissioning process to appropriately allow Substantial Completion of the Solar Farm Project.
- To ensure that appropriate maintenance is performed on the new equipment supplied during the commissioning phase.
- Assist Owner in coordinating with certification bodies and suppliers regarding the commissioning of equipment at the facility.

OEM Technical Advisory Services will be utilized to support commissioning of their respective supplied equipment. These services are carried out by qualified OEM supplied Technical Advisors. They provide support during installation, start-up, commissioning and testing of major supplied equipment.

The Commissioning Team will perform the following operational and administrative tasks:

- Implement and Manage the Commissioning Administrative and Technical Procedures
- Establish a Turnover Program to handle turnover of systems/subsystems from Construction to Commissioning and from Commissioning to Owner.
- Coordinate and perform Commissioning-related activities in the field. The following are examples of these activities:
 - Publish "Commissioning Plan of the Day" including "Critical Action Items"
 - Daily Site Commissioning Meetings
- Coordinate with Construction for support during Commissioning
- Maintain Commissioning and Start-up Test Records
- Prepare Turnover Packages and coordinate the turnover of systems/subsystems from Construction to Commissioning and Commissioning to Owner

The Commissioning Team will conduct all tests in accordance with contractual documentation and shall demonstrate that the Solar Farm Facility systems can be brought up to full load and shutdown under the OEM supplied acceptance criteria and/or demonstrate testing performance requirements as appropriate.

1.2 Commissioning

The commissioning stage starts as construction begins transitioning from an area work plan to a systems completion work plan. Commissioning continues through substantial completion. During this stage, Commissioning team will document the safe, orderly, and systematic commissioning of individual and integrated systems. Specifically, the commissioning team will do the following:

- Integrate safety into all commissioning/operation work practices
- Implement and manage the lockout/tag out program for all commissioning-related activities
- Manage the overall commissioning effort, ensuring compliance with the specifications and contracts
- Manage the process of construction turnover to commissioning, commissioning turnover to Owner Operations, and final acceptance of the facility by Owner.
- Develop a detailed commissioning schedule and detailed set of turnover packages to track commissioning completion and progress.
- Assist Owner-provided inverter skid supplier (OEM) in the advanced planning and preparation for their scope of commissioning activities and milestones. (Energizing inverter transformers, tie-in the solar arrays to their respective inverters, load-testing the inverters, connecting the Inverters to their transformers, synchronizing to the grid, etc.).
- Develop the necessary commissioning procedures to coordinate the commissioning effort.
- Coordinate and control all operational activities with the Owner Operations group throughout plant commissioning operations.
- Manage and maintain open communications with Construction, Technical Advisors, and Owner Personnel.

1.2.1 Commissioning Planning and Preparation

Project commissioning planning begins with the mobilization of the Commissioning Manager to the project. Early commissioning planning and preparation shall accomplish the following:

- Incorporate commissioning and operation concerns into the design, procurement, and construction effort at the design office when possible.
- Identify the systems/subsystems that will be delivered to the Solar Farm Project.

After the assignment of a Commissioning Manager to the project, the Commissioning Manager becomes responsible for the planning and preparation of all commissioning activities for the project. Other commissioning personnel assigned to support the project may assist the Commissioning Manager in the planning and preparation effort. The main activities are:

Develop a detailed start-up program consisting of the following items:

- a. Start-up Turnover Packages
- b. Commissioning Activity Planning & Scheduling
- c. Commissioning Resource Planning

It is necessary for the Commissioning Manager and commissioning personnel to become thoroughly familiar with the project design and contractual requirements to effectively carry out their responsibilities.

The Commissioning Manager is responsible for all project commissioning activities in the project schedule. The Commissioning Manager has the authority to allocate resources and make commissioning, and testing decisions, contractual requirements. The Commissioning Manager shall review the following documents to ensure any commissioning requirements contained in these documents are adequately addressed in the Commissioning Execution Plan for the project.

- Prime Agreement
- Subcontracts (construction/procurement/services)
- System Design and Operation Documentation.
- Project Specifications and Manuals Review
- Construction and/or Services Specifications
- Quality Program Requirements
- Procurement Documents
- Construction Execution Plan
- Project Schedule
- Project Organization Chart
- Review plans for coordinating construction and commissioning with the Project Manager and Construction Manager as appropriate. Items to review include the following:
 - Key construction-commissioning interfaces.
 - Construction versus commissioning crews task assignment.
 - Meeting schedules.
 - Resource sharing (supervision, craft labor, tools).
 - Handling of documentation.
 - Hand-over from construction to commissioning.
 - Commissioning activities which can start early (while construction is still in control of system).
 - Safety tagging procedures.

1.2.2 Start-up Turnover Packages

Start-up Turnover Packages divide the project into smaller, manageable units of work where components are logically grouped for the purposes of planning, scheduling, operation, and sequencing of testing and operational activities. All operating systems taken together constitute the entire operating facility. Systems/subsystems consist of equipment, components, and portions of systems. Systems/subsystems are defined on the project electrical one-line diagrams. In addition vendor drawings have been used to further define systems/subsystem boundaries. See below for a list of identified systems on the Solar Farm Projects. System Turnover Packages help to facilitate an early start and efficient development of the following:

- Construction completion
- Testing and commissioning activities
- Documentation organization
- Turnover to Owner

Systems:

- CAPF-01 – BLOCK 1 - 34.5KV CABLE BUSS AND MV PAD MOUNT TRANSFORMERS
- CAPF-02 – BLOCK 2 - 34.5KV CABLE BUSS AND MV PAD MOUNT TRANSFORMERS
- CAPF-03 – BLOCK 3 - 34.5KV CABLE BUSS AND MV PAD MOUNT TRANSFORMERS
- CAPF-04 – BLOCK 4 - 34.5KV CABLE BUSS AND MV PAD MOUNT TRANSFORMERS
- CAPH-01-1 – BLOCK 1 – INVERTERS, DC CABLING, COMBINER BOXES AND GROUNDING.
- CAPH-01-2 – BLOCK 1 – MODULES, HARNESESS AND RACK GROUNDING.
- CAPH-02-1 – BLOCK 2 – INVERTERS, DC CABLING, COMBINER BOXES AND GROUNDING.
- CAPH-02-2 – BLOCK 2 – MODULES, HARNESESS AND RACK GROUNDING.
- CAPH-03-1 – BLOCK 3 – INVERTERS, DC CABLING, COMBINER BOXES AND GROUNDING.
- CAPH-03-2 – BLOCK 3 – MODULES, HARNESESS AND RACK GROUNDING.
- CAPH-04-1 – BLOCK 4 – INVERTERS, DC CABLING, COMBINER BOXES AND GROUNDING.
- CAPH-04-2 – BLOCK 4 – MODULES, HARNESESS AND RACK GROUNDING.
- CAPB-01 – BLOCK 1 – INVERTER SKID AUX TRANSFORMERS AND 120/208V AC PANELBOARDS
- CAPB-02 – BLOCK 2 – INVERTER SKID AUX TRANSFORMERS AND 120/208V AC PANELBOARDS
- CAPB-03 – BLOCK 3 – INVERTER SKID AUX TRANSFORMERS AND 120/208V AC PANELBOARDS
- CAPB-04 – BLOCK 4 – INVERTER SKID AUX TRANSFORMERS AND 120/208V AC PANELBOARDS
- CCOA-01 – BLOCK 1 – SCADA COMMUNICATION / DATA EQUIPMENT, MET STATIONS, ETC.
- CCOA-02 – BLOCK 2 – SCADA COMMUNICATION / DATA EQUIPMENT, MET STATIONS, ETC.
- CCOA-03 – BLOCK 3 – SCADA COMMUNICATION / DATA EQUIPMENT, MET STATIONS, ETC.
- CCOA-04 – BLOCK 4 – SCADA COMMUNICATION / DATA EQUIPMENT, MET STATIONS, ETC.

