ScottMadden
Management Consultants

✓ Generator Operational Readiness

Preparing for Plant Start Up and Operations

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Introduction

This ScottMadden white paper provides our perspective on the process and benefits of a thorough plant start up and staff readiness assessment, called an Operational Readiness Assessment (ORA). Such an assessment can be very important despite the pressures to reduce costs and compress project schedule in getting a plant on line. It can save millions of dollars through avoided replacement power costs and more effective warranty claims. We call the ORA the investment to protect the investment.

Although the number of generating stations being built and brought on line in the United States has declined significantly, there are coal, gas, and renewable units in the construction pipeline for which this methodology can be of great value. Although there is a lull in the electricity load growth due to the current recession, it is estimated that this decline postpones projected reserve margin shortfalls by only 12-18 months. A slight uptick in demand could create a significant amount of either new plant construction or existing plant retrofits.

Emphasis on project cost containment and on minimizing project schedule slippage strains all the elements of the overall construction life cycle. It places particular pressure on the most important elements of plant construction: commissioning, commercial operations, and readiness of the staff to safely operate and maintain the new asset.

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Background

Prior to the recession, the cost of plant construction was increasing steadily due to rising commodity prices (concrete, steel, copper, etc.) as demand exceeded supply worldwide. Construction schedules were being pressured by the declining number of skilled workers and the limited supply of experienced construction management personnel. Construction schedule slippages occurred across many types of projects. Even a slight uptick in the number of plants being constructed could put substantial pressure on the construction workforce and push labor demand out of balance with supply.

This white paper will explore how asset owners, whether in regulated utilities, merchant generation companies, or governmental agencies can prepare themselves to perform a thorough plant start up and staff readiness assessment, despite pressures to reduce costs and trim schedule.

The Construction Life Cycle

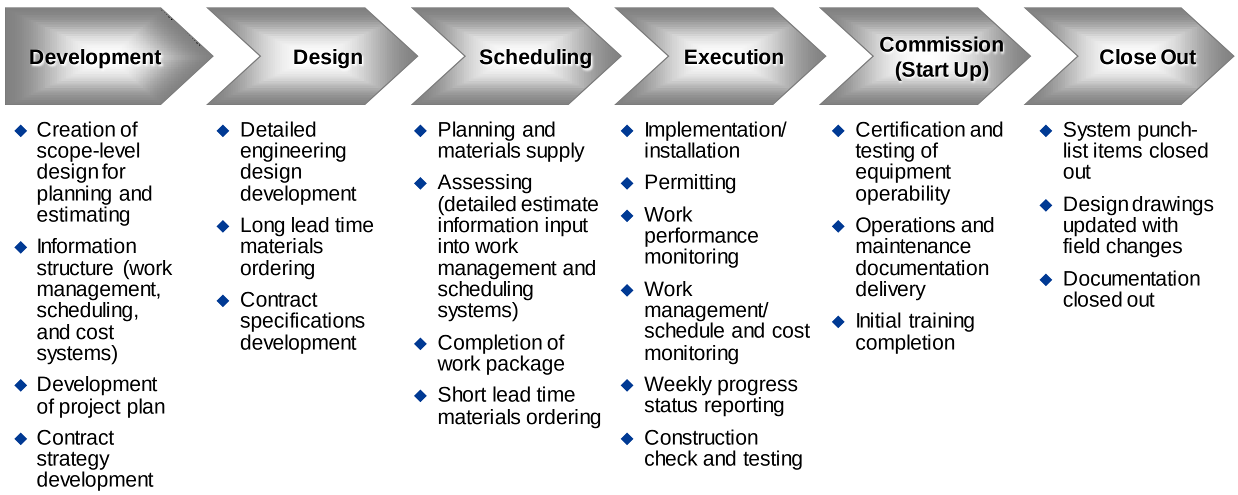
Construction of any major project is organized in a methodical, six-step process that is known as the construction life cycle. In the first step, a project scope and plan is developed. Concurrently, a strategy for managing the project will be managed and high-level, budgetary cost estimates are established. The second step is engineering design. This includes detailed design, more granular cost estimates, ordering long lead time materials, developing contracts that will govern the actual project execution, and then contracting with one or more entities to manage the construction. The third step is detailed estimating and scheduling of the project work scope into discrete work packages. This is followed by the fourth step, actual construction work.

