Best Practices for Planning and Executing Brownfield Projects




This article will discuss best practices for developing and executing brownfield projects. It will lay out the critical risks and considerations that must be considered for brownfield projects in an operating facility. Best practices based on recent project successes in mitigating these risks and challenges will be reviewed. They will focus on how to develop and deliver these projects safely, on time, and within budget while achieving a successful start-up and meeting project objectives.

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Introduction

Brownfield projects are especially challenging, in particular those with a major shutdown component or where work is taking place in proximity to plant operations. Executing these projects safely and efficiently requires substantial planning to mitigate key risks such as:

- Safety — Congested work areas, existing operations, energy isolation, cranes and mobile equipment, unknown underground utilities and structures, etc.
- Construction — Surprises during demolition/installation can significantly impact schedule and cost. Without proper planning, construction risks will compound, resulting in rework, delays, and increases for potential accidents or unplanned outages on the adjacent production equipment.
- Operational — The new process has to be seamlessly integrated into the existing operations. If an outage is required for the project, the equipment is to be started up in a timely manner and reach the required production rates in a short time. Major production losses impact both upstream and downstream units.
- Financial — Any shutdown in operations is lost revenue for the producer. The revenue impact can be substantial and depends upon the product, the process step in the production flow and if the facility is running at capacity, so lost production cannot be made up. Business plans are built around project schedules. Failure to start up on time can jeopardize financial statements or the ability to secure future financial backing for large capital investments.

Safety

For brownfield projects, safety risks are exponentially increased compared to greenfield projects with interfaces between existing operations, maintenance, cranes, mobile equipment, moving equipment and molten metal. Safely navigating through these existing conditions requires risk identification, planning, and key cooperation between the operations and construction. It is vital to have visible senior management commitment early into safety planning. Senior management sets the expectations, and when visible on-site for safety audits, their presence reaffirms the standard.

Most brownfield projects require a shutdown or tie-in to existing operations, process line, rolling mill or utility system(s). A significant risk is improper energy isolation procedures. Often the project team is not well versed in plant procedures, or the existing procedures may lack the detail for the types of isolations required. Rather than complete isolation, a bypass may be considered so the equipment that must be locked is properly isolated, while allowing equipment downstream to continue to operate. Regardless of a full isolation or bypass isolation, procedures must include the proper sequence for reenergization to facilitate start-up and commissioning. For example, flammable gases must include closure checks of downstream valves of the main shutoff to prevent accidental buildup of hazardous atmospheres if personnel not involved in the project inadvertently open a service valve. Planning and coordination with the plant operations and maintenance teams is integral to ensure the hazards are identified, proper mitigations are in place, and isolation procedures are understood and followed. Not only is the isolation of equipment and systems a risk, but reenergization can pose a significant hazard to personnel and equipment.

A key aspect of safety is in the daily safety routine; the project team must stress the importance and value of the daily routine to avoid complacency. The daily routine typically starts with a team toolbox talk to bring awareness of key safety items, high-risk activities and major tasks for the day. This flows down to the individual pre-task planning for the crew and foreman to identify the proper work steps, tools, and awareness and interfaces with adjacent crews and operations. For brownfield sites, this routine must go a step further to interface with plant operations and maintenance to ensure the crew knows the operational tasks for the day and vice versa.

Another aspect of the daily routine is conducting safety walkthroughs with all parties' safety teams, nominated craft and leadership representatives. This not only mitigates risk during construction but also empowers craft personnel to bring items that need addressed to the leadership team. Appropriate responses from the leadership team go a long way in establishing the proper safety culture of the jobsite. Again, senior leadership must be visible in the field to show commitment from the top down.

Often the tasks with the highest risks are commissioning and start-up, where proper planning and communication are critical. An appropriate way to mitigate risks during start-up is to pause certain tasks when a concern is brought up. Once the task has been paused, all key personnel should discuss prior to resuming start-up. Although there will be some anxiety over starting up the operations quickly, construction and commissioning should still be done carefully and not rushed.

