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Introduction

1.1 What Is EPCC Industry

Engineering, procurement, construction, and commissioning (EPCC) industry is very challenging due to a tight schedule and specific budget defined by the operating companies or by the customers. The terminology “EPCC” is further classified into four parts as mentioned below:

1. Engineering
2. Procurement
3. Construction
4. Commissioning

Typically, engineering of a processing unit is done by a process engineering company, such as Worley Group. Sometimes, the engineering is done by the operating companies if the project is small and if they have necessary expertise. Engineers working with the engineering companies have the necessary skillsets and technical capabilities to execute small (e.g. US$ 10 million) as well as larger projects (e.g. greater than US$ 500 million). It is the responsibility of the EPCC industry to make sure they have brilliant and capable engineers working for them. There are several engineering companies located all over the world. Some of the engineering companies could have specific expertise in a particular area, e.g. offshore field, and some may have expertise and capabilities in doing projects in all the sectors. To have a successful project, it is critical to have knowledgeable and experienced process engineers who can design a plant. Apart from the process engineers, different disciplines involved are piping engineers, mechanical engineers, piping designers, civil engineers, electrical engineers, control-system engineers, and project management.

Once the engineering is completed, primary components of an engineering processing plant, such as equipment, instrument, and piping, are purchased by the procurement or the buyer team. The different disciplines have a specific task of putting together different bid tabs for each component of the manufacturing unit. Bid tab is a comparative document of different vendors’ designs or a bid for a component. For example, mechanical engineer puts together a pump equipment bid tab or a comparative table showing details, such as flow, pressure, head, and cost for different vendors. The vendor selection next goes to the procurement department

Managing Engineering, Procurement, Construction, and Commissioning Projects: A Chemical Engineer’s Guide, First Edition. Avinashkumar V. Karre.

where procurement details, such as timeline, specification, and nondisclosure agreement (NDA), are added and the final purchase order is issued to the selected vendor. Process engineers provide comments to the bid tabs and their role is critical in the selection of the final vendor. The customer or the operating companies have a say in the final selection of the vendor. The procurement team is tasked to keep track of several items on the project, and they use industry software (e.g. system application and products [SAPs]) for tracking and checking status. Process engineers and all other disciplines are kept in the loop in the procurement cycle, and often process engineers help vendors with the technical questions and clarifications. All the communications for a piece of equipment in the procurement cycle are saved and typically handed over to the project customers at the end of the project for information.

Construction team starts the required planning at the beginning of the detailed design engineering. Construction team has knowledge and expertise in transporting large pieces of equipment, e.g. distillation towers. Other construction expertise required are planning and creating a hold-up zone until the structure is built, cranes and their sizes required, etc. Once the equipment or piece of the equipment or piping is delivered to the construction site, the construction team moves that piece to the allocated location to avoid traffic in the hold-up or laydown area. Construction team may have to get the structures and roads built prior to the installation of equipment, piping, instruments, etc. During a peak construction duration, the project construction team is very busy installing everything at the preplanned location. There are engineering challenges involved, and process engineers are consulted with questions. For example, designed nozzle size on equipment was 8-in. standard (STD) weight, but the fabricated equipment nozzle was 8-in. extra strong (XS) weight. The process engineer in this case performs quick hydraulics to make sure the change is acceptable.

During installation of all the construction components, such as equipment, piping, and instrument, a team of engineers and operators are involved in the final step of commissioning. Commissioning is basically making sure the plant or processing unit is ready to take a fresh feed. Key things in the commissioning step are hydrotesting, testing flange or pipes, checking internals of equipment, checking functionality of all instruments, and checking performance of all safety gears works. Process engineers from the EPCC industry are involved in the commissioning step as they know the operation and design aspects of equipment, and they could be a valuable resource during this step. The process engineers are sometimes asked to stay at the plant site to provide round-the-clock support to eliminate any engineering hurdles.

1.2 Types of Projects

Once the customer determines to do a project or installation of a processing unit, the customer chooses one or multiple EPCC companies to complete the project. If the project is small to large size, the engineering contract is given to a single EPCC company to keep the cost low and to gain fast pace to the project. Once the contract is received by the EPCC, the project is classified into several categories as mentioned below, and further planning and manpower loading is estimated by the EPCC. Multiple EPCC companies could be required for grassroot projects where the capabilities and size of a single EPCC may not be sufficient. This is done to meet the desired project timeline within the planned budget. The type of project is determined by following categories:

1. Cost of a project
2. Purpose of a project
3. Engineering needs
4. Licensor's involvement
5. Profit based
6. Schedule based

1.2.1 Cost of a Project

Total installed cost (TIC) determines the size of a project. TIC includes the cost of all the machinery parts of the processing unit, engineering and labor, government taxes, manufacturing steps, and transportation. Note that each operating company or EPCC company may have its own definition of the type of project based on the cost. Below is a crude definition of the type of projects based on the cost involved:

Engineering team in Table 1.1 refers to a team of piping engineers, mechanical engineers, piping designers, civil engineers, electrical engineers, control-system engineers, and project management. Small capital (also known as small cap) project needs one process engineer either part-time or full-time depending on the stage of the project. More details on stages of the project are explained in Part B of this book. Process engineers are mostly involved in the initial stages of the project. In the EPPC industry, it is also possible that a collection of several small-cap or ultra-small projects are engineered by one or two process engineers. It is also possible that a single process engineer from the operating company or the customer supervises a small-cap project, totally avoiding the need for an EPCC industry.