The next step is commissioning (or start up), first of individual systems and components and then of the overall unit. Finally, after components and systems are checked out successfully, the project must close out any punch list items, whether design or operating deficiencies, complete development of any training or documentation activities, and turn over all documentation, from procedures to technical manuals, to drawings and diagrams, to the project operating personnel.

Power plant construction follows this same project life cycle process, whether the unit is coal fired, combined cycle gas, biomass, or a nuclear plant. Although the duration of specific process steps will vary depending on the asset, the general process remains the same.

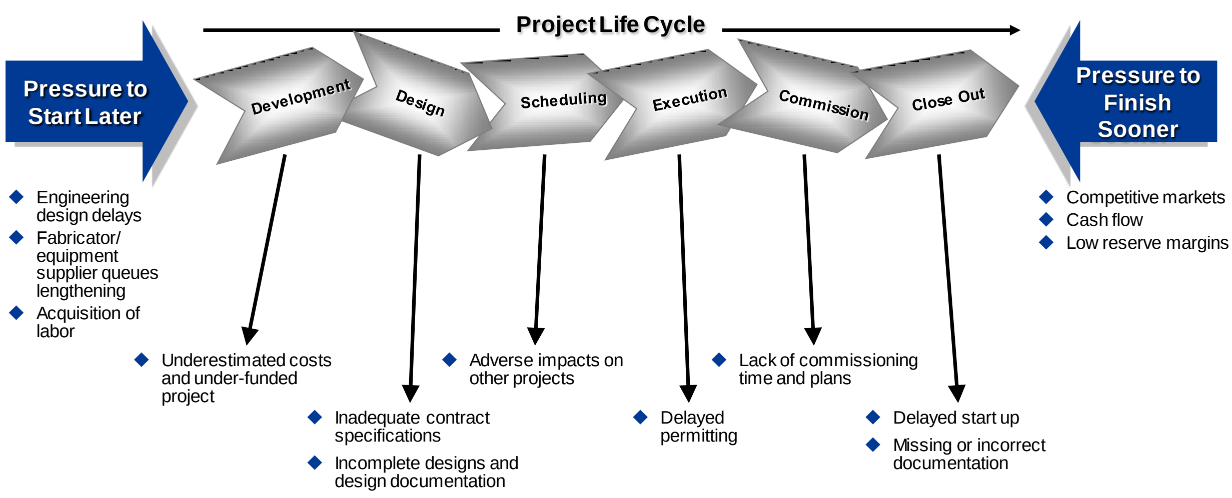
The construction life cycle is illustrated in Figure 1 below.

Figure 1: Construction Life Cycle



When project schedules become constrained due to delays in project design or cost/schedule over-runs during actual construction, the pressure to start later and end sooner impacts every stage of the project life cycle. This is illustrated in Figure 2 below.

Figure 2



The two elements of the project life cycle that invariably become the most stressed are project start up and project close out. All too often, projects are placed in operation before all systems and components are fully functional, punch list deficiencies are cleared, and project documentation is completed and provided to the asset operator.

Companies that own or build assets usually spend a great deal of effort in proper design, planning, engineering design, scheduling, and construction execution. But when everything is not executed according to plan (even with contingencies), the plant start-up and close-out activities usually take up the slack.

A parallel set of activities is necessary to assure project success. This set of activities is called the Operational Readiness Assessment (ORA). It is the process utilized to provide assurance to the owner/operator's management that plant personnel are prepared to start up and operate the facility. It is one thing to build the plant. It is another to be ready to operate it successfully. Operational readiness assurance via the ORA is essential to commercial success and is the focal point for the remainder of this white paper.

Plant Operational Readiness

Operational readiness refers to the set of activities that the plant owner/operator implements to ensure that plant personnel are prepared to start up a new facility nearing the end of construction and continue to operate the facility after the unit is completely turned over and all construction and start-up activities are completed.