Project Development Phase

The development phase of a project sets the foundation of a successful project. Projects that don't allocate sufficient development time typically encounter more surprises, changes, and roadblocks than a well-developed and planned project. To prepare and initiate a project, all stakeholders need to align on the project and scope. A design basis document should be developed to capture all necessary major scopes. A design basis typically includes:

- Production requirements (produce X tons per year, for example).
- Major scope inclusions (scope of supply matrix).
- RACI Matrix (a sample RACI Matrix is shown in Fig. 1).
- Take-over points (TOPs) for equipment and utilities.
- Utility requirements.
- Project exclusions.

Scope creep is generally encountered throughout a project, especially for less-defined projects. Scope creep is scope being added to a project without consideration and approval. Scope creep tends to occur when operations or maintenance attempt to add smaller projects or scope into the main project. To mitigate scope creep, it's critical that the project scope, assumptions and exclusions be included in the design basis document. Projects can lose momentum, time and, most importantly, money when scope is added, altered, or cut in the project execution phase. Confirming the project's scope and design with the operations and maintenance team early will mitigate scope creep, ensuring requirements for redundancies and backups are accounted for in early stages of the project.

Figure 1

Sample RACI Matrix.

Description	Owner	Owner Team	EPCM	OEM	Environmental Consultant
Project Management					
Engineering					
Procurement					
Procurement Management					
Contracting					
Purchasing					
Expediting					
Vendor Quality Surveillance					
Logistics					
Site Material Control					
Estimating					

During the project development phase, it is important to identify interfaces and gaps between the new equipment and existing. This could include utility availability for electrical power, natural gas, water, hydraulics, etc. Often, if not available, utility upgrades can be a significant portion of the project cost. In addition, schedule impacts can occur if external utility suppliers are unable to meet demands in time.

When the process has been identified and approved by all stakeholders, if applicable, the process should be simulated to confirm it functions properly within the existing operations and how it impacts material flow and logistics. Simulating and confirming the process early in the project development phase mitigates further risks during start-up and commissioning. A perfectly executed project would be a failure if the process cannot produce the project objective and meet the business case. Methods for simulation include:

- Static simulations: Simple calculations based upon a limited subset of process and production parameters.
- Dynamic simulations: Application of specialized simulation software, developed from a large set of historical process and production parameters for verification, providing for dynamic "what-if" scenarios.

Early in the project development phase, it is important to begin tracking and forecasting costs and scope. During the development phase of the project, change is often significant and rapid, but having a record of changes provides granularity of the project as scope, assumptions and design develop.

Project Definition Phase

The project definition phase generally begins when:

- FEED/FEL 3/Basic engineering begins.
- Critical process equipment is being ordered or engineered.
- Construction planning begins, including potential early contractor involvement.

Drawings of existing facilities are often not properly maintained and field changes not recorded. A 3D laser scan can rapidly establish as-built conditions with reliable accuracy. Early in the project definition phase, a laser scan of the impacted process area should occur. Laser scans mitigate risks by identifying:

- Field modifications not detailed or captured on existing plant drawings.
- Equipment clash points.
- Locations of piping, conduit and wire, often not detailed on drawings.
- Rapid development of 3D model background as opposed to modeling individual existing components.

There are different levels of accuracy for laser scanning. Understanding the environment and the function dictates how accurate the laser scan must be. A good rule of thumb is the spatial resolution of single scan points shall not be less than 1/4 inch at a scanning distance of 30 feet. The laser scan will generate a point cloud, which can therefore be converted to a 3D model. A point cloud of a substation can be seen in Fig. 3, whereas the same substation's 3D model can be seen in Fig. 4. For reference, the substation's laser scanning accuracy was to 1/8 inch.

Operational readiness planning should also occur in the project definition phase to allocate costs and identify and mitigate risks when the new process has been started up. Operational readiness can be a tedious process which is often ignored until the last minute. If started early, when the "equipment handover" occurs, it tends to be smoother than projects where no operational readiness tasks have occurred. Operational readiness involves:

- Hiring and training additional staff — operators, foremen, engineers, maintenance technicians, etc.
- Engaging with new processes early to learn how to operate and maintain them.
- Updating existing and writing new standard operating procedures (SOPs) and maintenance procedures.
- Planning for equipment maintenance.