1.2.2.1 Scoping

System/subsystem scope boundaries shall be established as early as practical in the project. This allows individual components to be tagged to specific systems as they are incorporated into the design database. In addition, it allows for incorporating the systems into the Project Schedule to provide initial link between construction activities and commissioning activities. The system/subsystem scope boundaries have been documented by marking the drawings (electrical one-lines, vendor drawings, etc.) with dark lines enclosing each specific package and noting the package number inside those boundaries. System/subsystem definitions shall use the following guidelines:

- System/subsystems are typically subsets of the normal functional systems defined by engineering. Subsystem boundaries shall suit specific project conditions (e.g., access).
- Systems/subsystems are defined for the entire Solar Farm scope of work/responsibility on the project.
- System/subsystem scope boundaries have been arranged to allow important commissioning tasks to be started as early as possible in the project. Package scope boundaries shall establish the optimum number and locations of isolation points to allow for such equipment to be operated separately. Factors to consider in establishing isolation points might include the following:

Locations of Cross Tie components.

- System/subsystem numbering should include the system letter designation of the base system with an added sequential number to differentiate between packages such as CAPF-01, CAPF-02, representing the split up of the 34.5 kV cable buses and equipment on this project.

- System/subsystem titles should incorporate the title of the base system but also distinguish between other packages making up the base system, such as CAPB-01 = Block 1- Inverter Skids 120/208 Vac Power Panels, etc.

1.2.2.2 Start-up Turnover Packages

The Commissioning Engineer will develop and maintain a Start-up Turnover Package Progress Tracking Sheet for the project that contains the list of all the planned Start-up Turnover Packages with information for each package, such as the following:

- Identification:
 - Package Number
 - Title
- Status:
 - Construction Completion Dates: (Target, Actual)
 - Commissioning turnover to Owner Dates: (Target, Actual)

Package Completion/Turnover Section. This section contains the following:

1. Construction Completion Certificates
2. Commissioning Completion Certificates
3. System Turnover Acceptance Certificates
4. Other miscellaneous documentation pertinent to recording progress towards package completion
 - Mechanical Section
 - Instrument and Control Selection
 - Electrical Section
 - Construction/Commissioning Electrical Completion Checklist
 - Electrical Checkout Verification Records
 - List of circuits
 - List of electrical equipment
 - List of electrical protective relays, meters, and transducers

Electrical Construction/Commissioning Checkout Forms (forms utilized to document completion of construction and start-up activities)

- Supplier/Miscellaneous Section.

For other miscellaneous information as required to complete the record of commissioning activities on the specific package (Vendor TA site visit reports, maintenance records, etc.)

- Package Drawings

Drawings identifying package scope boundaries (drawings may include One Line Diagrams, Schematics, Wiring Diagrams, etc.) Marked up (Red Lined) drawing reflecting the “As Built” condition of the system at the time of Turnover to Owner.

2.0 Commissioning Process

Commissioning activities will include, but are not limited to the following:

- Perform pre-operational programming and testing
- Perform Loop Checks through the Control System
- Coordinate with Owner’s vendor site visits
- Supervise the initial equipment operation
- Perform functional and logic testing
- Perform operational/demonstration testing
- System Operation
- Operational Testing
- Demonstration Testing

2.1 Commissioning & Start-up Sequence Process

The following subsections describe the project commissioning and start-up sequence of activities.

2.1.1 System Construction Completion (Construction Turnover to Commissioning)

Systems will be turned over to commissioning from construction based on the startup turnover package scope of the applicable system, and per the commissioning portion of the project schedule. Systems should be substantially complete and ready for pre-operational checkout. The remaining punch list will not contain any items that would prevent a safe and effective checkout. At this point, the equipment will have been:

- Torqued
- Cleaned
- Calibrated
- Wiring verified

2.1.2 Commissioning will provide the contractors the appropriate test forms to be included in the discipline/contractor portion of the turnover package if the contractors do not have their own test forms which contain the same information. Commissioning will assemble the comprehensive system turnover package for final submittal to the Owner.

2.1.3 At construction completion of a system, Commissioning will schedule a walk-down attended by a representative from Commissioning, Construction (both CM and Contractor personnel as appropriate), and also key vendor personnel as appropriate. Owner personnel will be invited to attend this walk down to provide them both an opportunity to verify progress on the project and to give input. A punch-list will be

created on the walk down and immediately entered in the project “Outstanding Work and Deficiency List” database (OWDL). Each punch list item will contain the following:

- System Code
- Item Number
- Date Identified
- Person who identified the punch list item.
- Priority (according to priority list below)
- Responsible Contractor.
- Date the punch list item was raised
- Person that verified the punch list was cleared
- Date the punch list was cleared

2.1.4 Priority codes will be assigned to punch list items as follows:

- Priority 1 System or equipment cannot be operated safely.
- Priority 2 Must be completed before operational acceptance.
- Priority 3 Cosmetic Issues
- Priority 4 Plant Enhancements / Items in Dispute.

2.1.5 After the construction/commissioning walk down, but prior to the commissioning walk down, the following personnel only will be authorized to clear punch list items from the OWDL:

- Commissioning Manager

This person is responsible to obtain concurrence that the punch list item in question is complete. Punch list items will be cleared by signing the item off on a copy of the OWDL; this information will be updated in the electronic copy of the OWDL and a hardcopy of the signoff's will be filed.

