IDEA TO OPERATION

Bob Watson and Rama Challa, Matrix PDM Engineering, USA, offer a step-by-step approach to the development of small scale LNG facilities.

An abundance of low cost natural gas has created a resurgence in the construction of LNG facilities, yet the collapse of gas prices has also created uncertainty, slowing development of some large scale projects. Despite this slow down, there is an ever-increasing demand for small to mid scale LNG facilities to meet increasing demand in the power, marine and transportation sectors.

While this demand creates significant opportunity for an owner/developer, the process from concept to cooldown – from an initial idea to commercial operation – can be both complex and onerous.

Developers have vast and diverse value interests that include cost, schedule, quality, reliability, life span, constructability, maintainability, etc.[1] Understanding and streamlining a process that addresses these value interests and can be rapidly executed is critical. The speed to market can mean more lucrative pricing and terms with offtakers and end users.

It all begins and ends with planning. In fact, pre-project planning has been shown to have the single largest impact on cost and schedule savings on all industry groups (Figure 1). The ability to influence a project (configuration, schedule, etc.) is dramatically decreased while expenditures rapidly increase as a project progresses. The optimum time to influence the final project at the lowest cost is during pre-project planning (Figure 2). A formalised and successful planning approach is the front end planning (FEP) process, developed by the Construction Industry Institute and discussed in its publication, RS213-1.[2] This FEP gate process is shown in Figure 3 and consists of four phases.

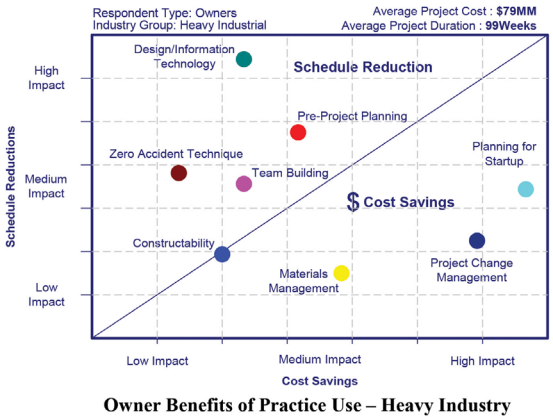

Figure 1. Owner benefits from practices used in the construction industry.[3]

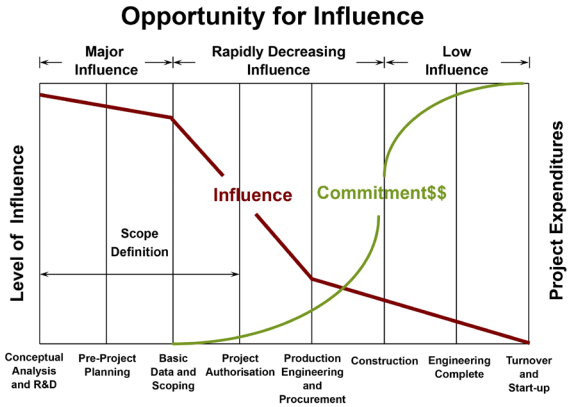

Figure 2. Project lifecycle: opportunity for influence.[4]

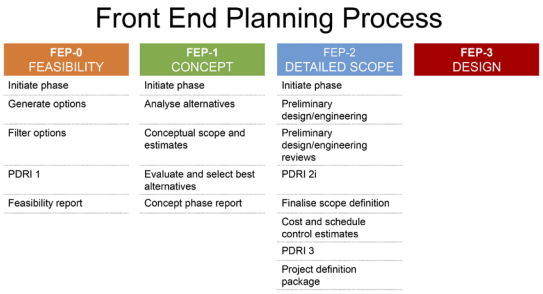

Figure 3. Front end planning (FEP) processes.

FEP-0: feasibility

The first action a developer takes toward deciding whether or not to pursue a project is to determine its feasibility or return on investment (ROI) – the likelihood of operating the facility at a profit. To calculate ROI, developers rely on either sophisticated internal models or external consultants. ROI variables include capital cost, operating costs and time to market. In FEP-0, parametric information is typically used. If the models yield a positive outcome, the project is pursued. FEP-0 components include the following:

- Identification of potential technologies and technology providers.
- Determination of a potential region or location with a significant unmet demand for LNG. This demand could be for marine bunkering; rail fuelling; remote location, high horsepower (HHP) equipment; or a combination thereof. Market research includes a review of historical purchases of diesel and heavy fuel oils (HFO), discussions with potential users and business intelligence regarding competitors.
- Establishment of initial project economics. Project economics are tied to both estimated total LNG demand from all potential users in the target region and the current LNG market cost. The initial economics models drive the project capital and operating costs and establish the profitability.
- Review of the federal, state and local regulations that are applicable and determination of the jurisdiction responsible for regulatory enforcement for the facility. Additionally, assessment of the community view of the risks and rewards of a future LNG facility is performed.
- Identification of a suitable site for the facility. Although the firm required footprint may be unknown, the general space can be estimated based on similar capacity facilities. Considerations should include additional regulatory buffer or exclusion zones between the new facility and existing neighbours.
- If a potential parcel is available and the acquisition costs are known, the project economic evaluation can be updated to determine if the projected costs and revenue are still consistent with a favourable ROI.
- If a site is identified, the developer can also have a geotechnical consultant perform minimum on-site sampling and testing to define soil properties and recommend foundations. As an alternate, existing geotechnical data within the vicinity can be used. This information can facilitate preliminary designs and cost estimates in FEP-1.

