Integrated Project Delivery: A Paradigm Shift for Oil and Gas Projects in the UAE and the Middle East Region

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Summary

In the *BP Statistical Review of World Energy* (BP 2014), it was cited that consumption and production have increased for oil and natural gas to record levels across the globe. In parallel, hydrocarbon companies have been ramping up spending to meet those capital needs. 2013 saw increased global energy consumption. Developing economies nonetheless strive to dominate global energy supply, accounting for 80% of growth last year and nearly 100% of growth over the past decade (BP 2014).

Additionally, 89% of all oil and gas projects overshoot their original budget in the Middle East, 68% in Asia Pacific, and 67% in Africa (EY 2014). These figures are directly in proportion to projects that have schedule delays; as an example, 87% in the Middle East, 82% in Africa, and 80% in Asia Pacific. In relation to the size of cost overruns and scheduled delays, it was highlighted that 65% of the projects analyzed were facing cost overruns, with an average increase of 23% of the approved budget (EY 2014). In several papers, it was highlighted that typical oil and gas megaprojects were very expensive and very late in their delivery schedule (Merrow 2012). This means that they were late to produce revenues and compensate for losses.

Worldwide, it was indicated that 40 to 50% of all construction projects are behind schedule, and one of the biggest costs impacting the projects is inefficiencies that are built into the project execution rather than the costs of raw materials, such as steel and concrete, or the cost of labor. Owners (sometimes also called clients) stated that they felt their project controls were unsatisfactory, quoting project-management teams and cost controls as the most critical requiring improvement (CMAA 2005).

Limited studies and research were conducted within oil and gas construction to identify the factors causing delays, which had been predicted as dispute, arbitration, total abandonment, and litigation (Aibinu and Jagboro 2002). The delivery delay and cost overruns cause loss of wealth, time, and capacity, which results in income losses and unavailability of facilities for the owners. Loss of money is caused by extra spending on equipment and materials, hiring the labor, and loss of time for the contractor (Haseeb et al. 2011). Research conducted in the past verified that the project delivery system has a great impact on the project result. Findings from the research by Gaba (2013) indicated that design/bid/build (DBB) and design/build (DB) combinations are strongly related to high levels of effectiveness (i.e., project success), with the latter also positively related to quality outcomes of construction projects (Gaba 2013). As an example, of the 351 projects used for the study by Sanvido and Konchar (1999), the DB project-delivery system was delivered 33.5% faster and was 6.1% less expensive as compared with the DBB project-delivery method. The focus of this paper is how efficiencies affect schedule, with the recognition of the secondary effect on project cost. This paper also proposes integrated project delivery as an effective project-delivery method for executing oil and gas projects with better performance expectations.

Introduction

The majority of reasons for project delay in oil and gas projects can be associated with the typical characteristics of the project-delivery methods used for executing the project (Gaba 2013; Sanvido and Konchar, 1999). Delays in projects can be attributed to design errors, improper communication, improper contract, conflicts and disagreements, and delays in decision making and approvals. These factors are identified not only in literature specific to the oil and gas industry, but are also common in other construction projects.

With such consistent failures in adhering to a project schedule in the construction sector and more specifically in the oil and gas sector, both sectors have realized the need to move beyond cutting the inefficiencies within the engineering, procurement, and construction activities of the project and to redefine the basics such as use of innovative project-delivery models.

The delays and cost overruns have forced the market to look for better execution methods and to minimize the cost overrun and expedite project recovery and production, which has led to a focus on developing a better project-delivery method that should enhance project performance. The integrated-project-delivery (IPD) approach was introduced more recently as an approach to resolve and improve performance and productivity of projects. IPD was conceptually introduced as a collaborative arrangement of the major project stakeholders early in the project, and implemented in an environment of "best-for-project thinking" and shared risk and reward (AIA and AGC 2011). This collaboration of stakeholders' objectives to define project issues at the outset helped to identify conflicts, establish performance criteria, minimize waste, increase efficiency, and maximize the scope for limited project budgets, with an ultimate goal of creating a project environment that produces a positive outcome for all stakeholders.