2.1.6 When all of the category 1 punch list items have been resolved, and all contractual obligations have been met by all discipline contractors for the construction completion of that system, Commissioning will accept the system and subsystem commissioning will begin. At this point, care, custody, and control of the system transfers to Commissioning.

2.2 Functional Checkout

2.2.1 Commissioning personnel shall check out each component/device or system to verify proper construction completion and confirm that each is in functional working order. Deficiencies are found and corrected. Preparation for operation is completed. This checkout may include limited operation of individual pieces of equipment.

2.2.2 Component Functional Checkout verification activities include the following:

- Comparison of as-installed condition with design drawings and specifications:

- Mechanical: mounting, orientation, location, access, installed condition, etc., panel alignment checks.
- Electrical and Control: wire/cable size, heater/overload settings, routings, terminations, electrical equipment and instrument; mounting, orientation, location, access, installed condition, etc.
- Electrical equipment and power/control circuit verification data review (meggering, hi-pot, wire ring out, termination verification).
- Development of completion punch lists expediting resolution of critical items.
- Review of vendor manuals for recommended preoperational checks and adjustments, and to establish proper start-up sequence. Development of plans/checklists to ensure proper sequence is followed.
- Documenting defective manufacturing. Correction of manufacturing defects with appropriate Supplier involvement and/or approval.
- Verification of equipment cleaning and lubrication according to equipment manufacturers' specifications, instructions, or manuals.
- Verification of auxiliary support systems or equipment checkout and setup, (Inverter equipment, combiner boxes, lighting, etc).
- Verification of miscellaneous adjustments, etc.

2.2.3 System Functional Checkout verification activities include the following:

- Comparison of as-installed condition with design drawings and specifications (panel supports, routing, mounting, orientation, location, access, installed condition, etc.).
- Development of completion punch lists; expediting resolution of critical items.
- Performing operability reviews. Reviewing the as-designed/as-installed systems; ensuring they will function properly for their intended purposes. Making process-related adjustments required to correct deficiencies. Obtaining approvals from the Engineer of Record as appropriate.

2.2.4 Making appropriate temporary provisions for start-up and commissioning (e.g., jumpers, etc).

2.3 System Logic Checkout

2.3.1 Start-up personnel systematically check out the instrumentation logic and alarms for all controlled components/devices. They evaluate the installed logic for overall functionality and operability. Necessary changes are made and documented to optimize the logic to ensure a more successful start-up as follows:

2.3.2 Simple Logic Checkout:

- Simulation of field devices and verification that associated logic has the correct response (often accomplished during the functional stage). Simulation from field devices (e.g.
- Graphic or screen displays are checked and corrected.
- Optimization of any logic which does not function as desired. Systematic documentation of all changes, for future reference.
- Logic reviewed and initial settings established.
- Verification of alarms.
- Verification of all alarms graphics, and clarity of text. At times, this is accomplished during functional stage circuit loop check.

2.3.3 Complex Logic Checkout:

- More involved checkout of complex logic requirements such as major electrical equipment energization or tripping requirements, etc. Multiple simulations should test all scenarios, which the logic is intended to control.
- Mandatory verification of critical interlocks and protective logic prior to placing equipment in service.

2.4 Cold Commissioning

2.4.1 System Initial Operation

During this activity, components and systems are initially operated as follows:

- Component Initial Operation. Items checked include, but are not limited to, temperature, parameters meeting supplier and design requirements and expectations, etc.
- System Initial Operation involves a more coordinated operation and checkout of system components to confirm proper combined operation.
- Items checked include, but are not limited to, temperature, parameters meeting supplier and design requirements, soundness of panel supports under all weather conditions, etc.
- Load Testing of inverters and panel sections

2.5 System-Coordinated Commissioning

During this activity, Commissioning personnel perform more complex commissioning tasks, involving multiple systems. These include major energization tasks and system coordinated operation. These are commissioning milestones and are indicated as such on the project schedule.

2.5.1 System-Coordinated Operation means operational checkout of more than one interconnected system to confirm and optimize proper combined operation prior to actual unit start-up.

2.5.2 Operating parameters and conditions are observed for potential problems.

2.6 Hot Commissioning

2.6.1 This activity is a culmination of all previous commissioning activities. It involves overall checkout of coordinated controls and system operations, including final operational verification and optimization, with all equipment and systems operating together as a unit.

- Solar Panel System Operation

Systematic observations are made to detect any possible problems or out of specification operating conditions such as output voltages, MVAR output, Power Factor control, Amp load, Voltage stability over all load points to full load.

2.6.2 Functional and Facility Test

Commissioning personnel will be performing specific performance, acceptance, and demonstration tests to confirm that the facility meets Contract-specific criteria.

- Component Demonstrations

Individual equipment performance tests.

- System Demonstrations
- System performance tests (Solar Panel output, Inverter Output, Switchyard voltage and Amp output.)
- Synchronizing to the Grid
- SCADA Operation and control
- Remote dispatch

2.6.3 Commissioning Turnover to Operations

When commissioning is complete on a system, Commissioning will schedule a walk-down attended by a representative of Commissioning, the Owner, and OEM TAs as appropriate. At this point, the system turnover package will be submitted to the Owner with no category 1 or 2 open punch list items. In addition, any vendor supplied spare parts and special tools will be turned over to the Owner. The outstanding punch list items for the system will be reviewed on the walk down, and new items, if any, will be added during the walk down and immediately entered in the project punch list database. These items will be completed prior to final acceptance by the Owner.

3.0 Schedule/Sequence

3.1 As the project progresses, the Commissioning Manager and Project Scheduler will update and maintain the commissioning portion of the project schedule on a weekly basis.

4.0 Commissioning Procedures

4.0.1 These procedures define how the plant start-up process will be managed, documented and coordinated. All Commissioning procedures are included in the "Procedure" section of this manual.

4.0.2 The Commissioning Execution Plan contains procedures for the setup and energization of individual systems, modules and solar blocks. The Commissioning Manager will review and modify these procedures as required for the project's needs.

4.1 Contractor Activities

4.1.1 The Commissioning Manager and other engineers assigned to commissioning shall review and monitor all testing activities performed by contractors. The commissioning engineers shall be responsible for verifying that the contractor's scope of construction and testing is complete on a system and

assembling all applicable documentation from the subcontractor in the appropriate turnover packages, prior to commissioning activities beginning on that system. On some occasions commissioning activities may begin prior to formal construction turnover, and in those cases, the Commissioning Engineer will verify the system is in a condition where they can perform these activities in a manner that is safe for all workers and the equipment.