Throughout the definition phase, while 3D models and drawings are being developed, review sessions should be held with key stakeholders, including engineers, operators and constructors, to identify any missing data which would be critical for installation, operations and maintenance. Early review periods allow engineers to produce improved designs and more detailed drawings in a timely manner.

At the end of the definition phase, it's important to establish the right level of detail in the project schedule and budget baselines to allow for proper control, forecasting and change management. Throughout the project, changes can occur, and it will be important to determine where the forecast budget stands compared to the initial budget. Real-time cost tracking throughout the project duration allows all parties to monitor spending trends when slight changes occur. If the forecast appears to be above the initial budget, it is important to be able to identify why and alert the correct parties early.

Project Execution Phase

The project execution phase generally includes:

- Detailed engineering (may have started in the previous phase).

Figure 2

Substation point cloud.

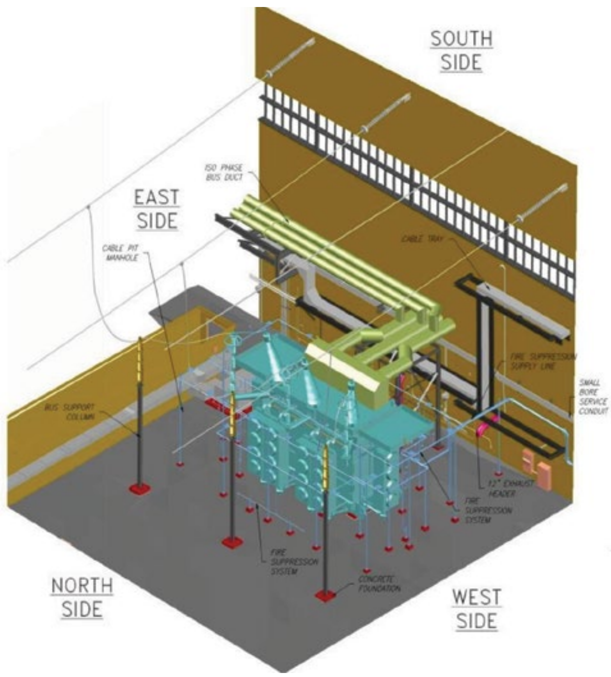
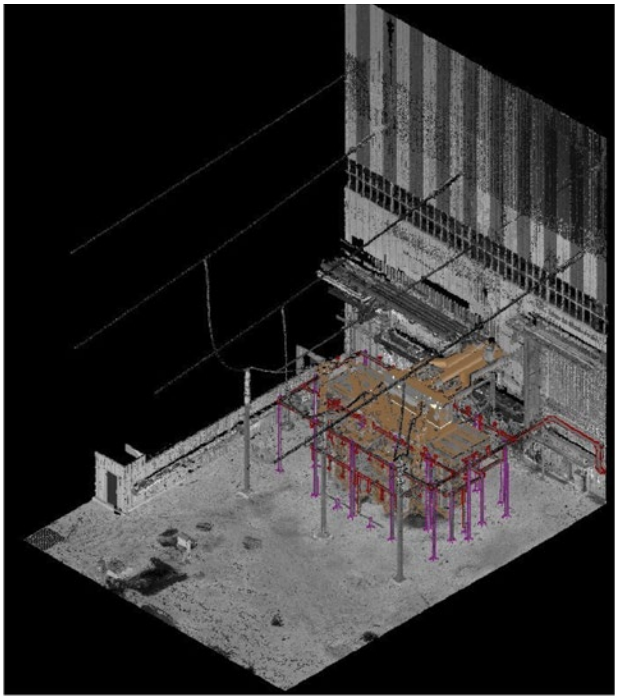


Figure 3

Substation 3D model.



- The remaining equipment (generally auxiliary systems) is ordered.
- Construction packages are awarded.
- Commissioning and start-up plans are finalized.