As described by Ashcraft (2014), IPD works on principles that reflect a new balance between the parties and creates a system in which the structure and inherent incentives keep the project centered on the agreed upon goals.

The key challenge in the oil and gas industry is to control cost and project schedules. Establishing a collaborative approach from the project's early design phase [also referred to as the concept-design or front-end-engineering-design (FEED) phase] is an essential step for oil and gas projects to improve schedules and costs. Introducing an IPD approach can help to resolve and eliminate various delay and cost-overrun factors; however, it is crucial to understand how to introduce an IPD approach to oil and gas projects early from the concept/FEED phase, what is the best framework that can be developed to overcome the challenges and difficulties to implement an IPD approach, and what are the delay factors that can be resolved by the IPD framework.

Although this research may address specifically those projects that have been executed in the UAE and Middle East region, the research serves all oil and gas projects worldwide because oil and

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gas projects around the globe are similar in design, execution, and financing methods, and while they may vary in terms of the various environmental conditions of each location, this is accounted for during the design phase and execution. In addition, all the projects are designed globally by use of international standards and well-known designing consultants, such as Flour Daniel (USA), Bechtel (UK), and Technip (France), and execution is typically carried out by use of well-known executors (engineering, procurement, and construction contractors) around the globe. In terms of financing, well-known banking institutions and insurers sponsor the oil and gas projects globally, such as Shell, BP, ExxonMobil, and Total.

The objectives of this paper can be summarized as follows:

1. Undertake a detailed literature review covering project-delay factors in the construction and oil and gas sectors together with the IPD approach, with its implementation and the current project-execution strategies in oil and gas projects.
2. Analyze the critical project-delay factors in construction and in oil and gas projects.
3. Present the initial framework for studying IPD.
4. Identify the way in which the IPD framework will improve the project-delivery factors.

Major Causes of Delay in Oil and Gas Projects: Secondary-Data Collection (by Literature)

The major reasons for project delays were studied in the pertinent literature. Technical papers were selected, and the identified delay factors were categorized in terms of time of occurrence, areas/disciplines, and responsibility of stakeholders; therefore, the data are considered as "secondary data."

A summary of the factors causing delay is shown in **Tables 1 and 2.** These delay factors were highlighted by the literature for projects that were executed in the US, Canada, Iran, Australia, Ghana, Malaysia, Korea, Saudi, and the UAE; therefore, the delay factors are considered as global delay factors. Even though this is not an exhaustive list, the most-frequent, highest-priority, and most-repeated factors highlighted by the authors are mentioned. The factors are based on the conclusions drawn from earlier studies by various authors on the delay factors for projects.

Delay Factors Categorized Related to Oil and Gas Projects

Lack of effective management	Improper bidding and award
Lack of communication between engineers/stakeholders	Client participation
Improper planning	Financial issues
Inadequate or improper planning	Inappropriate practices/procedures
Inadequate project-scope definition	Owner interference
Slow decision making and lack of staff involvement	Design complexity
Design variations or changes in client requirement	Project managers do not have full authority
Inadequate design-team experience	Incomplete or inaccurate cost estimate
Change orders	Inadequate contractor experience
Poor estimation of labor productivity	Inconsistency of technical specifications
Mistakes and discrepancies in design	Megasized projects
Lack of mechanism for recording, analyzing, and transferring project lessons learned	Inadequate control procedures
Issues regarding permissions/approvals from other stakeholders	Nonadherence of material specifications (provided by client) to drawings
Poor documentation	Insufficient design information
Conflicts/disputes	Project-management characteristics
Incomplete drawings/specifications/documents	Social and cultural factor
Delays in producing design documents	Improper contract
Wrong choice of contract type	Delay in procurement
Unforeseen ground conditions or insufficient site data	Delay in tendering and award
Regulations, policies, and local law changes or issues	Engineering clear roles and goals
Insufficient and inexperienced management personnel from owner	Improper documentation of project objectives
Delay in site mobilization	Excessive bureaucracy in owner's organization
Shortage of experienced and qualified engineers	Lack of information technology use in communication and information management
Inadequate experience of project team	Delay in approval during construction
Insufficient team building	Inappropriate bidding instruction
Improper/outdated design software	Inappropriate overall organizational structure linking all project teams
Delayed design information	

Table 1—Categorized delay factors that are resolvable: oil and gas projects (Fayek et al. 2006; Salama et al. 2008; Mashayekhi et al. 2010; Orangi et al. 2011; Chanmeka et al. 2012; Kombargi et al. 2012; Fallahnejad 2013; Mortaheb et al. 2013; Long 2015).