4.1.2 The Commissioning Engineer(s) shall inspect and verify that integrity testing (megger, continuity, TTR, hi-potential VLF, etc.) is performed and documented correctly by the subcontractor. The Commissioning Manager shall review all detailed subcontractor procedures to ensure they meet applicable project specifications and coordinate the overall commissioning effort.

4.2 Start-up Coordination

4.2.1 The Commissioning Manager has the primary responsibility for coordinating all commissioning activities.

4.2.2 This is accomplished in a matrix fashion through the various groups and levels:

- Construction (to include subcontractors)
- Commissioning (to include subcontractors and vendors)
- Operations
- Project Management

4.2.3 The Commissioning Manager normally attends the daily construction coordination meeting in order to identify and coordinate activities at the operational level in construction. The Commissioning Manager and the Construction Manager will work closely to coordinate activities and to identify and implement alternate plans as necessary.

4.2.4 A daily commissioning coordination meeting is held with the commissioning staff, and key vendors in order to plan and coordinate the daily business of the commissioning group. As operational activities begin, a representative from the Owner's Operations group will also attend this meeting. A project level commissioning coordination/status meeting is also held at least once a week or more frequently as necessary.

4.3 Spares and Consumables

4.3.1 Any spare parts purchased by the Commissioning team will be turned over to the Owner for the Owner's use.

5.0 Staffing and Organization

5.1 Plant O&M Personnel

5.1.1 O&M personnel will be trained in the operation of all plant equipment and systems. A formal training plan and schedule will be provided separately, but there are additional benefits to having O&M

personnel observe and assist commissioning activities and operate equipment, as practical, during the start-up phase of the project. It is Commissioning's intent to incorporate O&M personnel, at an appropriate level and time, into the start-up activities- both pre-operational and operational.

5.2 Vendor Technical Advisors

5.2.1 Commissioning will schedule, coordinate, and manage all vendor TA activities. Craft support for TA activities will be coordinated with the appropriate discipline contractor as required. Their time will be effectively utilized for installation, commissioning, operations, as testing as appropriate.

5.3 Interfaces with Construction

5.3.1 Commissioning will interface and coordinate with construction staff and craft at all levels in order to ensure the safe and proper overall coordination of all commissioning related activities. The discipline installation contracts define the boundaries between construction and commissioning activities and the following attachments further detail and assign discipline and level specific responsibilities to the appropriate parties.

5.4 Interfaces with Power Delivery

5.4.1 Commissioning will interface and coordinate with Power Delivery commissioning staff to ensure the safe and proper overall coordination of all Power Delivery scope of supply.

APPENDICES

APPENDIX A - CONTRACTING STRUCTURES AWP BEST PRACTICE EXCERPT

The following is an approved excerpt from CII AWP implementation guide volume 2⁹.

Chapter 2: Contractual Guidance and Strategies

This chapter focuses on contractual requirements that organizations must consider when formulating contracting strategies and plans for projects utilizing AWP. It also introduces a set of assessment tools that aid execution and that are part of owner pre-qualifications or contractual audits/assessments. Such contractual considerations are recommended in this chapter and prescribed at specific points in project execution in Chapter 3.

2.1 Introduction

The contractual requirements will cover two phases: 1) the FEED phase, either self-performed by an owner or performed by a contractor under contract to an owner; and 2) the engineering, procurement, and construction (EPC) phase, performed by one contractor or multiple contractors (i.e., EPC, EP-C, or E-P-C), all under contract to an owner. Further, contractual requirements will specify and contrast the roles, responsibilities, and obligations of the owner, engineer, suppliers (major equipment), and construction contractor for effective implementation of AWP and workface planning, depending on the execution strategies and contracting structures selected. Finally, this implementation resource provides tools to assist in the development of recommended contract deliverables for the various phases of implementation of AWP.

The following guidance addresses three primary segments of focus for organizations dealing with vendors from a contractual perspective. The first area involves the approach and process for upfront identification and qualification of vendors to verify that they have the organizational and technical capabilities to implement AWP. The second segment involves establishing sufficiently detailed contract requirements that ensure that owner expectations for development and execution of AWP deliverables are clearly defined and communicated. The third segment focuses on the measurement and assessment strategies and communications protocols that are necessary to tracking the progress of the AWP-related project activities during the project life cycle.

The considerations this section presents for contracting for AWP use must be complemented with the basic contracting principles required of any project to produce positive project outcomes. Basic contracting principles include utilizing established, financially sound, reputable contracting firms with financial capacity commensurate with expected contract value and compensation type. Contractors invited to bid should also have the following characteristics:

- demonstrated experience executing projects of similar type and scope at the location under consideration
- a good safety record

⁹ Construction Industry Institute. "Advanced Work Packaging - Implementation Guidance." Implementation Resource 272-2, Version 3.0 Volume II. 2013. PDF. Chapter 2 Pages 13-23

- adequate work processes, systems, and tools for the size and scale of the project under consideration; people familiar with and knowledgeable in the use of the work processes, systems, and tools
- adequate capacity to staff the project with experienced, knowledgeable people in key leadership positions.

2.2 Compensation Selection

The compensation structure of contracts typically takes one of three forms: 1) lump sum or fixed price; 2) reimbursable cost; or 3) unit price/time rate. The selection of a lump sum or fixed price compensation structure should take the following into consideration financial capacity of contractors to fund the anticipated contract value and manage associated cost and schedule risks:

- stable market conditions that enable accurate estimates of delivery times and the costs of materials, equipment, and labor
- adequate scope and project definition to allow contractors to accurately estimate the cost and time to complete the work scope without including high contingencies in their bid prices.

The selection of a reimbursable cost compensation structure should take the following into consideration:

- willingness of owner to accept cost and schedule risk, in exchange for greater control and flexibility in making changes and adjustments to project scope
- lack of well defined scope at time of bid
- prioritization of schedule as a key project objective, or schedule compression; also, inadequate time to accommodate full bid cycle(s)
- unstable market conditions (e.g., heated market) that make equipment/material prices and delivery times and labor availability and costs unpredictable
- unwillingness of owner to expose proprietary technology to the contracting market by supplying complete design specifications to multiple contractors to solicit lump sum bids.

The selection of a unit price compensation structure should take the following into consideration:

- more defined scope of work is than in reimbursable cost model, but less defined than full lump sum model
- willingness of owner/prime contractor to accept quantity and indirect cost risks in exchange for construction contractor accepting productivity risk.

Given all the above considerations, this document is not intended to be a step-by-step “cookbook” outlining an ideal sequence, the output of which guarantees success; rather, it describes a number of ingredients that should be considered during the development and execution of these types of contracts with respect to AWP. As will be apparent from the following sections, there are multiple ways to divide project activities into separate organizations and contractors, all of which can lead to a successful outcome. The guidance provided in this resource simply describes attributes that should be considered during the upfront planning and contract language development so that the downstream execution provides the expected results.