Before moving on to FEP-1 (concept) and FEP-2 (detailed scope), the developer should also decide on the contracting approach.

In a conventional contracting approach, FEP-1 and FEP-2 studies are performed by a consultant selected by the developer based upon reputation and expertise. At the end of FEP-2, a detailed performance specification and scope of work is prepared by the consultant and bids solicited from technology,

engineering, procurement and construction (TEPC) teams. With the facility requirements, the TEPC teams will next develop competing conceptual (FEP-1) and preliminary (FEP-2) designs and cost/schedule estimates. The developer will then evaluate these proposals to see which solution best fits the project needs. The successful bidder is then awarded a firm price contract for detail design, procurement and construction in FEP-3. Typically, technology providers team up with engineering, procurement and construction (EPC) contractors to provide proposals. The TEPC team models follow multiple structures, such as a joint venture (JV) or a consortium. Certain TEPC organisations can come from one single entity as well.

An alternate approach is for the developer to solicit competing unfunded FEP-1 work from TEPC teams. At the end of FEP-1, two TEPC teams are funded to develop FEP-2 packages and compete to be chosen for FEP-3 and beyond activities. With the estimates and preliminary documents developed in FEP-2 by each team, the developer will confirm the project economics and make a final selection of the TEPC team to proceed with detail design (FEP-3). Finally, the selected TEPC team executes the procurement and construction of the facility using a target price with incentive model contracting method.

This alternate approach typically requires less overall time and minimises time to market. The cost optimisation risk of selecting a TEPC earlier is offset by the schedule optimisation and faster time to market.

This alternate approach will result in the following:

- A clearer understanding of the project objectives by the developer and the TEPC.
- The development of mutually beneficial contracting terms.
- Value engineering to effectively lower costs.

To initiate FEP-1 and FEP-2, the basic performance requirements for the facility need to be defined by the developer. These include:

- Feed gas composition and variability.
- Required LNG output (flowrates, pressures).
- LNG delivery method (truck fill, cryogenic pipeline to berth for ship or bunkering barge).
- Facility location and footprint constraints.

FEP-1: concept

During this sub phase, proposals are solicited from the technology providers. Based on submissions, facility information is further developed and refined. Capital costs, schedule and operating costs are parametrically estimated, and competing ROI models for each technology are prepared.

Items completed may include options to reserve identified potential plant property while additional evaluations are made, and additional geotechnical data to firm up foundation design recommendations.

At the end of FEP-1, the developer selects the technology that best furthers his/her business interests and identifies at least two technology vendors, and, secondly, has a rough order of magnitude estimate of costs (+50%/-30%).

FEP-2: detailed scope

During this phase, suppliers are invited to provide technical and commercial proposals based on any changes and/or revisions resulting from the balance of plant. Upon receipt and evaluation of the proposals, the facility design and process can be finalised so that it can be handed off for detailed engineering. FEP-2 outcomes include a +/-30% EPC cost estimate, an operating cost estimate and a preliminary project schedule.

FEP-3: design

Once the FEP-2 or front end engineering design (FEED) teams are selected and contracts placed, the teams will begin preliminary designs. Key decisions by each team include the following:

- Liquefaction processes.
- On-site buffer LNG storage to meet the required throughput.
- Sizing of major equipment, such as gas pretreatment, compressors, heat exchangers and pumps.
- Initial facility layout.
- Utility demands.

The main deliverables include the following preliminary documents:

- Process flow diagram (PFD).
- Piping and instrumentation diagrams (P&ID).
- Plot plan.