Delay Factors Categorized Related to Construction Projects	
Unforeseen ground conditions or insufficient site data	Mistakes and discrepancies in contract document
Design variations or changes in client requirement	Disagreements or modifications on specifications
Lack of communication between engineers/stakeholders	Obsolete technology
Improper planning	Inadequate experience of project team
Inadequate or improper planning	Inadequate control procedures
Slow decision making and lack of staff involvement	Shortage of materials, poor quality, and material nonavailability
Mistakes and discrepancies in design	Finance issues
Delayed approval of design documents	Social and cultural factor
Lack of effective management	Material changes in types and specifications during construction
Change orders	Lack of effective managing and controlling of subcontractors
Conflicts/disputes	Rework
Inadequate contractor experience	Unavailability of financial incentive for contractor to finish ahead of schedule
Incomplete or inaccurate cost estimate	Consultant recruitment delay
Poor quality assurance/control	Inappropriate project-delivery system
Inappropriate overall organizational structure linking all project teams	Insufficient team building
Inadequate design-team experience	Incomplete approval of design documents
Lack of consultant's experience	Inadequate project-scope definition
Design changes	Improper/outdated design software
Excessive bureaucracy in owner's organization	Suspension/termination of work
Waiting for information	Inaccuracy of materials estimate
Delayed design information	Improper contract
Owner interference	Overdesign
Incomplete drawings/specifications/documents	Issues regarding permissions/approvals from other stakeholders
Design complexity	Delay in procurement
Shortage of experienced and qualified engineers	Improper technical study by the contractor during the bidding stage
Poor estimation of labor productivity	Poor competency of subcontractor
Improper bidding and award	High performance or quality expectations
Delay in approval during construction	Poor documentation
Poor site management and supervision	Unrealistic client initial requirement
Inadequate progress review	Inconsistency of technical specifications
Regulations, policies, and local law changes or issues	Time extensions
Wrong choice of contract type	Poor qualification of consultant engineer's staff assigned to the project
Delay in site mobilization	Improper construction milestone definition
Conflicts of the drawing and specification	Increase in quantities
Insufficient design information	Delay in approval of major changes
Shortage of labor, skills shortage, and poor productivity	Contract modifications
Regulatory changes	Lack of integration of skills at early stage of planning and design
Delays in producing design documents	Joint ownership of project
Improper codes used for design	

Table 2—Categorized delay factors that are resolvable: construction projects (Sullivan and Harris 1986; Assaf et al. 1995; Ogunlana et al. 1996; Kaming et al. 1997; Majid and McCaffer 1998; El-Razek et al. 2008; Al-Khalil and Al-Ghafly 1999; Al-Momani 2000; Aibinu and Jagboro 2002; Odeh and Battaineh 2002; Frimpong et al. 2003; CMAA 2005; Assaf and Al-Hejji 2006; Faridi and El-Sayegh 2006; Zaneldin 2006; Zou et al. 2006; Alaghbari et al. 2007; Sambasivan and Soon 2007; Le-Hoai et al. 2008; Sweis et al. 2008; Han et al. 2009; Kaliba et al. 2009; Tumi et al. 2009; Afshari et al. 2010; Ahsan and Gunawan 2010; Yang et al. 2010; AIA & AGC 2011; Hamzah et al. 2011; Haseeb et al. 2011; Chanmeka et al. 2012; Doloi et al. 2012; Odeh and Battaineh 2002; Ramanathan et al. 2012; Barton 2013; Kuo and Lu 2013: Ashcraft 2014; BP 2014; Marzouk and El-Rasas 2014).

Merrow (2003) concluded that of the 14 megaprojects he studied, seven had failed to meet the project-performance expectations by a huge margin. He suggested that using value-improving practices and having a higher level of integration to support front-end loading are the most important factors of project success (Merrow 2003).