2.3 Contract Structure and Compensation Basis Selection: Advanced Work Packaging Implementation Considerations

Owners will need to contractually mandate implementation of the AWP work process on projects, and do so in greater detail and specificity in the short term, until industry gains enough related experience to recognize its advantages over conventional execution approaches. Moreover, contractors’ experience with AWP methods and techniques will need to be extensively explored and tested during the contractor screening and prequalification process conducted prior to selecting bid slates.

Contractors that rank lower on the AWP maturity matrix will likely perceive higher indirect costs upfront and will include additional contingency money to accommodate the unknown learning curve associated with AWP activities. Given this likelihood owners may want to consider a reimbursable cost compensation structure when using contractors new to or unfamiliar with AWP. This strategy will afford the owner more flexibility and control over the contractor’s AWP activities, without necessitating an unmanageable number of change orders to the contract.

If the owner selects a lump sum compensation structure, and contractors with a lower maturity model score are included on the bid slate, higher contingency costs should be anticipated. In such situations, the owner will likely not realize the cost benefits associated with AWP, because the contractors will retain any savings as additional profit. However, if the owner selects a lump sum bid slate with contractors that have higher AWP maturity scores, bid prices will likely be more competitive than those contractors with less experience. These lower bids will be possible because high-maturity AWP contractors understand and can quantify the AWP benefits, and they will require less contingency for the AWP process.

Regardless of compensation basis, for a given project, higher numbers of interfaces *potentially* make the AWP process itself (or any work process) more expensive and less efficient to execute. For example, a single EPC contract that makes one contractor responsible for project delivery would be easier to administer in terms of contractual obligations, work processes, organizational structure, information management, and interface management than would contracting strategies with more than one company performing engineering, procurement, construction, or any combination of the three.

To minimize contractual interfaces, one EPC contractor would be engaged to execute the entire project work scope. However, project-specific characteristics often drive the decision to engage multiple contracting entities, which necessarily requires additional interfaces. Examples of projects requiring more than one EPC contractor include the following: projects with long durations (e.g., nuclear power projects); projects subject to governmental or regulatory body requirements; projects of unusual size and scale (e.g., mega-projects); projects that need the capabilities of different contractors; and other types of projects. Regardless of contracting structure and the number of interfaces and entities required, contracting documents must include all applicable AWP requirements.

There are four major types of contract structures that have been considered from an AWP perspective. These include the following:

- a contract between the owner and a single company to provide the owner with all services related to project engineering, procurement, and construction (EPC) (See Figure 7.)

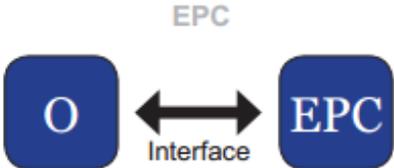


Figure 7. Interface for EPC Contract

- contract(s) that split the project work between two entities, such that one organization provides the engineering and procurement services, and a separate company provides the construction services (EP-C) (See Figure 8.)

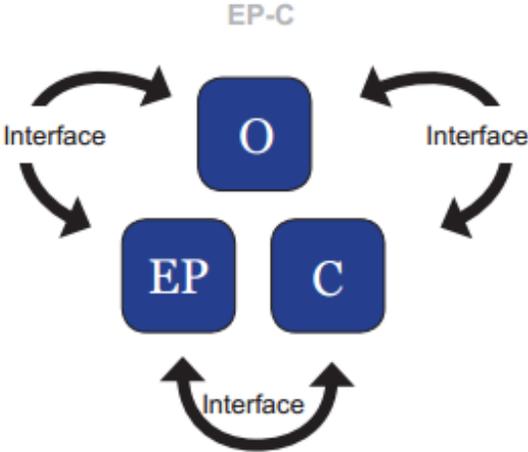


Figure 8. Interfaces for EP-C Contracts

- contract(s) that split the project work between two entities, such that one organization provides the engineering services to the owner for a project, and another separate company provides the procurement and construction services (E-PC) (See Figure 9.)

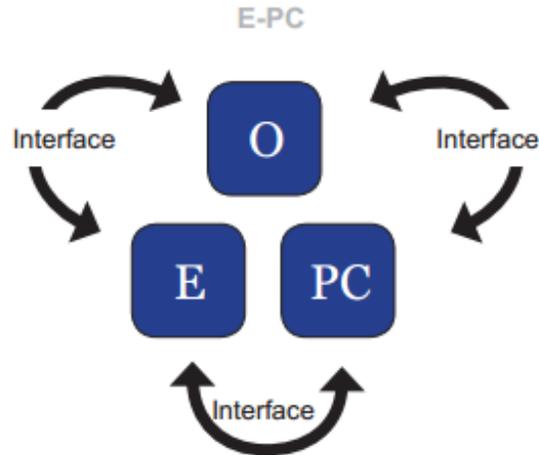


Figure 9. Interfaces for E-PC Contracts

- contract(s) that split the project work individually, such that separate organizations contract directly with the owner individually for engineering, procurement, and construction services (E-P-C). (See Figure 10.)

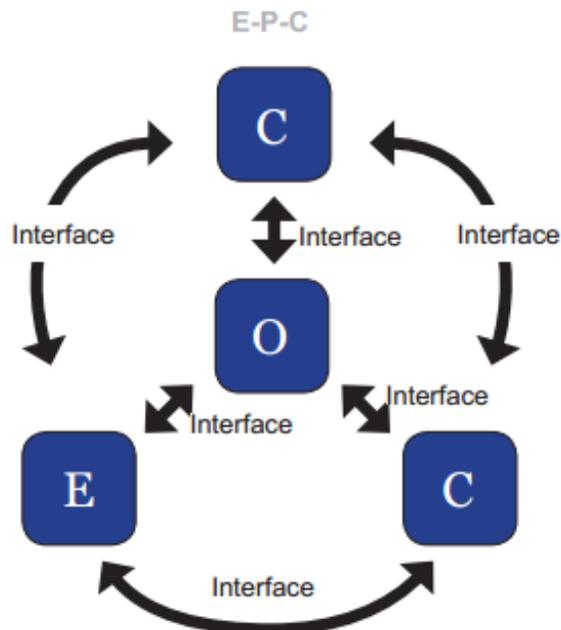


Figure 10. Interfaces for E-P-C Contracts

EPC Contract Structures

When preparing an EPC contract, the assumptions and considerations presented below should be taken into account.