Midsized project is often executed by an EPCC company due to unit-level complexity involved and needs 3–6 process engineers full-time. Since it involves installation of a new unit or revamping of an existing unit, the lead process engineer supervises all the process engineering activities and other process engineers support the design. The lead process engineer is required to communicate with all the disciplines and customers for a smooth transfer of engineering information.

Large-sized project is done by a single EPCC company due to multi-unit level complexity involved and needs 8–10 process engineers full-time. Since multiple units or areas are involved, several leads are assigned to different areas, and some process engineers support each area's lead process engineers. Examples of such areas include reaction, storage, tank farm, separation, and utilities. Each area lead process engineer is required to communicate with all the disciplines, customers, and interconnecting areas to make sure smooth transfer of engineering information is completed. For example, the utility area lead process engineer is required to communicate with all the areas as each area needs some utility in its processes. Examples of

Table 1.1 Definition of type of project based on cost involved.

Project types	Cost involved	Example of a project	Engineering team size (No. of engineers)	No. of process engineers
Ultra small	Less than US$ 5 million	Installation of small section of a pipeline	1–5	0.5–1
Small capital	US$ 5–US$ 50 million	Installation of a vessel and a pump	6–20	1–2
Midsized	US$ 51–US$ 300 million	Installation of a new unit or multiple small or simple units	21–80	3–6
Large	US$ 301–US$ 600 million	Installation of multiple complex units	81–200	8–10
Grassroot	US$ 601 million and more	Installation of multiple and complex plants	201+	11–25
Mega	More than US$ 2 billion	Installation of a new refinery	500+	26–50

some of the utilities are cooling water and instrument air. The tank farm area lead process engineer is required to communicate with the main process area team where the raw material and products are designed.

Grassroot projects are larger in size and might not be handled by the customers or a single EPCC. Multiple EPCC companies are involved, and the project is strategically divided into sections. For example, a large tank farm area is handled by an independent EPCC who has expertise in the tank design, the 2nd EPCC is handling the main reaction, purification, and separation of the processing plant, and the 3rd EPCC industry could be handling design of utility services (utilities such as cooling towers and boilers). A unit lead process engineer supervises all the engineering activities for a unit and there are multiple unit lead process engineers. Each unit lead process engineer is required to communicate with all the disciplines, customers, all the EPCCs involved, and interconnecting areas to make sure smooth transfer of engineering information.

Megaprojects are much larger in size compared to grassroot projects. They are often rare and involve installation of a brand new plant, e.g. a refinery complex. Multiple EPCC companies are involved, similar to grassroot projects, the megaprojects are also divided strategically into sections. Preplanning, communication, coordination, and consistency among all the EPCCs are key parameters for the successful completion of megaprojects.

1.2.2 Purpose of a Project

Each project is unique and can be initiated by the customer due to a revamp potential, a grassroot opportunity, a capacity expansion feasibility of a unit, age or corrosion of a processing plant, safety upgrades, and environmental emissions factors.

Revamping a processing plant means utilizing some or part of the existing equipment and addition of some new equipment. A good example is revamping preheated trains of crude and vacuum distillation units in a refinery to achieve higher crude temperatures and higher energy integration efficiencies. There could be an opportunity for the customer to install a new grassroot plant to support already-existing plant. New chemical grassroot plant would make sense next to an already-existing refinery complex as the raw materials needed for the chemical plant could be readily available next to the refinery.

Most of the plants in the United States are 40–100 years old and they are designed based on certain throughput originally. Over the years, the plant operation has pushed the limits of the existing plant design, and over time they see operational problems, like choking in the lines, fouling, coking, high-pressure drops, and vibrations of equipment/supports. All these operational problems suggest that the existing unit has a capacity limitation. The customers could be interested in removing such bottlenecks in the system through capacity expansion projects. Simply replacing a piece of pipe or a pump in such projects can eliminate a capacity limitation in the processing unit, increasing throughput for the unit.