Throughout this white paper, we have referred to several entities that are involved in the construction life cycle. Now we are introducing entities that are involved in plant operational readiness. The following definitions are provided for clarity:

> **Owner:** The owner of the plant or asset that has the majority equity ownership
> **Operator:** The entity that operates the plant or asset during start up and after unit turnover
> **Owner/Operator:** The owner and operator of the plant or asset
> **Constructor:** The entity hired by the owner to perform the activities included in the project life cycle

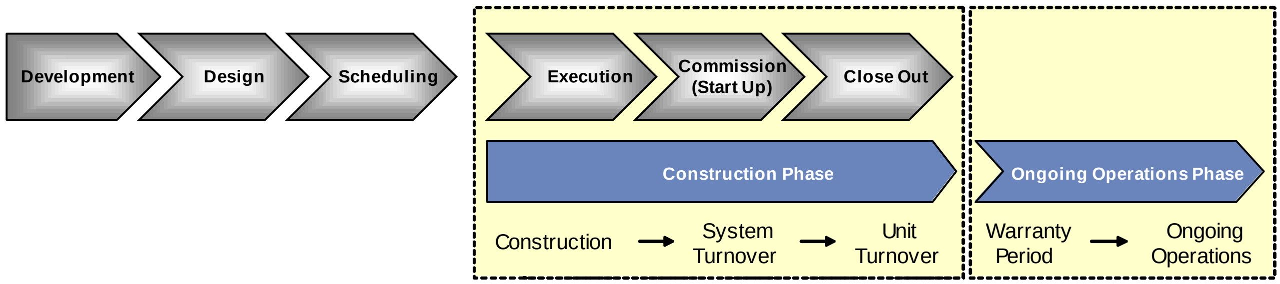
In practice, there are many variations in roles and responsibilities. The constructor could be many different contractors that have responsibilities for specific activities within the project life cycle, but ultimately there is one entity that manages and integrates all of the activities.

Alternatively, there may be one Engineering, Procurement, and Construction (EPC) contractor that manages all aspects of the project life cycle. The owner/operator may also be the constructor in some instances.

For simplicity, we will assume that there is an owner/operator who hires an EPC contractor as the constructor. Where major operational readiness activities would be significantly different from the assumed model, it will be denoted.

Figure 3 illustrates the overlap of project life cycle activities and plant operational readiness activities.

Figure 3



Typically, plant operational readiness activities begin in the execution step of the construction life cycle process. Plant operators prepare for plant start up activities such as system and component operational checkout and testing. The owner/operator must ensure that systems and components are tested and checked out in accordance with procedures that they have a part in preparing and approving. As the plant start up proceeds and plant operational guarantees are met, the owner/operator must sign off and accept ownership of the plant. Plant turnovers usually have associated punch lists of deficiencies that must be cleared by the constructor per the terms and conditions of the EPC contract.

The ORA ensures that the owner/operator staff is prepared to handle the rigor associated with the constructor interface and plant acceptance activities. The ORA typically includes the following items for the unit start up and turnover:

Table 1

SYSTEM TURNOVER PERIOD	UNIT TURNOVER PERIOD
• What are the criteria for system acceptance and how are punch-list items handled?	• What are the criteria for unit acceptance?
• What environmental considerations/permits must be taken into account, and how is permit compliance being ensured?	• What environmental considerations (permits) must be taken into account for start up?
• How does plant personnel track changes to the design between system turnover and unit turnover?	• Were all of the system acceptance issues resolved from system turnover?
• How are system start-up procedures created, and are the procedures specific to this plant or generic?	• When are the final as-built drawings going to be received by the operator?
• What does the EPC contract specify for delivery at system turnover?	• How are design changes handled from unit turnover through the warranty period?
• Is plant personnel being trained to operate the facility (simulator ready)?	• What does the EPC contract specify for delivery at unit turnover?

The ORA is typically conducted by an independent entity to ensure impartiality and objectivity in the assessment. An EPC contract will usually have specifications for unit start up, unit turnover, and acceptance. However, more often than not, the contract language is at a higher level than what is required by the owner/operator to ensure the plant is turned over in the best possible operational condition. Even though there are warranty provisions, once the plant is accepted, it is considerably more difficult for the owner/operator to remedy deficiencies. The ORA provides owner/operator confidence that plant personnel are ready to manage the intricate contractor interface points and ensures that the terms of the contract are met.