Assumptions

- The owner plans to contract with an EPC contractor, and is responsible for managing interfaces between EPC vertical splits of work. The EPC contractor is responsible for the entire work scope for a particular vertical split of work or project, i.e., the engineering, procurement, and construction of one entire unit in a multiunit expansion. The EPC contractor uses its own work processes and determines which software platforms will best manage interfaces (or information transfer) between internal departments and/or work groups.
- Engineering, procurement, and construction management will be self-performed by the EPC contractor.
- Construction will be performed either on a direct-hire basis (using EPC contractor's employee craft labor and specialty subcontractors, e.g., heavy haul/heavy lift), or on a subcontract basis (using subcontractors under contract to the EPC contractor) where the EPC contractor is responsible for construction.
- Field material management will be performed either by the EPC contractor or a subcontractor working under the direction of the EPC contractor. (Subcontractor management includes additional interfaces and associated risks).
- Start-up/commissioning activities may be performed by either the EPC contractor or the owner (with the support of the construction contractor).

Considerations

- Interface management and knowledge transfer between disciplines for AWP is easier for the contractor because the contractor is using its own work processes, procedures, systems, and consistent software platforms.
- Owner AWP audits may be more difficult with EPC contractors because information transfer occurs internally (by being available in the document control system or LAN share drive) and does not occur externally through formally transmitted documentation/hard copy.
- Construction expertise for execution planning, determination of the path of construction, Construction Work Areas (CWAs), Installation Work Packages (IWPs), Engineering Work Areas (EWAs), and supply chain management are in-house and available, and does not need to be contracted externally.
- The EPC project sponsor generally has sufficient standing and authority within the EPC organization to fix problems, without having to work with other companies or entities.

A variation of the EPC contract structure is the EPCM structure, where the EPCM contractor is responsible for providing construction management services, but the construction contracts are let directly by the owner, and liability for construction performance and payment remains with the owner. With this structure, the owner controls the level of autonomy given to the EPCM contractor with respect to the construction contractors. If the EPCM contractor has a lower maturity score and is less familiar with AWP, the owner may want to exercise additional oversight over the construction contractors' AWP activities. This oversight might take the form of AWP contractual requirements and direct supervision/guidance, and should be alert to the EPCM contractor's responsibility for construction management and overall project execution and delivery.

EP-C Contract Structure

When preparing an EP-C contract, the assumptions and considerations presented below should be taken into account:

Assumptions

- The owner plans to contract separately for EP services and C services. The owner is responsible for managing interfaces between EP and C horizontal splits of work, and will need to work with the EP contractor to determine and/or specify which work processes and software platforms shall be deployed to best manage interfaces (or information transfer) between the EP and C contractors.
- Engineering and procurement of engineered equipment and bulk materials is self-performed by the EP contractor.
- Construction is performed either on a direct-hire basis (using the C contractor's employee craft labor and specialty subcontractors, e.g., heavy haul/heavy lift) or on a subcontract basis (using subcontractors under contract to the C contractor) where the C contractor is responsible for construction. The construction contract will be bid out and awarded well after the EP contract has been awarded, since engineering deliverables will form the basis of the construction bid documents. The C contractor's compensation basis can be lump sum, unit price, or time and material.
- Field material management is performed either by the EP contractor, C contractor, or a subcontractor working under the direction of the EP or C contractor (subcontractor management includes additional interfaces and associated risks).
- Start-up/commissioning activities may be performed by either the EP or C contractor or the owner (with support of the construction contractor).

Considerations

- Interface management and knowledge transfer between disciplines for AWP is easier for the EP contractor because the contractor is using its own work processes, procedures, systems, and consistent software platforms. However, a C contractor will need to be engaged early to provide construction expertise for execution planning, determination of the path of construction, CWAs, IWPs, and EWAs, and supply chain management.
- Owner AWP audits upstream of IWPs may be more difficult with EP contractors because information transfer occurs internally (by being available in the document control system or LAN share drive) versus occurring via formally transmitted documentation/hard copy externally.
- The C contract may need to be bid out before the scope is completely defined to allow the C contractor to participate in AWP planning and activities. (Methods to accomplish this include use of unit prices based on early quantity forecasts with applicable means of adjusting for final quantities or to have a means of adjusting a reimbursable contract at early stage to a lump sum when scope fully defined and parties have opportunity to finalize an acceptable contract.)
- The owner will need to take steps to facilitate C contractor buy-in to the AWP process and plan if pre-construction contract award AWP was completed by a different construction organization.

E-PC Contract Structure

When preparing an E-PC contract, the assumptions and considerations presented below should be taken into account.

Assumptions

- The owner plans to contract with one E contractor and one PC contractor. The owner is responsible for managing interfaces between E and PC horizontal splits of work. The owner will also need to work with the E contractor to determine and/or specify the best work processes and software platforms to deploy to manage interfaces (or information transfer) between the E and PC contractors.
- Procurement of engineered equipment and bulk materials is self-performed by the PC contractor.
- Construction is performed either on a direct-hire basis (using the PC contractor's employee craft labor and specialty subcontractors, e.g., heavy haul/heavy lift) or on a subcontract basis (using subcontractors under contract to the PC contractor), where the PC contractor is responsible for construction. The procurement and construction contract will be bid out and awarded well after the engineering contract has been awarded, since engineering deliverables will form the basis of the procurement and construction bid documents. The procurement and construction compensation basis can be lump sum, unit price, or time and material.

- Field material management is performed by the PC contractor, or by a subcontractor working under the direction of the PC contractor.
- Start-up/commissioning activities may be performed by PC contractor or by the owner (likely utilizing PC contractor resources.)

Considerations

- Interface management and knowledge transfer between disciplines for AWP is easier for the E contractor because that organization is using its own work processes, procedures, systems, and compatible software platforms. However, a PC contractor will need to be engaged early to provide construction expertise for execution planning, determination of the path of construction, supply chain management, and CWAs, IWPs, and EWAs. Also, it will likely be more difficult for the C contractor to receive electronic data (i.e., model data for construction planning tools) from the E contractor.
- The owner will have responsibility for monitoring the interface between the E and PC contractors. Critical information transfer across this interface includes equipment and material requisitions from the E contractor to the PC contractors for inclusion in requests for quotations and purchase orders, and all subsequent vendor data transfer from the PC contractor to the E contractor to support detailed engineering design. Timely E contractor responses to requests for information (RFIs) will also require monitoring by the owner.
- The owner's AWP audits that occur upstream of IWPs may be more difficult to perform with PC contractors, because information transfer happens internally (by being available in the document control system or LAN share drive) rather than externally through formally transmitted documentation/hard copy.
- The PC contract may need to be bid out before the scope is completely defined to allow the PC contractor to participate in AWP planning and activities.
- The owner will need to take steps to facilitate PC contractor buy-in to the AWP process and plan if pre-construction contract award AWP was completed by a different procurement and construction organization.