All processing plants age with time like humans. The reliability of the equipment in those units is at risk over time despite rigorous preventative maintenance programs. Some of the critical equipment, such as recycled gas compressor in hydrocracker unit or the steam jet ejectors in vacuum distillation unit, have direct impact on the functionality of the processing unit. If they are old and need frequent maintenance, it is good idea to replace such critical equipment to gain reliability. Also, some of the processing plants are prone to more corrosion than others, and often require frequent maintenance due to corrosive process fluid or hydrogen sulfide (H_2S) gases being handled. After certain history of maintenance and age of the plant, it is important to perform a corrosion survey in the unit and have the affected equipment or pieces replaced. An example is sulfur-containing equipment in the sulfur recovery unit (SRU) of the refinery. Since the SRU is at tail end of the refinery, where H_2S gas is treated and converted to recover sulfur, it is of prime importance for the refinery to keep the SRU running without any interruptions. All the upstream refinery unit operations are affected if the SRU's operation is affected. In such cases, it is very critical to make sure all the critical components of the SRU are functioning to their best performance.

Some of the old plants may not have all the safety instruments to work safely according to the latest industry standards and could be putting plant personnel at risk if not attended to promptly. For example, the old plants may not have a good safety standard around the fired heater burners. Installation of a new burner management system (BMS) on the old heater ensures all the safety standards are met.

Some of the projects are driven primarily by emission standards and regulated by government agencies. To meet the highest or new emission standards, the processing plant may have to adapt to a new process or a new catalyst. Some of the customers or operating companies go one step further and desire projects that take care of such emission standards for next 20–30 years, as long as there is an economic sense. Such visionary thinking also avoids any future changes to the processing plant, saving millions for the customers.

1.2.3 Engineering Needs

Some projects are unique and are dependent heavily on work that involves a specific discipline. Process-based projects primarily require process engineering and feasibility studies. There is no construction or procurement needed for such projects. Some projects consist of mechanical equipment, such as Hoppers or Bins, where process engineering support is not needed, and they depend primarily on mechanical engineers for equipment purchase. Some projects, such as installation of a new concrete pad for the existing unit, need support from civil engineers. Installation of safety instrumentation or cables and panels requires instrumentation or electrical engineers, and process engineers may not be needed here. Reworking or replacing existing piping with identical piping needs support from piping engineers and piping designers, and in such instances, process engineers are not required.

1.2.4 Licensors Need

Some processes require a process licensor package prepared by a licensor and support from an EPCC company. The collaboration between an EPCC and licensor is required so that the process package is designed safe and sound. EPCC in this collaboration could help with defining the feed, utilities, and routing of different products. Licensor-based projects are very common these days and neither EPCC nor the customer may have the process capabilities in that area. Once the licensor finishes their process package, the EPCC company takes the package and further incorporates that into the main design of the project, which involves working directly with the customer.

1.2.5 Profit Based

Sometimes engineering team in the operating company has found a process or modification opportunities to the existing unit to make a quick profit. A payback period could be less than two to three years in such scenarios. For example, there could be an instance where one of the customers finds that the very old and unused distillation columns could be repurposed, and by installation of some additional equipment, a quick profit could be made. In this instance, the customer should make sure that the old existing distillation columns are in usable condition and minimal civil structural modifications are needed for the columns to keep the project cost as low as possible.

In other scenarios, the customer could be doing some laboratory experiments, and figures that by installation of a simple purification process to the already-existing unit could double their profits in two years.

Profits based on small-cap projects are very attractive to the customers as they provide high profits with smaller possible capital investment. Another good example would be replacing existing low-efficiency natural gas burners for a fired heater with an ultralow NOx burner (ULN). The replacement of burners ensures high efficiency is achieved in the burners, saving on operating cost of fuel gas with minor capital investment.

1.2.6 Schedule Based

Several piping, electrical, or instrumentation tie-ins could be possible when installing new equipment in the existing facility. The turnaround time of the processing plant plays a vital role in such projects. A tie-in is defined by a connection of a new piece of piping or instrument to the existing one, e.g. tie-in new 4″ pipe to the existing 4″ piping. The project schedule is planned around the shutdown timing of the processing plant.

Although the schedule is monitored for every project, it may not be necessarily critical for all the projects. Some of the projects could be completed within one or two years in advance based on procurement strategy or availability of material or cost of items.

For most of the projects, project schedule is very critical for the successful completion of a project, as the profits are directly proportional to timely completion and start of a processing plant. Some of the projects are designed to be completed based on the emission timeline set by the government agencies.

1.3 Function of Different Disciplines

As mentioned earlier, several disciplines are involved depending on the size, stage, and type of a project. This section briefly touches on responsibilities of each discipline in relation to the project and coordination with a process engineer. Following different disciplines are involved:

1. Process engineer
2. Mechanical engineer
3. Piping engineer
4. Piping designer
5. Control-system engineer
6. Electrical engineer

7. Project manager
8. Procurement manager
9. Project controls
10. Project administrations
11. Document control
12. Estimating

Process Engineer:
Primary responsibility of a process engineer is to design equipment, develop equipment specification sheets, catalyst design and selection, develop piping and instrumentation diagrams (P&IDs), develop heat and material-balance tables, perform hydraulic studies, catalyst research, catalyst inventory calculations, participate in Hazard and Operability Analysis (HAZOPs), participate in 3D model reviews, flare and relief system design, provide process input for the instrument and line list data, input to the material selection and plot plan arrangement diagrams, and coordinate with other disciplines and customers.