One of the major tasks during the execution phase is finalizing the detailed engineering considering the final vendor design information, along with considerations from the constructability and operability reviews completed throughout the definition and execution phases.

During the execution phase, routine progress meetings should be held with:

- Information technologies.
- Production planning.
- Product metallurgy.
- Operations and maintenance.
- Plant engineering and automation.
- Plant and corporate management.

These progress meetings should focus on the high-level items each group would be interested in, such as cost forecasting, equipment delivery timelines, operation shutdown schedule and engineering progression. Weekly meetings can help all parties stay engaged throughout the project execution phase, especially for those whose deliverables are directly linked to the project schedule. A shift in a critical milestone can significantly impact a project's timeline.

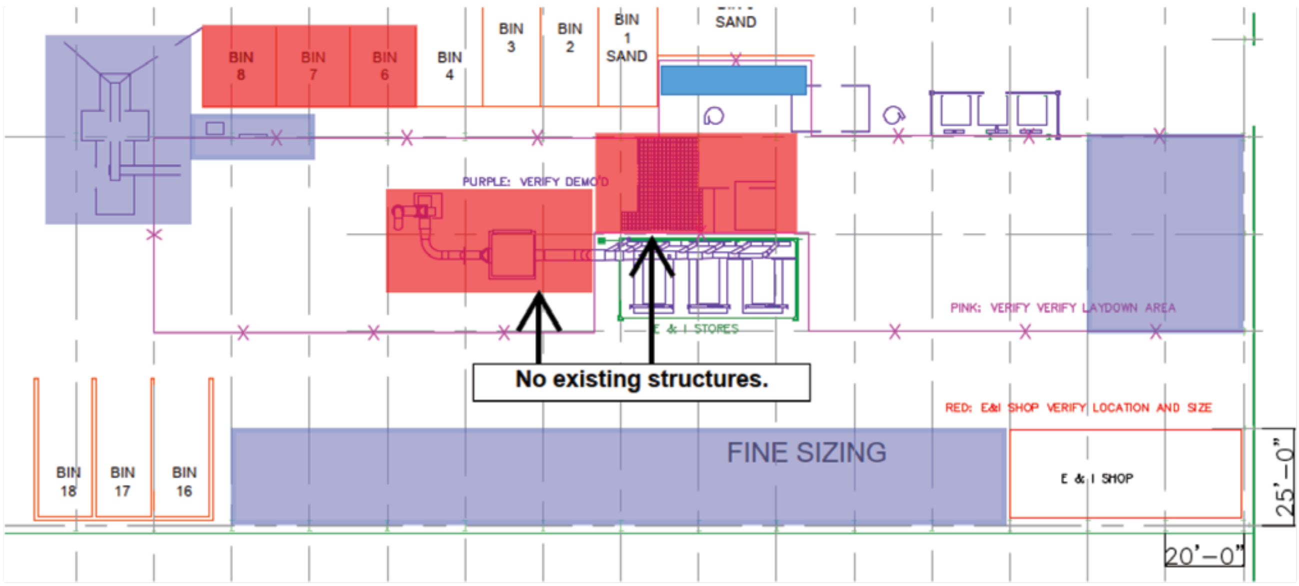
Proper site access and logistics should be determined prior to the construction phase. Site access refers to:

- Contractors entering and exiting the plant facilities.
- Parking lot(s) for contractors, with potential bussing routes to and from the jobsite.
- Areas for the contractors' working trailers.
- Traffic throughout the plant — how contractors and existing operations safely work together.
- Laydown and construction staging for equipment and materials.

Before equipment is delivered to site, a laydown yard should be established for the project-procured equipment and contractor-supplied materials and equipment. Generally, outdoor laydown yards are utilized for easier mobile crane access if equipment is not required to be stored indoors. An alternative in older facilities is to use nonutilized mill bays with electric overhead traveling cranes that can be used for unloading. The laydown yard should be relatively close to the jobsite and have a well-established and safe route to the jobsite. The laydown yard should have security fencing around it to mitigate equipment being stolen, misplaced or used in the operating plant. Shipping containers provide an extra level of security and organization for small parts and valuable

Figure 4

Example laydown yard imposed over existing floor plan.



electronic components. It is not unheard of for expensive pieces of equipment to "walk away" from a jobsite! Fig. 4 is an example of a laydown yard imposed over an existing floor plan. All red areas represented "claimed" areas, whereas all purple areas represented space available for equipment. The laydown yard drawing should be updated and distributed regularly to the project team.