E-P-C Contract Structure

When preparing an E-P-C contract, the assumptions and considerations presented below should be taken into account.

Assumptions

- The owner plans to enter into one contract with an E contractor, one contract with a P contractor, and one contract with a C contractor. The owner is responsible for managing interfaces between E, P, and C horizontal splits of work. The owner will need to work with the E contractor to determine and/or specify the best work processes and software platforms to deploy to manage interfaces (or information transfer) between internal departments and/or work groups, and between the E, P, and C contractors.

- Procurement of engineered equipment and bulk materials is self-performed by the P contractor. And, even though procurement is handled by the EP or P contractor, minor items and consumables may be provided by the C contractor.
- Construction is performed either on a direct-hire basis (using the C contractor's employee craft labor and specialty subcontractors, e.g., heavy haul/heavy lift) or on a subcontract basis (using subcontractors under contract to the C contractor) where the C contractor is responsible for construction. The procurement and construction contracts will be bid out and awarded well after the engineering contract has been awarded, since engineering deliverables will form the basis of the procurement and construction contract bid documents. The engineering, procurement, and construction compensation basis can be lump sum, unit price, or time and material.
- Field material management is performed by either the P or the C contractor, or by a subcontractor working under the direction of the P or the C contractor.
- Startup/commissioning activities may be performed by the C contractor or by the owner (likely utilizing C contractor resources).

Considerations

- Interface management and knowledge transfer between disciplines for AWP is easier for the E contractor because the contractor is using its own work processes, procedures, systems, and consistent software platforms. However, the P and C contractors will need to be engaged early to provide procurement and construction expertise for execution planning, determination of the path of construction, supply chain management, and the CWAs, IWPs, and EWAs. Also, it will likely be more difficult for the C contractor to receive electronic data (i.e., model data for construction planning tools) from the E contractor and electronic data (i.e., PO details with dates, timely expediting reports, and pipe and steel status reports).
- The owner will have responsibility for monitoring the interface between the E, P, and C contractors, and, thus, must define all interface points, deliverables (with deadlines), and interdependencies between the contractors, according to their respective contracts. The owner should also require contractor to appoint an interface liaison with responsibility for attending regularly scheduled interface coordination meetings. Critical information transfer across this interface includes equipment and material requisitions from the E contractor to the P contractor for inclusion in requests for quotations and purchase orders, and all subsequent vendor data transfer from the P contractor to the E contractor to support detailed engineering design. Timely E contractor responses to requests for information (RFIs) from the P and C contractors will also require close monitoring by the owner.
- The owner AWP audits that occur upstream of IWPs will be easier with this contract work breakdown structure because information transfer occurs externally through formally transmitted documentation/hard copy. Engineering staffing costs may be higher than non-AWP projects because the E contractor must provide staffing for a longer duration than is typically needed to support the creation of the IWPs by the C contractor.

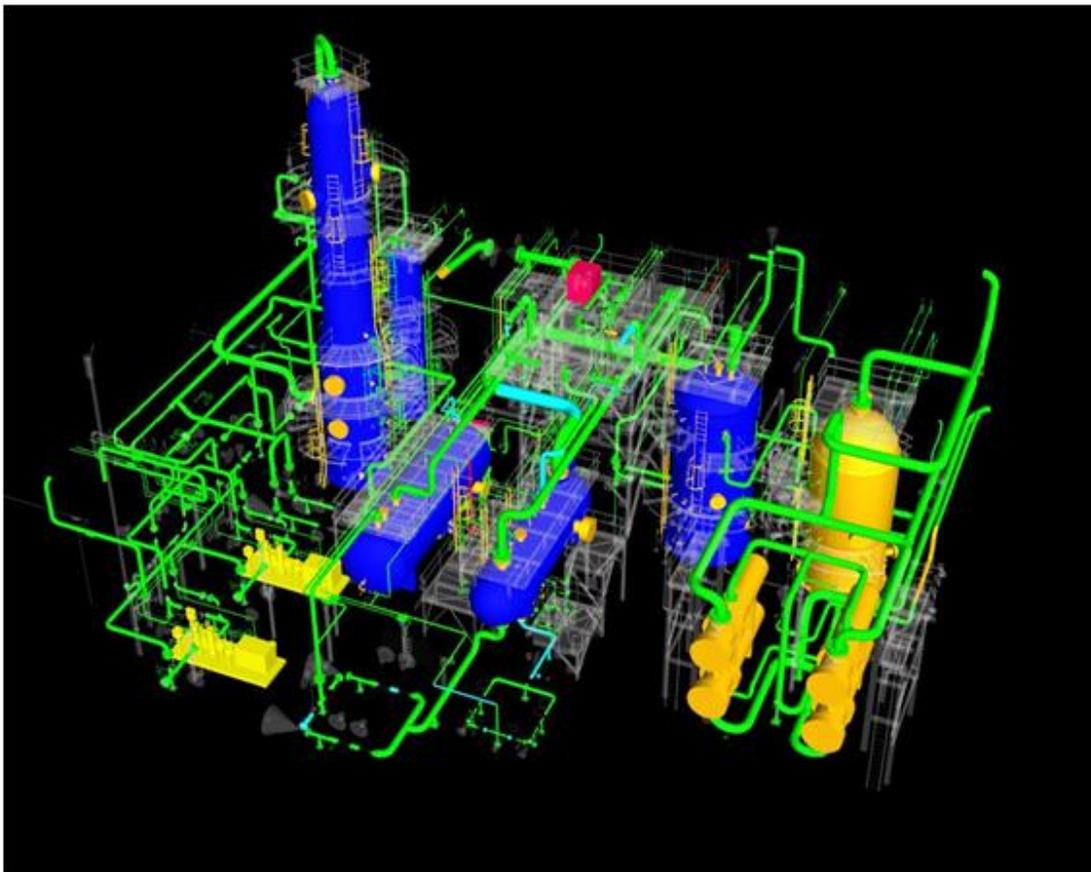
- The P and C contracts may need to be bid out before the scope is completely defined, to allow the P and C contractors to participate in AWP planning and activities.
- The owner will need to take steps to facilitate P and C contractor buy-in to the AWP process and plan, if AWP was planned by different contractors than those that are awarded work.

APPENDIX B – WORKPACKAGE TEMPLATE FOR CWP

Full editable work package template can be found on the COAA website Library, search for 'CWP Template.'