Mechanical engineer:
Primary responsibility of a mechanical engineer is to provide mechanical equipment details to the process specification sheets, prepare bid tabs or compare different vendor quotes, coordinate with other disciplines and vendors, participate in 3D model reviews, provide mechanical input to the P&IDs, prepare procurement packages for equipment, and facilitate meetings with vendors as needed.

Piping engineer:
Primary responsibility of a piping engineer is to provide engineering details (such as insulation and thickness) to the piping line list, develop specialty piping items (such as steam trap), develop piping specification documents, and coordinate with other disciplines and customers.

Piping designer:
Piping designers develop 3D models, prepare squad-check packages for piping isometric drawings, develop isometric drawings, provide piping input to the P&IDs, prepare piping tie-in packages, and coordinate with other disciplines and customers.

Control-system engineer:
Control-system engineers develop instrumentation specifications, perform instrument sizing calculations, provide input to the P&IDs, prepare instrumentation installation details, prepare panel layout drawings, prepare procurement packages for instruments, participate in 3D models reviews, and coordinate with other disciplines and customers.

Electrical engineer:
Electrical engineers perform electrical load calculations, determine substation/generator size needed, finalize electrical lighting needed for the process areas, prepare wiring loop diagrams, provide input to the P&IDs, participate in 3D models reviews, prepare procurement packages for electrical equipment, and coordinate with other disciplines and customers.

Project manager:
Project managers coordinate with other disciplines and customers, supervise cost and schedule of a project, facilitate meetings for the project as required, solve project engineering problems, maintain decision/risk/action, register, control change orders, and participate in 3D models reviews.

Procurement:
They work closely with other disciplines and ensure that all the items are procured according to the schedule.

Project control:
They prepare schedules based on input from other disciplines, monitor manhours on the project, monitor and adjust schedule with changes on the project, track change orders, and prepare progress reports on a weekly basis.

Project administration:
They provide onboarding guidelines to the new members coming to the team, arrange meetings, track safety training for individuals, track and maintain project meeting calendars, and coordinate with several disciplines and customers.

Document control:
They issue all the documents provided to them by different disciplines, track all vendor documents and their progress, and coordinate with several disciplines and customers.

Estimating:
They perform cost evaluation of the project in every phase of the project and provide feedback to other disciplines and customers. They are important disciplines as the cost results determine the fate of the project.

1.4 Different Phases of the Project

Each project is sectioned into several phases to ensure that the money spent on engineering and toward the final installation of the project makes economic sense. Each phase of the project undergoes a rigorous cost estimate. If the estimated cost comes out higher than the target price the project is canceled, or further options are explored to optimize or reduce cost. A brief description of each phase is given below:

Phase 1 – Scope feasibility:
The customer of the project typically has an idea in their mind from very beginning. Once the contract is given to the EPCC company, the customer and EPCC company together make progress with the scope planning. Process engineers from the EPCC company may be tasked to perform several feasibility studies and explore options. At this stage, there is a high-level technical interaction/meeting with the process engineer from the EPCC and customer. Process engineer prepares preliminary scope reports and presents them to the customers in several meetings. Sometimes there are different technologies available, and the customer and EPCC must choose one

technology that makes economic sense. At this stage of the project, mainly the process engineer from the EPCC company is actively involved in the early design and communicates directly with the customer. The project manager from EPCC has few responsibilities to document the decisions and track the progress of the phase. Estimating team is involved toward the end of the phase. No drawings or P&IDs are developed at this feasibility stage.

Phase 2 – Scope definition:
Once the scope of the project is planned, selected, and feasibility is checked, further definition is done in this phase. Development of a process or a block-flow diagram, identification of major pieces of equipment, preliminary sizing of major equipment, and preparing estimated quality P&IDs (sometimes optional) are done in this phase, and cost of the project is estimated. A project is dead in this phase if the cost estimates are higher than the target values. The financial risk of canceling the project at this stage is very low. If the cost estimates are higher, in such cases, the customer may decide to cancel the project or explore an option to cut a part of the processing scheme and start in the middle of the process, which may make the project viable. For example, if the cost estimate for producing product C from raw material A is very high, the customer may choose to start from raw material B to get to C. This should work, provided there is an adequate supply and economics to start with a raw material B. Following two equations show that avoiding a raw material A in the modified option saves project cost.