Addressing the questions listed in Table 1 verifies that the contractor procedures for unit checkout are designed specifically for the plant specifications and ***not*** generic procedures that the contractor has used on other projects. Another purpose of the ORA is to ensure that there are clear procedures that will capture any changes to system or component operations developed during unit start up (which could take several months for a large power plant). Finally, the ORA is an assessment of the internal processes, procedures, and documentation (aside from EPC contract issues) that will be needed from an operational perspective once the plant is turned over. Internal processes and procedures include training for supervisors, operators, and support staff; environmental compliance procedures; and documentation management processes and protocols.

The ORA is also designed to clearly outline the criteria for unit acceptance and thereby minimize the number of punch list items when the unit is turned over to the owner/operator for plant operations. In the event that there are corporate pressures to push the plant to commercial operations before all start-up deficiencies are cleared, it is essential to prepare plant staff to handle all start-up and interface activities and operate the plant safely and efficiently. In addition to specification of unit acceptance criteria, there must be a clear process for management of deficiencies and also for handling any as-built changes to drawings, whether system flow charts, P&IDs, or electrical drawings.

Plant Warranties

Once the contractor turns the plant over to the owner/operator and the plant is accepted for operations, there is a warranty period. During the warranty period, system and component deficiencies that develop after the plant is turned over are managed in accordance with contract terms. Warranties may also cover deficiencies noted during plant start up that could not be remedied prior to plant turnover. The warranty period is typically 24 months, but could differ with asset type and the terms of the EPC contract.

Clearly outlining the process for management of warranties could save the owner/operator millions of dollars through properly executed warranty claims. The purpose of the ORA is to ensure the owner/operator has such a warranty management plan in place and typically addresses the items delineated in Table 2.

Table 2

WARRANTY PROCESS
• How are warranty claims handled?
• How will design changes be tracked for warranty items?
• What sort of craft resources will the EPC contractor have onsite to perform warranty work?
• What type of off-normal operations will have an impact on warranty coverage?
• How are significant changes made in the warranty period incorporated into plant operations?

A warranty management process could involve a number of personnel and for a large plant project could require a virtual team for an extended period of time, depending on the number of warranty issues to be processed. Plant deficiencies that require plant personnel to take immediate action may have backcharge elements (recouping plant out-of-pocket costs to repair a warranty item) in addition to longer lead time warranty claims.

Ongoing Plant Operations Readiness

In addition to warranty claims, the owner/operator must assume all day-to-day plant operation and maintenance activities for the plant once it is turned over and accepted. The details for how a new plant will be operated must be developed long before actual plant operations. Moreover, the tone for management is usually set during the first three months, making it very important to launch plant operations properly.

The ORA is designed to uncover any weaknesses in operations preparedness long before the plant is operational so that deficiencies can be remedied. The types of activities reviewed during the ORA are illustrated in Table 3.

Table 3

ONGOING OPERATIONS PROCESS REVIEW
• How will the configuration control program work?
• How are major incidents going to be investigated and logged?
• What does the day-to-day operation of the plant look like?
• How robust is the continuous improvement program?
• What is the maintenance program philosophy (condition-based maintenance – CBM)? How will that work in the real world?
• Is there a robust work management program?
• Is there a central issues management system (i.e., action tracking system)?
• What governs overall plant operation?
• What are the duties of represented personnel (conduct of operations)?

ORA Mechanics

The previous discussion in this document has focused on what an ORA is and what it is designed to cover. The remainder of the document is dedicated to how the assessment is conducted, findings are typically stated, and recommendations are developed and implemented.