Establishing a clear plan for materials management and inventory management of small parts to large assemblies for main and auxiliary equipment saves valuable time during assembly and installation, generally paying for itself during the project life cycle in lower labor costs and replacement costs for lost components. If utilizing a fixed fee/reimbursable construction contract with a general contractor, it is recommended to include this in their scope of work, where they are naturally incentivized to optimize construction sequencing and minimizing labor costs with the reward of a nice bonus at the end of the contract.

Overhead entry doors to the plant buildings should be measured to confirm all equipment can fit into the building for installation. Crane capacities should be accessed and compared to assembly weight provided by equipment suppliers. If some equipment is large to fit into the building or too heavy to transport with existing cranes, a choice has to be made:

1. Disassemble and reassemble the equipment inside.
2. Remove the building siding to fit the equipment.
3. Temporarily remove the roof and use a large crane to move the equipment into the building.

Options 2 and 3 may have to be chosen if the equipment is unable to be disassembled.

Where possible, it is preferred to have equipment assembled and tested in the factory. If equipment is not tested at the factory, following its delivery, an opportunity may be available to test the equipment off-line prior to installation to confirm it works correctly. This can, and will, save crucial time during commissioning if faults are identified prior to installation. If the site has space, preassembly of subcomponents into larger assemblies, and flown into the construction zone, should be considered. This confirms fitment, shortens craft time and optimizes construction crane usage. Although this may not be possible for every piece of equipment, equipment testing should be completed as much as possible prior to construction.

An energy isolation or lockout/tagout (LOTO) plan for all equipment being worked on/near must be developed during the project execution phase. A LOTO plan includes:

- A list of all equipment being locked out.
- Proper steps to lock out said equipment.
- Person(s) responsible for locking out equipment.
- List of energy potentially being encountered (mechanical, electrical) and how to deenergize the systems.
- Steps to verify equipment is properly locked out.
- Steps to reenergize and unlock equipment when work has been completed.

If an existing LOTO plan exits, it should be routinely checked prior to the construction phase to ensure the steps are still appropriate for any field modifications. The LOTO plan should be available to any stakeholder for reference throughout the project execution phase.

Existing equipment which must be disconnected during a brownfield project is likely bolted in place. The removed bolts will likely be damaged or lost during the construction phase. Therefore, a bolt list should be developed prior to the construction phase so the contractors can procure the correct bolts to reinstall existing equipment. Most plants have a stock of bolts in their storeroom, although this should be confirmed prior to the construction phase.

Throughout the project execution phase, a commissioning plan should be developed with a commissioning manager and the operations team. Commissioning is often overlooked and results in delayed start-ups. This is especially true for auxiliary systems, where the main process equipment is typically supported by field specialists from the original equipment manufacturers (OEMs). If the commissioning manager coordinates appropriately with the appropriate LOTO personnel, commissioning can commence in some areas prior to construction completion. Although this takes careful planning and consideration, this mitigates start-up risks due to commissioning certain processes early.

Lastly, prior to entering the shutdown outage, it's recommended to conduct a mock outage with all relevant parties:

- Contractors.
- Plant operations and maintenance teams.
- Engineers.
- Safety personnel.
- OEM personnel (if applicable).
- Start-up/commissioning team.
- Key project team members.

During the mock outage, every work step is reviewed in detail to confirm all task durations and sequencing are aligned with all parties.

Construction Phase

When all detailed engineering has been completed, all equipment is on-site, and any preoutage work completed, the operations can be shut down (if applicable) and the construction phase begins.

Once the shutdown or outage begins, all equipment must be locked out according to the previously developed LOTO plan. Following the LOTO plan, all on-site contractors should confirm all equipment is locked out and place their locks on the appropriate equipment and/or lockout boxes.