Problem Statement

Although there are a great many oil and gas projects executed worldwide, few papers have been written and little research has been conducted to identify and assess the delay factors behind schedule delays and cost overruns. 64% of the projects analyzed had cost overruns with a budget escalation of 23% from the original approved budget (EY 2014). Although detailed processes and assurance tools are used currently by the oil and gas industry to ensure the project's objectives are aligned during all the execution phases, with traditional execution strategy [design/bid/build (DBB)], frequent and repeated factors occurred. The current traditional project strategies (methods of execution) consist of DBB, concept/front-end-engineering design (FEED), then bid, then construct. The concept phase is defined as the act of conceiving and planning the structure/parameter values of a system, device, and process. The initial design phase (FEED) is the stage of design between concept evaluation and detailed design during which the chosen concept is developed such that most key decisions can be taken. The output of FEED includes an estimate of total installed costs and schedules. Execution/build/construction, known as engineering, procurement, and construction (EPC), is a prominent form of contracting agreement in the construction industry. The EPC contractor will carry out further detailed-engineering designs, procure all the project equipment and materials as per the specifications and data sheets, and then construct to deliver a functioning facility or asset to their clients. The duration, also called the EPC phase/stage of the project, is known as the execution phase, which normally follows FEED.

There are numerous stakeholders in oil and gas projects, and they are involved in different phases and stages of the project. A stakeholder in an organization is any group or individual who can affect or is affected by the achievement of the organization's objectives (Sharp et al. 1999). Examples of stakeholders are owners (also referred to as clients), government bodies, design consultants (also referred to as FEED consultants), management consultants (also referred to as project-management consultants), construction contractors (also referred to as EPC contactors), subcontractors, main manufacturers, submanufacturers, end users (operation and maintenance), insurers, and third-party auditors. There is no fixed integration method or collaboration identified to safeguard stakeholders' involvement in the various project milestones and stages.

A collaborative alliance between all stakeholders is used widely throughout all stages; however, the EPC contractor, manufacturers, and end users join and integrate at a later stage (i.e., they miss the concept-design and FEED phases). This late integration and scattered collaboration causes various problems, such as massive change orders, uncertainty/risk of costs that are inflated, severe delays to schedules, technical/design deviation, lack of quality, commercial claims, and stakeholders dissatisfaction, all of which contribute to schedule delays and cost overruns (Fayek et al. 2006; Salama et al. 2008; Mashayekhi et al. 2010; Orangi et al. 2011; Chanmeka et al. 2012; Kombargi et al. 2012; Fallahnejad 2013; Mortaheb et al. 2013; Long 2015). No definite framework has yet been introduced to identify roles and responsibility of each stakeholder and determine at which stage they should become involved to eliminate schedule-delay factors.

An integrated-project-delivery (IPD) approach, which is new to the construction industry and also new to the oil and gas industry, can resolve the issue of late involvement and lack of integration of stakeholders. IPD introduction may face challenges because of current sequential phasing and stages in project-execution strategies. It is expected that the introduction of IPD will help to overcome a majority of the problems related to the design phase and to communication, and related technical problems.

Literature Data and Analyses

Data were collected from literature available from various online sources. Data were collected on subjects related to integrated project delivery (IPD), major delay factors in the construction industry, delay factors in oil and gas projects, and current oil and gas project-execution strategies.

First, an IPD approach and its implementation were selected to understand the behaviors and size of IPD implementation worldwide. It was obvious that IPD is still considered a new approach, which requires further trust and buy-ins from all involved parties and mainly from the owners.

Second, the delay factors in oil and gas projects were selected from the available literature. It was noticed during the data consolidation from the literature that limited papers are available related to oil-and-gas-project delays. In addition, some factors were repeated, and it was essential to expand the review to cover other sectors to regionalize the delay factors. Papers related to pipeline, power-plant, and utilities projects are considered to be of the same nature and field. Two papers were added to oil and gas projects to enhance the data.