$$A \rightarrow B \rightarrow C \ldots \text{(High project cost)}$$

$$B \rightarrow C \ldots \text{(Low project cost)}$$

Phase 3 – Scope development:
Once the project is approved in Phase 2 and moves forward to Phase 3, further development in the design is done in this phase. Actual design and specifications for all the equipment, instruments, civil-related designs, and electrical designs are prepared, but there is no purchase order placed in this stage, P&IDs are developed to show all the piping and details, line list is prepared with a preliminary process data, heat and material balance is finalized, 30% accurate 3D model is prepared for the project, detail hydraulics and preliminary safety valve evaluation are done, preliminary allocation of equipment is done, field visits are carried out, HAZOP meetings are held toward the end of the project, and finally cost estimate is completed. Most of the projects are likely to move forward to the next phase of the project as the financial risk has reduced toward the end of the phase through the knowledge of unknown pieces of the project. But if the project were to be canceled at this stage (perhaps due to geopolitical reasons), the financial losses for the customers are limited to only labor costs incurred for the engineering, as the engineering material needed for the project is not ordered at this stage.

Phase 4 – Detailed design:
All equipment, piping, control-system items, electrical items, and civil items are purchased from vendors, and the progress of the procurement is tracked throughout

phase 4 until all the items reach the project plant site. All the drawings, including P&IDs, are issued for construction, piping design issues out isometric drawings to the pipe fabricators, and electrical and control diagrams are issued to vendor for construction. Frequent meetings related to design changes on various engineering drawings are held and are approved through management of change (MOC) process. Many plant operation people are involved at this stage actively to review the 3D model and provide recommendations as needed. Initially, 60% accurate model review meeting is held, and based on the comments from various disciplines and operations, the 2nd 90% accurate model review meeting is held. In this phase, there are very few unknowns, less than 2%, toward the end of the project, and financial risk at this stage is eliminated completely, and the customer and the EPCC company are confident about the returns on their investment and their hard work. It is possible, but very rare, that the customers may decide to cancel the project at this stage due to some reasons, e.g. sudden increase in raw material cost at this stage. Ultimately the customers should decide if the project is making economic sense on a broader scale based on the cost estimate completed by the EPCC industry.

Phase 5 – Construction and support:
In this phase, all the equipment, piping, control-system items, electrical items, and civil items are delivered to the plant site. Construction team is involved heavily in planning and installation of all the pieces of the project. Engineering team from the EPCC industry provides support to the construction team and answers any questions they may have. There is no going back on project in this phase as the materials and pieces needed for the project are at the site. But sometimes due to sudden changes in global economics and supply/demand logistics, the project may not be feasible at this stage. Also, if the government agency denies permission to manufacture a product at this stage, the customers have no choice but to stop the construction process. The customers may choose to work on recommendations, which costs them some money, from the government agency to continue with the construction, and make a product and project feasible.

Phase 6 – Commissioning and start-up:
Before the plant is introduced with a fresh feed, all the necessary plant operators are trained for operations and safety. These are the personnel who will be maintaining the routine operations of the processing plant. Standard operating procedures, training materials, start-up and shutdown manuals, equipment manuals, and several operation manuals are helpful to these personnel in maintaining the health of the plant. The process engineers from the EPCC industry develop all these manuals with support of plant operations and input from the vendors.

In this phase, all the installed equipment, piping, control-system items, and electrical items are prepared to take a fresh raw material into the process. A team of operations and engineers go through several preprepared procedures, and several activities are carried out. All the equipment are hydrotested, all pipe flanges are checked for leaks, all instruments are checked for their functioning, and all electrical equipment are tested with standards. If the team finds an engineering problem, e.g. a leak in major equipment, the problem is solved before they proceed to the routine activities of the commissioning. Once all is ok, water or cold feed is circulated through the entire processing plant. Sometimes circulating water through a system, e.g. reactor filled with a catalyst, is not permissible. Sometimes the system cannot work on a cold feed, in that case, heating the processing system or heating the cold feed is necessary. In such cases, the heating system is made ready first before starting the main process area.

1.5 Importance of Chemical Process Engineers

Process engineers understand the process and they can perform the calculations, analyze the results, and provide a sound design to achieve the desired product. They develop a block-flow diagram based on a preliminary understanding of the process. Based on additional information, they develop process-flow diagrams and P&IDs. P&IDs are like veins of the project without which there is no project. P&IDs are further used as a guideline to develop the process and functional specifications.

Process engineers must maintain constant communication with, pretty much, everyone on the project to make sure everyone receives the correct information in timely manner. As illustrated in Figure 1.1, process engineer provides and communicate varieties of information and data to different disciplines. This information and data are vital for other disciplines to make progress on the project and to develop their design deliverables.

