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Comparative analyses of common project execution alternatives

With major projects (FIG. 1), alternatives are generally considered in overall project execution and in construction. These alternatives may be viewed as opposing approaches, but there are often overlaps with the different methods. This article discusses different sides of the following commonly considered execution alternatives:

- Engineering, procurement and construction (EPC) vs. engineering, procurement and construction management (EPCM)
- EPC vs. technology, engineering, procurement and construction (TEPC)
- Self-performing vs. subcontracting
- General contractor (GC) vs. construction manager (CM)
- Shop vs. field construction
- Design-bid-build vs. design-build.

Here, the various methods are explained, and differences noted. Misconceptions of the various approaches are clarified, and guidelines are presented to define the best methods for a wide range of situations and projects. This work also addresses limitations of the different execution approaches. Implementing the proper execution and construction strategies is key to a successful project that meets quality and schedule requirements, as well as financial constraints.

Guidelines for determining execution strategy. Determining the best project execution and construction strategies early in a project can be challenging. Many factors must be considered, and the benefits and disadvantages of alternatives must be carefully weighed.[1,2] For example, does the owner (contracting company) have significant internal resources to execute a major project? This could drive a strategy that involves fewer outside companies. If limiting risk is very important, then an EPC approach might be advisable to pass risk to another entity. If scope is ill-defined, the owner may want to use piecemeal contracts as the information becomes available. Challenging field conditions may warrant more shop module construction than onsite construction. The subtleties of the various methods are not always obvious. The following discusses competing strategies.

EPC vs. EPCM. An EPC contract involves putting in place a company to take a project from initial inception to completion. Accordingly, this is often known as a "turnkey contract." Typically, the scope of work must be clearly defined under this contract, and the work is done on a lump-sum basis. The risk under this contract arrangement is primarily with the EPC contractor. The EPC contractor will generally enter into separate agreements with subcontractors and vendors but retain the responsibility for their work. Therefore, the owner is insulated from any sub-agreement disputes.

Under an EPCM contract, the contractor is not directly involved in the building and construction of the project, but, rather, is responsible for the detailed design and management of the project on behalf of the owner. Cost risk is with the owner under this arrangement. In most cases, the EPCM model is structured on a cost-reimbursable payment structure or on a unit rate fee structure. All sub-contracting is done by the owner; therefore, they face any disputes that may arise.

Both EPC and EPCM contracts have their upsides and downsides, and contract arrangements must be made with eyes wide open. EPC contracts do not deliver the lowest cost, since the contractor is covering its risk. However, the owner minimizes its risk under an EPC contract, and this arrangement is well-suited when the owner has limited project execution resources. The EPCM contract is a good compromise for a situation where costs are to be minimized, yet the owner is looking for a party to drive the project. This has developed into a flexible contract arrangement that is being increasingly used in the process industry. One can argue that the EPCM contract is not as financially committed as an EPC contract, but this can be counteracted by including incentives to drive the EPCM contract.

EPC vs. TEPC. Perhaps this can be viewed as a subtlety, but a differentiation is sometimes made between a normal EPC contractor and a TEPC contractor that offers unique technology for a project.[3] Some companies offer various technologies crucial to the oil and gas industry, often providing the capability of taking a project from "cradle to grave." The benefit of this arrangement is that all factors for a successful project are in direct control of a company (TEPC),

including startup and guarantee demonstrations. An EPC company without a technology base may be forced to buy technologies from another company, and this adds cost and an interface that can complicate project execution. The downside of using a TEPC contractor is that it may not have the strong project execution resources that are typically available in a world-class EPC company. In the end, project cost, along with the perceived ability to achieve project success (including startup), may drive the decision of an EPC contractor vs. a TEPC contractor.

Self-performing vs. subcontracting. General contractors (GCs) may undertake construction activities with in-house resources (self-perform), or they may outsource activities to outside firms (subcontracting) and only provide oversight. Each arrangement has its own advantages and disadvantages. Some of the factors that need to be considered include:

- Quality
- Schedule
- Cost savings
- Better control
- Flexibility
- Risk.