To further enhance the database and to find the similarity between the two industries, factors were added from construction projects and lessons learned from previous local-market projects. Several delay factors were common between construction projects and local lessons learned; therefore, delay factors cited in the literature relating to construction projects were included because they may occur in oil and gas projects. This literature expansion has allowed enhancement and augmentation of the oil and gas delay factors. As a result, a total of 29 papers were selected, which directly address delay factors encountered during the execution of construction projects. The selected papers presented research from many areas, including North America, Latin America, Africa, Europe, and Asia. All papers address major reasons for having project delays and cost overruns.

As an initial finding, of the 193 prominent factors identified by oil and gas papers as causing delays in oil and gas, power, utility, and pipeline projects, 124 factors can be addressed potentially during the early design [front-end-engineering design (FEED)] phase. Of the 863 most prominent delay factors in construction that have been identified, 393 can be addressed potentially by implementing an IPD approach. Resolvable delay factors during early design include conflicts in drawings and specifications, inadequate or improper planning, outdated standards, overdesigns, incomplete designs, lack of communication between parties, conflicts/disputes, incomplete or inaccurate cost estimates, and inappropriate overall organizational structure linking all project teams.

When similar findings from all papers and authors were collated, the total number of unique findings was only 139. For example, additional work, change orders, contract modifications, multiple change orders, new scope additions, redesign and change orders, swift changes in contract specification, and unavoidable changes during construction were grouped under a common header—change orders. Of these combined 139 delay-factor groups, 90 can be eliminated during the early design phase by implementing appropriate measures. Several findings fall under a different-area category; for instance, conflicts and disputes can occur because of improper communication between various entities, improper contract terms, improper design that can lead to additional work not envisaged during early design or bidding, improper management, and different nationalities of labor.

On the basis of the detailed analysis of the delay factors, it was understood that even though the delay caused by one factor can occur at different phases of the project, it can be resolved by implementing proper mitigation measures during the early design phase (during FEED). For example, change orders raised during the

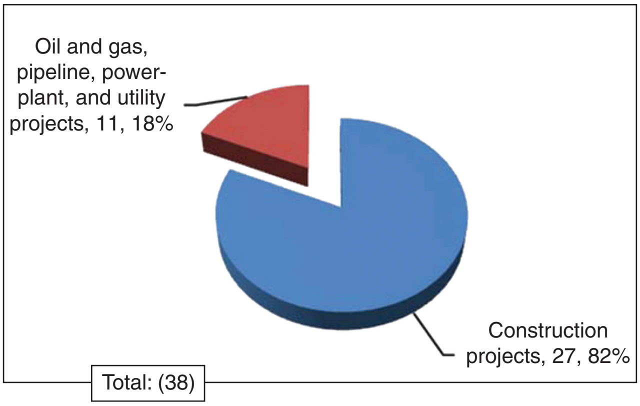


Fig. 1—Literature findings: oil and gas, pipeline, and power/utility projects vs. construction projects.

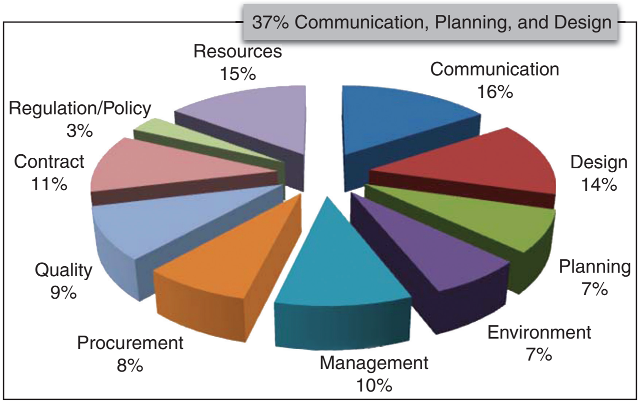


Fig. 2—Categorywise delay factors—all projects.

procurement phase can be eliminated if material specifications are developed with early consultation with the contractor and manufacturers (e.g., if the specification is calling for materials not available in the market, the contractor and manufacturers can provide an alternative solution at an early phase and avoid anticipated delay and cost because of change-order approvals). Change orders can also occur during the construction phase because of constructability constraints. If constructability is studied in detail during early design with contractor involvement, then delays and change orders can be resolved and reduced during the design. We strive to eliminate the problem, but generally just to reduce the problem or impact.