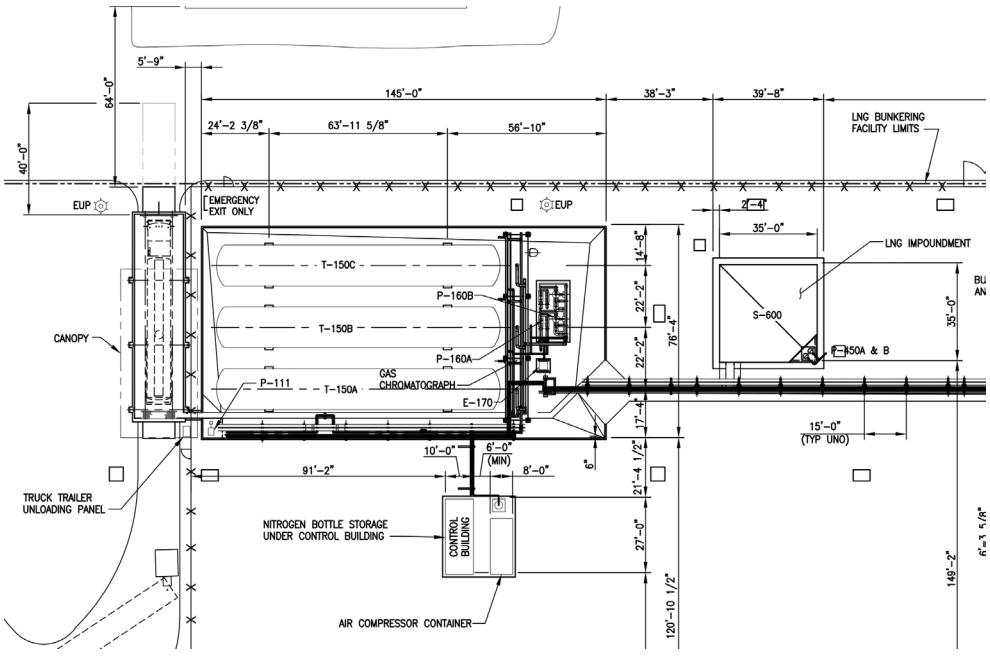

Figure 4. The plot plan: LNG bunkering facility.

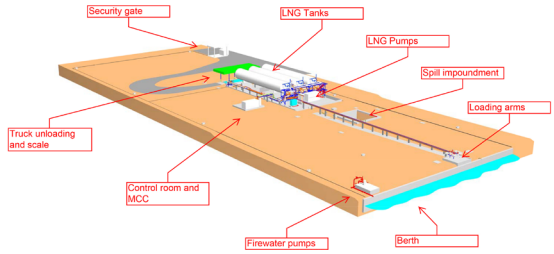

Figure 5. 3D model: LNG bunkering facility.

- Pipe and tray/conduit routing.
- Electrical one line diagrams for power distribution.
- Control system architecture.

Figures 4 and 5 indicate the plot plan and a 3D model for an LNG bunkering facility.

Detailed design activities in FEP-3 include the following:

Develop target price proposal

The selected TEPC team will build on the work done in FEP-2 and develop construction-ready drawings and specifications for the facility. This includes finalised updates on all of the FEP-2 deliverables, as well as detailed structural, piping, and electrical and instrumentation drawings. With these documents and equipment bids, the TEPC team will update the procurement and construction estimate to obtain a target EPC price for the facility. This target price is the basis for the contract to construct the facility.

Secure project permits

Concurrent with the detail design, the developer should begin review of the federal, state and local requirements for the facility and the permits required. Depending upon the location and use, some facilities may be under the jurisdiction of the Federal Energy Regulatory Commission (FERC), US Maritime Administration (MARAD)/US Coast Guard (USCG), or the Pipeline and Hazardous Materials Safety Administration (PHMSA). The permitting process normally requires submission of the design documents prepared during FEP-2.

Negotiate feedstock and utility contracts

Using the process calculations performed in FEP-2 and refined in FEP-3, the developer will negotiate purchase contracts with suppliers of the incoming natural gas feedstock and for suppliers of other utilities, such as electrical power, potable water, and wastewater treatment.

Secure offtake agreements

Sales contracts will also need to be developed and secured by the developer for the LNG output of the facility. These contracts will finalise the quantities and timing discussed with potential customers during the earlier FEP-0 phase.

At the end of FEP-3, the developer has a near firm price within 10% of the cost estimate of the facility. The final phase is the complete EPC of the facility.

EPC execution

With the FEP-3 designs completed and a target price negotiated, the formal project execution can begin, with the TEPC team procuring the required process, electrical and control equipment and fabricating piping systems and structural steel.

Certain projects are executed in the following two phases:

- A limited notice to proceed (LNTP) phase with limited funds for engineering and early procurement activities.
- A final notice to proceed (FNTP) when funds are fully committed to the project.

Once the FNTP and permits have been obtained, the TEPC can begin site construction, including the following:

- Site work, grading and drainage.
- Foundations for buildings, equipment and piping supports.
- Building and structural steel installation.
- Storage.
- Piping systems installation.
- Tray, conduit and wiring installation.
- Facility checkout and testing.

Finally, the TEPC team will start-up and commission the facility. When all systems are operational and working as planned, the TEPC team will conduct performance testing to verify that all process goals have been met. Typically, developer personnel that will operate the facility are trained by the TEPC team during performance testing and initial operation.

Commercial operation

When all contractual requirements have been met, the TEPC team will turn the facility over to the developer for commercial operation. The developer may contract with the TEPC team to provide ongoing maintenance and operation support after the warranty period has passed.

Summary

Regardless of whether a developer chooses a conventional or alternative approach to contracting, using an FEP process to go from concept to cooldown is essential to overall project success. In instances where schedule is less important, employing a conventional contracting approach in FEP can be both economic and efficient. However, when speed to market is essential, the alternate contracting approach to FEP provides streamlined benefits without compromising planning and scope definition. **LNG**

References

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2. Construction Industry Institute Support for Pre-Project Planning Research Team, 'Front End Planning: Break the Rules, Pay the Price', CII Research Summary RS 213-1, (November 2006).
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4. Construction Industry Institute, 'An Introduction to the Construction Industry Institute', CII Power Point, (January 2009).

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