CONSTRUCTION WORK PACKAGE												
Project Name:												
Project CWP WBS No:												
CWP		Plant			Area			Discipline			Sequence No	
C	W	P	-				-				-	
Description:												

Rev. No	Rev Description	Date	Author	Checked By:			Approved By:	
				Contracts admin.	Project Controls	WFP Manager	Contractor	Construction/Planning Manager
A	Issued For Review	MM/DD/YYYY						
B	IFC	MM/DD/YYYY						
C	Contractor Finalization	MM/DD/YYYY						



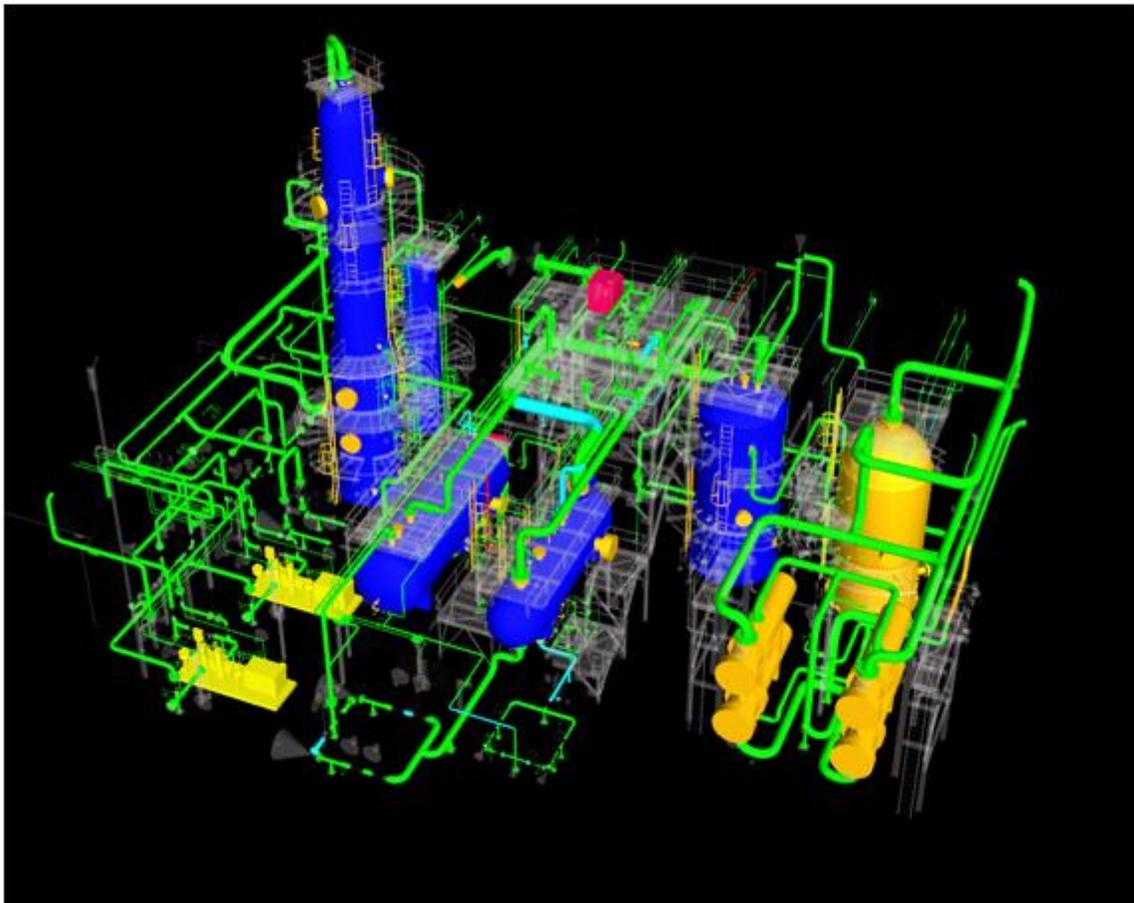
APPENDIX C – WORKPACKAGE TEMPLATE FOR EWP

Full editable workpackage template can be found on the COAA website Library, search for ‘EWP Template.’

ENGINEERING WORK PACKAGE														
Project Name:														
Project WBS No:														
EWP		Plant			Area			Discipline			Sequence No			
E	W	P	-				-				-			
Description:														



Rev. No	Rev Description	Date	Author	Checked By:			Approved By:	
				Contracts Admin.	Project Controls	WFP Manager	Contractor	Construction/ Planning Manager
A	Issued For Review	MM/DD/YYYY						
B	IFC	MM/DD/YYYY						
C	Contractor Finalization	MM/DD/YYYY						



ENGINEERING WORK PACKAGE												
Project Name:												
Project WBS No:												
EWP		Plant			Area			Discipline			Sequence No	
E	W	P	-				-				-	
Description:												

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3.0	Engineering Information	
4.0	Quality	
5.0	Vendor Support	
6.0	WorkFace Planning	
7.0	3D Model Shots of EWP	
8.0	Contact List	

APPENDIX D – WORKPACKAGE TEMPLATE FOR IWP

Full editable workpackage template can be found on the COAA website Library, search for ‘Expanded IWP.’

Project name	WP#	Unit	Cost Area	Const. Area	System Code	Disc.	Seq.	
		XX	XX	XXX	XX	XX	XX	
Project Logo	Area: xxxxxx xxxx			Discipline: xxxxxx			Preparer: xxxxx xxxxxx	
	WP Description: xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx							
3D Coversheet								
<div style="border: 1px solid black; width: 20%; margin: auto; padding: 10px; display: inline-block;"> Paste Picture Here </div>								

Project name	WP#	Unit	Cost Area	Const. Area	System Code	Disc.	Seq.	
		XX	XX	XXX	XX	XX	XX	
Project Logo	Area: xxxxxx xxxxx			Discipline: xxxxxx			Preparer: xxxxxx xxxxxx	
	WP Description: xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx							
Coversheet								
APPLICABLE SPECIFICATIONS			APPLICABLE FCQP PROCEDURES			COST CODE		
Number	Description	Attached				Activity Description	ID Number	
OTHER REFERENCE DOCUMENTS/WORK PACKAGES			APPLICABLE FCQP FORMS			MATERIALS		
Number	Description	Attached	Forms	Attached		PO Number	Material Type	
EXCEPTIONS			APPROVALS/CONCURRENCE SIGNATURES					
			WP Lead Planner:			Date:		
			Superintendent:			Date:		
			General Foreman:			Date:		
			Safety:			Date:		
			Issued By:			Date:		
			Completed By:			Date:		
			Status:			Rev Date:		
DISTRIBUTION								
Person	Number of Copies							