All the collected factors were consolidated, tabulated, and categorized for further analysis and processing. The following criteria were considered and categorized for each factor:

1. Types of Projects: oil and gas, construction, power-plant, and energy projects; utility projects; and civil infrastructure. This categorization assisted the researcher in evaluating the current available delay factors for oil and gas vs. construction projects. It was found that there are limited oil and gas papers compared with construction and infrastructure projects, leading the researcher to enhance the data and include local lessons learned and to include the construction projects **(Fig. 1).**
2. All factors were categorized on the basis of their discipline or area that could be attributed to delays caused by planning, design, resources, contract, communication, environment, quality, management, regulation/policy, and procurement areas. This categorization quantified the size of the factors related to each area (i.e., the size of delay factors related to all areas and which created the most impact). It was found that design, communication, and planning represent a high percentage and have repeated factors in a majority of papers.

   All delay factors have been filtered/categorized into 10 categories on the basis of the discipline or area. It was noticed that some factors had occurred in more than one phase of the project and also related to different disciplines; thus, they should be presented in each affected area. However, in this research, it was decided to present these factors in the most dominant area, to minimize repetition.

   From this categorization, it was noticed that communication, design, and planning represent the highest percentage in delay factors. The same categorization was repeated for construction projects, and then oil and gas projects and construction projects were combined to observe any similarities. The design, communication, and planning delays were more frequent and represent the higher number (**Figs. 2 through 4**).
3. The factors were further filtered on the basis of the responsibility and accountability of the stakeholder (e.g., whether the factor is caused by owner/client, project-management consultant, concept/FEED consultant, contractor, subcontractor, manufacturer, or government). This filter indicated the size of factors related to each of the stakeholders and which stakeholder holds the greatest accountabilities.

   It was found that the greatest responsibility falls under the contractor/subcontractor category, with 44% of the delays; second were the owners, with 22% of delay factors; and third were the FEED designers, with 11% **(Fig. 5).** This shows that contractors miss many of the engineering details

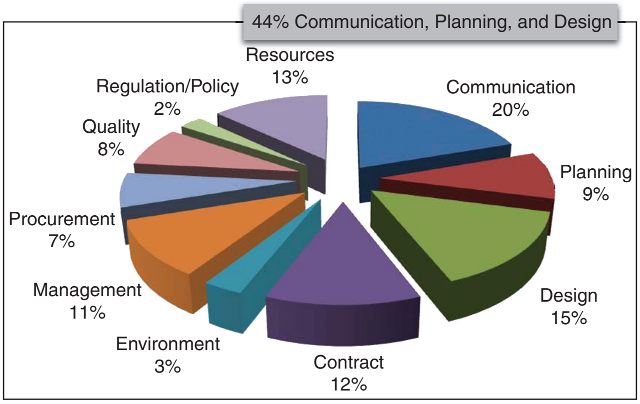


Fig. 3—Categorywise delay factors—oil and gas, power, utility, and pipeline projects.

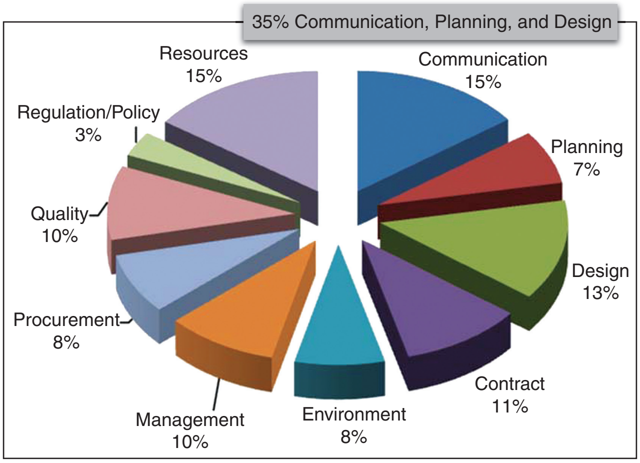


Fig. 4—Categorywise delay factors—construction projects.