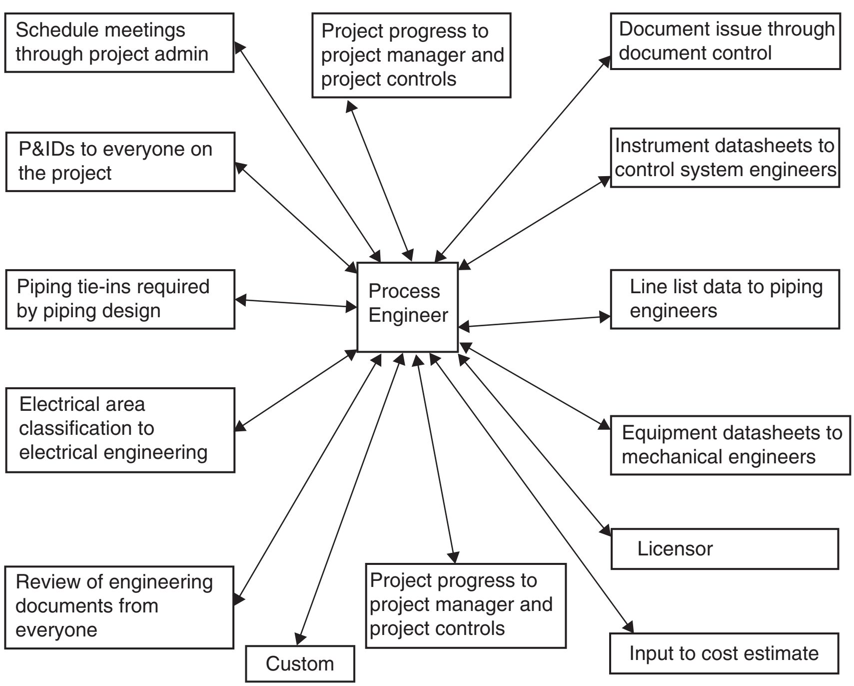

Figure 1.1 A diagram showing interaction of process engineers with other disciplines.

Table 1.2 Primary responsibilities of a process engineer in all phases of the project.

Phase	Primary responsibilities of a process engineer
1	Develop feasibility report and perform studies
2	Identify major pieces of equipment and develop a block-flow diagram
3	Prepare equipment datasheets and develop P&IDs
4	Vendor data review, safety valve development, issued for construction (IFC) P&IDs, and prepare instrument datasheets
5	Review questions from construction and provide support as needed
6	Commissioning support to plant and prepare operator training procedures

Process engineering support is required through all phases of the project, and the information provided by process engineer affects engineering deliverables of other disciplines. Table 1.2 shows the primary responsibilities of process engineer in all phases of the project. It is important to note that process engineers are required and essential in all the phases. It may not be true with other disciplines, for example, mechanical engineers are only involved from Phase 3 and onward.

1.6 Interaction with Operating Industry or Customers

The customers and the operating industry have a general idea of outlook of the final product, and they support the EPCC industry and make decisions. There could be more than one person from the customer side who would be making decisions. Most of the decisions are based on solutions and options provided by the process engineers from the EPCC industry. The EPCC company has no clear idea on important pieces without consulting the customers. Oftentimes, the customers may ask EPCC engineers to perform studies and present options before making decisions.

The customer has a key role in the project as they supply information on design guidelines, information on feed and product compositions, and item specifications as needed. Sometimes the specifications and guidelines desired by the customers are not suitable, and the EPCC process engineers should communicate the need or deviation with the customer. Several addendums and revisions to customer specifications may be required specific to the project. It is important to have the latest customer design guidelines practiced by all the EPCC engineers involved in the project. If a certain guideline is not available, the customer may ask the EPCC process engineer to prepare one with their support.

1.7 Interaction with Vendors

Interaction with vendors is very important in any project. There could be more than one vendor involved in a project. On a larger project, several vendors are involved in providing several designs and support. Vendors are typically involved in the project toward the beginning of Phase 4 or detailed design. Several meetings may be required with vendors to come to agreements and terms. At the end of selection of a vendor, a delivery schedule and delivery plan are discussed. A delivery timeline for the item associated with that vendor is then tied to the overall project schedule. Delivery plans