A GC that self-performs uses in-house resources that are properly trained and employing good safety practices. Since the GC's reputation is at stake, the self-perform model ensures a quality project execution. Additionally, a self-performer can add resources to adhere to the schedule and offer flexibility. Since a separate markup is not needed for a subcontractor, a self-performer can be more cost-competitive. However, a self-performer may lack certain specialized trades that need to be subcontracted. By subcontracting, the GC can have a lower overhead cost structure. Additionally, by subcontracting certain trades, the GC can shift risk to the subcontractor. Each project must be carefully evaluated in terms of scope and schedule against available options to determine the best solution.

GC vs. CM. GCs and CMs perform similar roles. However, there are important differences. A GC is a separate business entity with employees specialized in certain skills such as estimating and project execution. A GC has a contract with the end user based on competitive bids. If a GC delivers a project for less than the bid price, the profit is the GC's to keep. Simultaneously, a GC carries cost and schedule risk. This can create friction, since it is a win/lose proposition.

A CM can be a single person or a group of people that works for the owner for a percentage of the project cost. Typically, the CM joins a project team early on and has significant influence over project definition. They are really agents of the owner, and can hire additional subcontractors to carry out the work, as needed. A CM does not carry much risk. The owner gets complete visibility into project costs through the CM. A good CM has a strong relationship based on trust with the owner. In some situations, CMs may self-perform some of the work themselves. This arrangement erodes the objectivity of the relationship between the CM and the owner.

The owner can shift risk to a GC through a firm fixed-price contract. However, risk transfer is not possible with a CM. The CM is an agent of the owner, and does not gain or lose money depending on the project's outcome.

Modularization vs. field construction. It has been well documented that modularization or prefabrication offers the possibility to minimize project risk, improve quality and stabilize field costs, which are typically high.[4] Modularization may be considered for many reasons, including:

- Limited availability of skilled and affordable labor
- Remote site access and severe site weather constraints
- Desire to minimize field time and reduce construction costs
- Repeatable construction that lends itself to duplication
- Modification at an operating plant where downtime must be minimized.

Modularization also offers the inherent benefits of improved site safety, and quality is generally improved due to work being performed in a controlled environment. In addition, factory acceptance testing (FAT) can be performed on a controlled, piecemeal basis with modules, and there is generally less site waste.

However, some projects do not lend themselves to modularization. For example, if reasonably skilled and affordable labor is available, and site conditions are routine, then field construction should be considered. It may be noted that shipping is a major consideration for modularization, and this aspect should be carefully studied before a decision is made regarding prefabrication. If shipping becomes unreasonably costly, or if

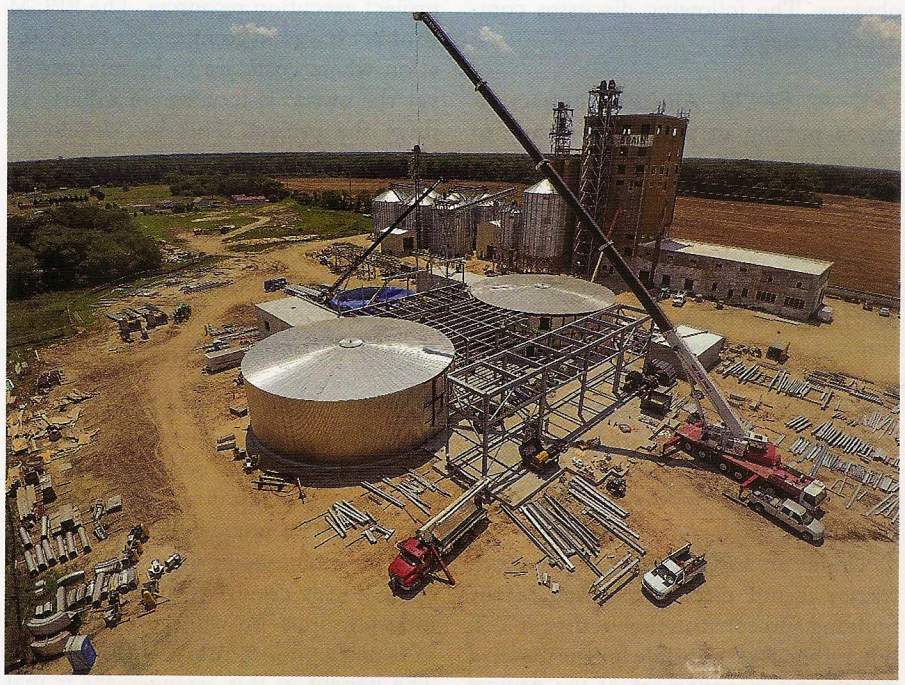

FIG. 1. The best arrangement for project delivery depends on several factors, including location, timing and available resources.