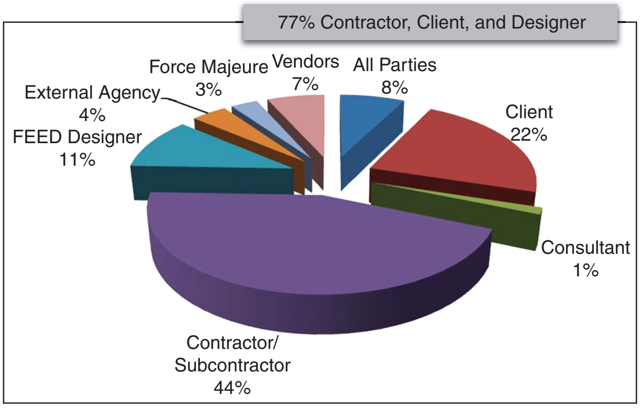


Fig. 5—Responsibility distribution for findings from literature.

and previous detail because of late arrival to the project; it was also noticed that the contractors' late arrival created a gap in communication with the owner, which caused many delay factors because of misunderstanding of the owner's objectives, requirements, and engineering quality.

The StageGate® model is widely used by organizations for executing oil and gas projects. In this model, check points are set in predefined stages to ensure that the minimum requirements to move to the subsequent stages are met and approvals are obtained (Barton 2013). Though very effective in ensuring that the quality requirements are met thoroughly, this model is limited to the constraints of the delivery method that is used for the project, hence it does not assist in engaging the key stakeholders during the early design (concept/FEED) stage for more-detailed and precise design. Engineering, procurement, and construction (EPC) contractors and major manufacturers get involved at the execution stage, and still the gap to involve them exists in this stage-gate process; the end user is involved during the startup of the projects.

4. The occurrence stages/phases of each factor were also categorized on the basis of occurrence (i.e., when each factor had occurred or when there was more than one phase/stage in which the same factor was found). This stage is also used to find out which phase of the project has the highest number of occurrences (i.e., design, construction, or concept).

   It was found that the execution phase (construction) represented the highest delay occurrence, followed by the concept/FEED stage. The same was repeated for the construction project with similar outcomes (i.e., in construction projects, the highest number of delays occurred in the construction phase, followed by the concept/design phase) **(Figs. 6 and 7).** "All phases" in these figures means that the same factor was found in various phases (i.e., it occurred in execution, concept/FEED, and during tendering).
5. Finally, the factors were examined to identify whether they can be resolved at the early phase (concept/FEED) or if they should be addressed and resolved during related phases. It was found that there were delay factors that have occurred and are repeated in various phases of the project (i.e., concept/FEED, tendering, and construction), and they could be tackled and resolved at an early design phase (FEED) once they were bought forward and addressed in a timely fashion with the concerned stakeholders. Two figures displaying these findings have also been presented: oil and gas, as shown in **Fig. 8,** and construction projects, as shown in **Fig. 9.** They were further analyzed to present resolvable factors under the individual discipline **(Figs. 10 and 11).**

The collected and categorized data were standardized by use of common terminology. This enabled a reduction of repetition and allowed for the comparison of delay factors listed by different authors in their literature.

The delay factors in Table 1 represent the selected resolvable factors identified from the literature relating to oil and gas, utility, power, and pipeline projects. The major delay factors related to design, communication, and planning were common and repeated in different phases during the project. Again, common and repeated delay factors relating to construction projects were similar, and this is presented in Table 2.

After the literature review and data analysis were complete, it was possible to conclude these initial findings:

1. All authors concluded that the majority of the delays were caused by a lack of early communication between the required stakeholders, which ended with change orders and schedule and cost impacts.
2. Insufficient and unclear engineering design was one of the major delay factors highlighted in all the literature. This also indicates the weak role of the design team (FEED), which led to late commencement of the activities—a late start to the engineering procurement. The FEED consultant did not communicate early