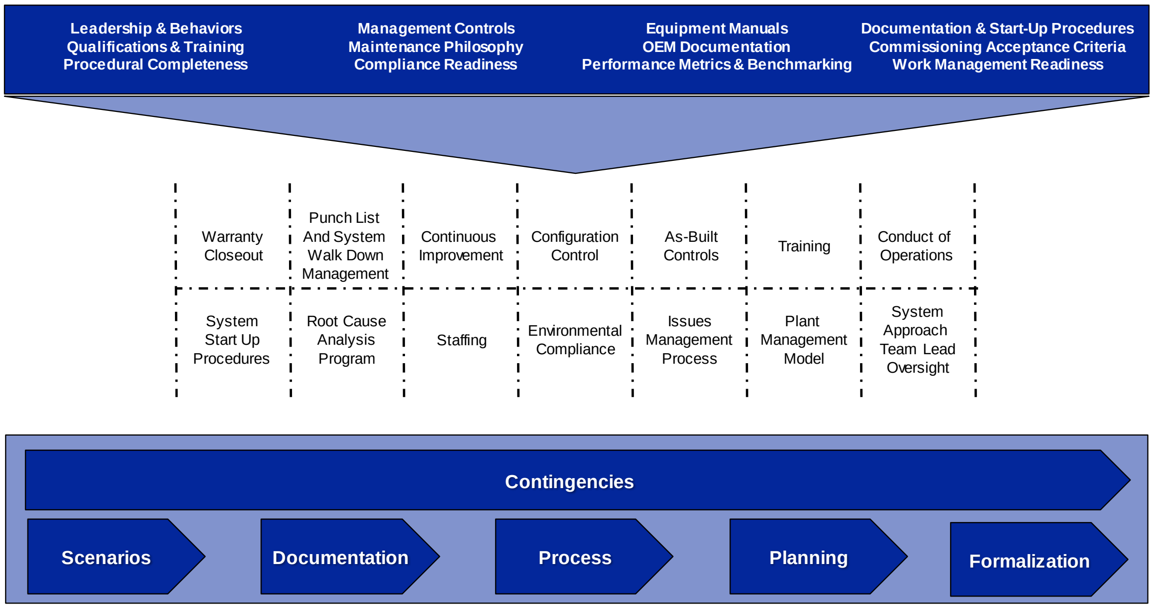
When a new plant is being constructed and placed into service, many of the personnel that will manage and operate the facility are staffed long before the construction is completed and the plant is placed into operation. This staff will typically develop training modules, gather and catalog component technical manuals, develop procedures, create system information packets, and design administrative protocols that will be used once the plant becomes operational.

The purpose of the ORA is to independently evaluate how prepared the staff is to accept ownership of the plant during start up and to safely operate the plant after turnover.

Figure 4 outlines the typical structure of an ORA. A thorough process requires scanning all aspects of plant operation and formulating recommendations based on identified discrepancies, coupled with an analysis of all the necessary contingencies.

The 12 items listed at the top of the diagram in Figure 4 are the audit source material areas. These materials include the underlying processes, procedures, documentation, internal systems, data storage and controls, metrics, and other things of importance to successful plant operations.

Figure 4



The 14 areas of observation displayed in the middle of the diagram are focal points for observing and commenting on how well the owner/operator is prepared to assume full plant operations. These are filtered through the five contingency components shown on the bottom of the chart.

An assessment of this nature typically requires 8–10 weeks in order to develop meaningful recommendations. It is important to note that the difference between the costs of prevention and the costs of remediation can be quite dramatic. It is critical that the ORA be done properly. In many respects, this is the investment to protect the investment. It is also important that the plant staff be an integral part of the assessment and buy into the recommendations.

The specific recommendations can be articulated in a number of ways, but the most important attributes associated with each specific recommendation are:

- **Priority** (categorizes impacts of the recommendation on operations)
  - High: Likely to impact plant operations
  - Medium: Impacts plant documentation and potentially impacts plant operations
  - Low: An administrative issue which could create documentation problems and future impacts to plant operations
- **Basis** (the rationale for the recommendation)
- **Benefits** (the expected gains to be realized from recommendation implementation)
- **Current State** (the way tasks would currently be handled – without recommendation implementation)
- **Options** (identifies solutions for recommendation implementation)
- **Recommended Methodology** (the steps needed to implement the recommendation)

Implementation of recommendations is typically managed as a project with a combination of internal plant staff, often with some outside assistance where needed.

Self-assessment audits are commonplace in the nuclear industry and have served as catalysts for major improvements in all functional disciplines. Applying this technique to the readiness of coal, gas, and renewable facilities may be viewed by some as a new concept. However, the value derived from nuclear self assessments is also evident in ORAs for other technologies.

The result is a more effective plant start up and transition to operational ownership as well as reduced transition costs and the assurance that the plant will be safely and commercially operated from day one. The alternative to the ORA, an unplanned transition and turnover, is nicely summarized by this quote:

> "The nicest thing about not planning is that failure comes as a complete surprise and is not preceded by a period of worry and depression." *John Preston*