a large amount of bracing steel is needed to maintain the module configuration, then it may be prudent to stay with field construction. Finally, early engineering completion is key for modularization to support accelerated material deliveries needed to build modules.[5] Modularization can certainly shorten time in the field, but all elements of the process must be weighed to determine if prefabrication is feasible.

Design-bid-build vs. design-build. The traditional approach is to design-bid-build. In this approach, a design firm completes a set of drawings and documents, which go out for competitive bids. Typically, a minimum of three bids are solicited and the lowest bidder is usually selected. In this arrangement, the emphasis is on low cost and not on a short schedule or on high quality. Additionally, the outcome of a project is determined by the performance of multiple parties. The design-bid-build approach results in the lowest price. However, resolution of differences is more complex, since there is no single point of contact or accountability.

By contrast, in a design-build arrangement, the entire project is awarded to a single firm that does the design and builds the project. This minimizes the owner's involvement and risk. This turnkey approach means that the contractor is responsible for the design outcome, cost and schedule. The project schedule can be accelerated, since construction can begin before the design is 100% complete. Additionally, the owner has a single point of contact, which simplifies contractual arrangements.

Guidelines for an appropriate execution strategy. The following is a list of some general guidelines for the appropriate execution strategy. The final choice will need to be made based on project-specific considerations. Some of the factors that should be considered are project location, schedule, budget, and the availability and skill set of in-house resources. General guidelines include:

- EPC is favored where cost considerations are paramount and where the owner wants to shift project execution risk to the EPC company. EPCM is a good arrangement when the owner wants a CM to be involved as the agent early in the project development phase, and the owner is willing to assume the construction risk.
- TEPC is appropriate when the underlying process technology is available from a contractor that executes the project. The TEPC arrangement entails a single entity that is responsible for all the aspects of a project, from design to startup, and guarantee demonstrations. An EPC arrangement makes sense when the process technology is licensed from one company and execution is by an EPC contractor. In both cases, a lump-sum contract is possible.
- Self-performing is suitable when the contractor has all the required skills in-house. Quality and schedule are directly controlled. If specialized trades are not available in-house, then a subcontracting strategy is necessary, although this adds complexity in contracting and execution.
- A GC is suitable when the defined scope and owner want to shed construction risk to an outside entity. A CM approach is beneficial when early engagement by an expert is needed in project development. Construction risk remains with the owner.
- Modularization may be appropriate if the site is remote, but accessible by road or waterways. The plant design should be such that it can be broken into modules of a size that can be shipped to the site. Modularization is also favored in situations where the climatic conditions are extreme and local skilled labor is limited. For modularization to be cost effective, detailed engineering design must be completed in advance.
- Design-bid-build is appropriate when low cost is important and there is adequate time to get competitive bids. With a design-build approach, there is a single point of contact and accountability.
- Importing fabricated materials and components from overseas suppliers can be cheaper in some cases compared to procuring all the materials domestically. However, it is important to take freight, schedules, custom duties and currency exchange risks into account. Furthermore, more complex coordination with multiple entities in different languages and time zones can add logistics issues not present with domestic suppliers.

Takeaway. Various arrangements exist for project delivery. These include the following approaches: EPC, EPCM, GC, CM, shop fabrication, field erection, design-bid-build and design-build. Each approach has its own advantages and disadvantages, which can be assessed for cost, schedule, risk and quality.[6] The best choice depends on location, timing and available resources. A detailed assessment must be made on a case-by-case basis by experienced personnel who can make wise decisions based on incomplete knowledge. HP

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