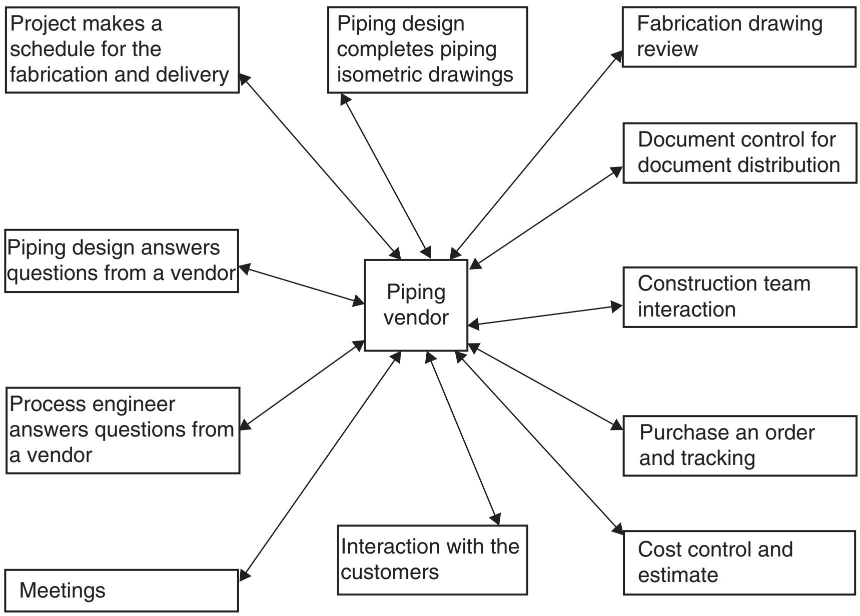

Figure 1.2 Example of an interaction of a vendor with the EPCC team.

Table 1.3 Classification of vendors (vendor is categorized based on material percentage contribution of the components in relation to the capital cost of the project).

Vendor category	Classification of the area	Function of vendor
Small vendor	Piping components	Provide piping components, such as strainers, sight glass, and valves
	Electrical components	Provide switches, lights, bulbs, cable trays, etc.
Medium size vendor	Instrument components	Provide instrument, wiring, converters, panels, etc.
Major vendor	Electrical major pieces	Provide electrical wiring, junctions, transformers, substations, etc.
	Piping fabrication	Fabricate and deliver piping in sections or modules
	Major instrument	Fabricate and deliver major pieces of instruments, such as fire and gas panels and distributed control systems.
	Equipment	Fabricate and deliver equipment in sections or modules

of the goods supplied by the vendor are discussed with the construction team and special shipping arrangements are then planned, if needed. For example, delivery of a 600 Klb/h steam boiler from Dubai needs a large barge. Figure 1.2 shows an interaction of a piping vendor with the EPCC team. Table 1.3 shows classification of vendors based on their function.

1.8 Workshare with Multiple Offices

Sometimes the home office where the project is being executed may not have all the engineering labor support to meet the schedule requirement, and sometimes the home office is looking for expertise in certain areas of the project within the company. All such scenarios result in needing workshare with other offices. The workshare office must provide high-quality results within the schedule requirement specified.

1.8.1 Importance of Workshare

1.8.1.1 Low-Cost Services

Every country is different in its economics and labor market. Countries, such as India and China, offer low-cost labor that's because the cost of living in those countries is low compared to western countries. The cost of living in western countries, like US, UK, and Canada, is very high and so the cost of labor is very high. Table 1.4 compares the cost-of-living numbers in India and USA. It can be interpreted from the table that the cost of living in India is much lesser than USA when compared with few basic parameters. The engineers in countries, like India and China, are well qualified; in fact, they're competitive in their skills and knowledge compared with engineers in the western countries. The salary of process engineer in the low-cost countries

Table 1.4 Comparison of cost of living in India vs. United States [1].

Parameter	Country: India	Country: USA	% of higher cost in USA compared with India
Basic utilities for an 85 m^2 apartment	$32.06	$162.08	506
Cinema ticket price	$3.22	$10	311
Pair of Nike shoes	$50.18	$76.09	152
Internet	$18.58	$45.72	246
Pack of Marlboro cigarettes	$1.77	$6	339
Price of 1 l of milk	$0.58	$0.99	171
Price of 1 kg rice	$0.36	$1.75	486
Rent of 3-bedroom apartment per month	$388.6	$1685.98	434
New car price	$11 748.63	$20 000	170

Source: Adapted from National Master [1].

varies anywhere from US$ 200 to US$ 300 per month as compared to US$ 4000–US$ 5000 in western countries. When the salaries are compared, it's very attractive for an EPCC industry based in a western country to do business with the low-labor-cost countries.

1.8.1.2 Labor Shortages

The labor market, especially in countries like United States, is not so great. As an example, about 478 million people are available to work in India compared to 155 million people in the United States. These numbers show that India has a good labor market compared to United States, and labor force in India is easily available. Due to the labor shortage in countries like United States, it makes economic sense to find labor in countries like India, where labor is available easily.

1.8.1.3 Level the Workload

There are several reasons the home office cannot supply the manpower needed for the project. There are other challenges, like immigration and availability of the skilled engineers. The home office EPCC industry deals with such things. Hiring skilled labor can be expensive in a western country and could be time consuming. If a global team is well trained and ready to receive additional projects, then this additional work can be sent to the workshare office. It is important to level out the workload to maintain the project schedule. The project schedule is most important for any project (Figure 1.3).