One common issue that can occur during construction is contractors using outdated drawings and scopes of work. A dedicated document control person and system should be used to distribute revised drawings to the appropriate contractors. It is not uncommon to find a craft worker using a Rev 0 drawing when the drawing has already been revised to Rev 1. It is best practice to reference printed documents and drawings as uncontrolled copies. That version control relies on the document server and the controlled version resides on the document server.

Daily progress meetings with on-site contractors ensure everyone is aligned. A successful format is in Table 1.

Disagreements in the field are almost always guaranteed. Whether a drawing is wrong, or there are issues between contractors, disputes are best addressed immediately in the field. A strategy is to round up all parties involved to discuss any disagreements or discrepancies and develop a plan to resolve them.

Contractors should be encouraged to lock up all toolboxes and work trailers to eliminate theft. Although the theft is likely not malicious (a worker borrowed a tool and forgot to return it, for example), lost tools are inconvenient and can potentially slow work.

When excavation and foundation work occur, contractors may uncover unknown utility lines. When this

Table 1

Sample Progress Meeting Format

	Contractor A	Contractor B	Contractor C
Today's work tasks	Foundations for platform. Equipment install.	Refractory install in furnace.	Cable pulls on 3rd floor.
Tomorrow's work tasks	Foundations for platform. Equipment install.	Refractory install in furnace.	Cable pulls on 3rd floor.
One-week lookahead	Install platform for Contractor B.	Spray gunnite on platform.	Wire equipment Contractor A installs.

occurs, it's best to pause all nearby work and bring plant personnel to investigate. It's best to confirm the utility with a drawing and/or tracing the line to a main header. Checks should be completed both upstream and downstream of the utility line to confirm that unintended outages are not experienced when the line is shutdown. Once the line is confirmed, a proper LOTO procedure should be followed so work can continue.

When construction is nearing completion, the commissioning team is tasked with starting up the equipment safely. The commissioning team can work with the equipment vendors as an additional resource if equipment troubleshooting is required. This will tie into the previously developed operational readiness plan for equipment handover and how to operate and maintain the new equipment. During commissioning, it is common for parts to malfunction and/or break, therefore it's critical to have an adequate number of spare parts on hand during commissioning. Equipment suppliers generally provide a list of recommended spares for commissioning, consumables, first year, long-term and large capital spares at time of order placement. Capital spares can be deferred, but commissioning spares, consumables and first year spares are highly recommended.

The commissioning team must coordinate with the LOTO personnel to unlock the proper equipment at the correct time. If equipment is unlocked and commissioned while construction is still ongoing, it is safe practice to lock out the equipment again. During commissioning, the operations and maintenance team should be involved too to begin learning the new process. Ideally, the on-site vendors field service personnel will walk the operations and maintenance team through on-site training programs.

Summary

In summary, successfully developing and executing brownfield projects is challenging, but detailed and methodical planning and utilizing the right tools and procedures greatly improve the odds of a successful project. Things will always come up in the field no matter how much planning is done, so having a properly resourced team with backup plans prepared will give the project team the greatest chance to succeed.

It is important to remember the following:

- Safety is the number-one priority. Brownfield projects pose higher risks and must be properly staffed with the appropriate number of safety personnel throughout the entire project life cycle.
- The project definition and development phases are crucial, and shortcutting these phases is a considerable risk; these phases align the project team on scope, schedule, costs and key performance indicators.
- Existing plant documentation and drawings must be field verified because it is unlikely all modifications were captured on drawings. Laser scanning the project area also can provide a valuable basis for design.
- Communication is critical to the success of the project; all stakeholders across the plant must be pulled in and aligned.
- Proper logistics planning for the materials and equipment (receiving, staging, preassembly) will ultimately result in budget and schedule improvements.
- Engaging with contractors early provides an opportunity for design drawings to be reviewed by a third party, resulting in a more complete drawing.
- Commissioning and start-up planning must begin in the project definition phase. These plans are often overlooked, resulting in start-up and production delays. ✦

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