1.8.1.4 Time Differences in Countries

Time differences in different countries affect how EPCC industry workshare. The time difference between US and India is roughly 11 hours and the time difference between China and US is roughly 15 hours. So, India and China are roughly 11 and 15 hours ahead of US timing, respectively, which gives US companies an added advantage in the workshare area. For example, a process engineer in the USA can

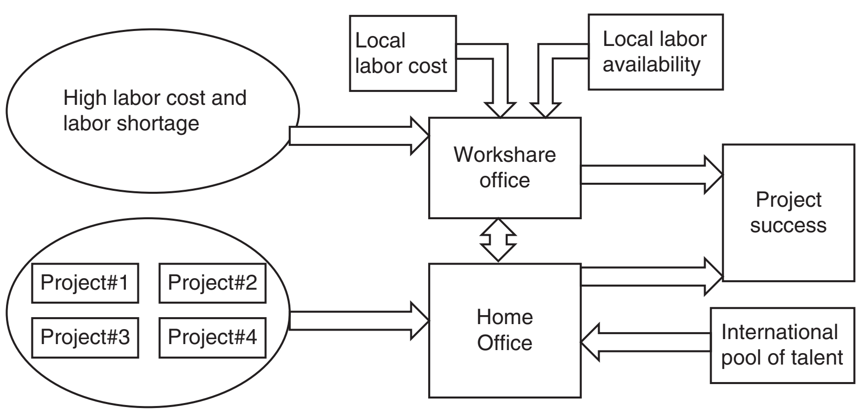

Figure 1.3 Importance of workshare, manpower loading, labor shortage, and low cost.

send the instructions to the workshare office and by the time the home office wakes up, the workshare office may have completed the work within 11–15 hours. The home office engineer can present these results, produced by the workshare office, straight to the customer, saving time on the project. The EPPC industry can work round the clock with the help of workshare office, which is the biggest benefit.

1.8.2 Types of Workshares

There are three types of workshare processes. They are mentioned below:

1. Workshare with an individual
2. Workshare a piece of a project
3. Workshare part of the engineering team

1.8.2.1 Workshare with an Individual

Sometimes the project doesn't need to workshare the entire workload with the workshare office. Sometimes the EPCC is looking for a skilled person in a particular area. EPCC can search for a skilled person in the workshare offices. Once EPCC finds a capable individual, then the home office can workshare with that individual. So, it's easier to hire someone with that skill level in the global pool of talent.

1.8.2.2 Workshare a Piece of a Project

It is important to know the capabilities and a history of the workshare office engineers in hand. Once the home office has that database, it can figure out which piece of project can be sent to workshare office. For example, the workshare office may be great at rating existing equipment and doing hydraulics. So, this is a piece of a project that can be shared with the workshare office, and the lead engineers in the home office can monitor the progress of the workshare office through the organizational network communications, such as Microsoft team.

1.8.2.3 Workshare Part of the Engineering Team

As previously stated, there are several disciplines involved in an engineering team either in a workshare office or a home office. If the home office doesn't have a capability in certain area of engineering, for example, civil engineering, and at the same time if the workshare office has the skill sets required to execute the project, in such cases, it would make sense to give the entire civil engineering work to the workshare office rather than hiring the entire civil engineering team at the home office. Hence, it is important to have access to the global pool of knowledge and skillsets within the company. Figure 1.4 shows a flowchart of process engineering activities between the home office and the workshare office. The workshare office executes most of the process engineering activities and the home office provides guidance to have process deliverables completed on the scheduled timeline. All other disciplines utilize these final products, such as line lists, to further develop their deliverables.

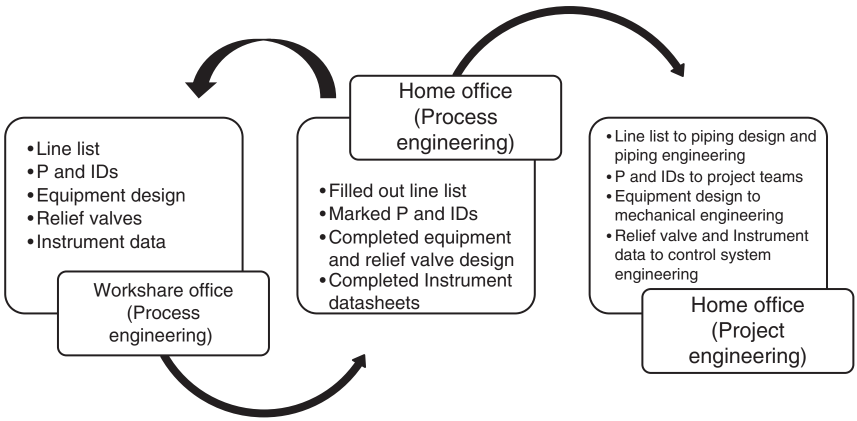

Figure 1.4 Flowchart of process engineering activities between home and workshare offices.