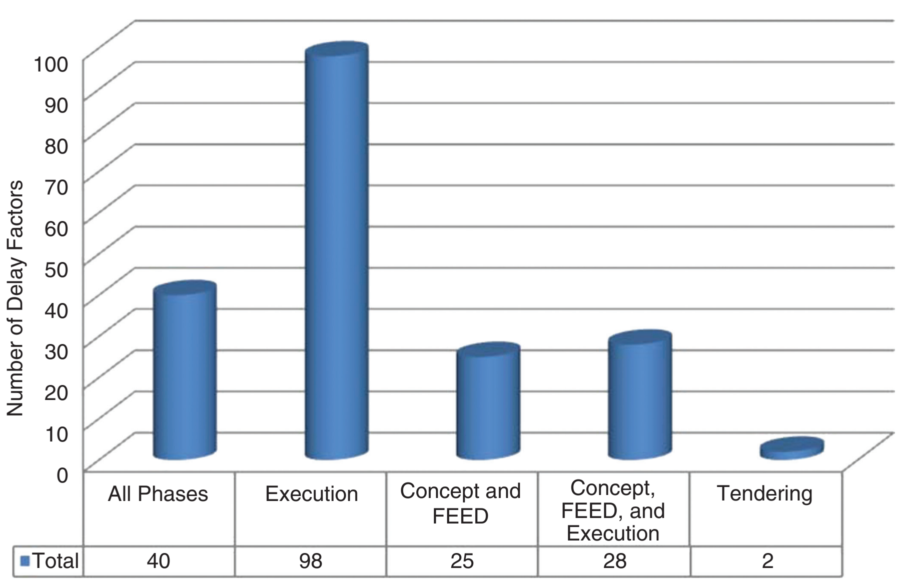
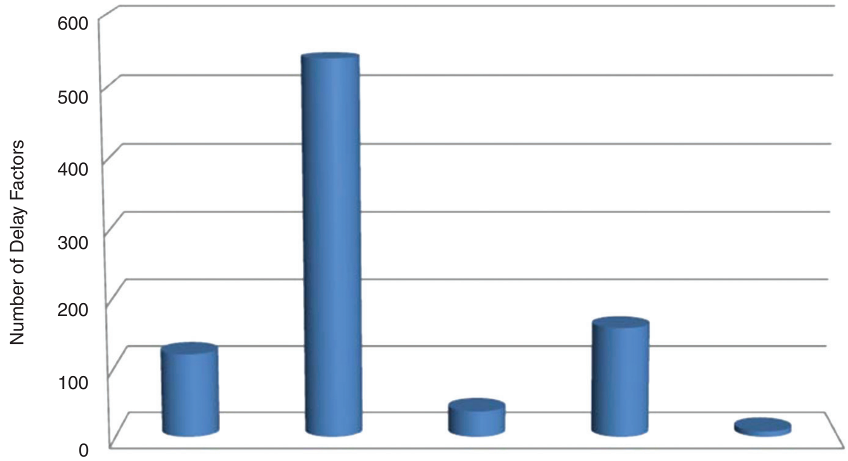


Fig. 6—Delay factors on the basis of the occurrence time—oil and gas projects.



	All Phases	Execution	Concept and FEED	Concept, FEED, and Execution	Tendering
Total issues	120	540	37	158	8

Fig. 7—Delay factors on the basis of the occurrence time—construction projects.

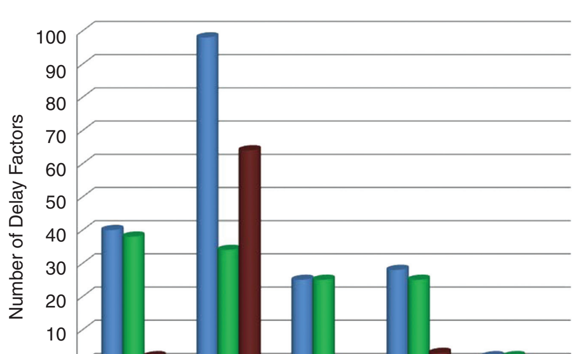
enough and did not integrate with the owners, team, or designers to evaluate the feasibilities of the executions or the critical activities to enable the contractor to start. All of this led to change orders and difficulties in implementation.

3. Late delivery of materials was caused by a lack of communication between the owner and the contractor to approve the purchase orders. This was furthered by a communication gap between the contractor and the manufacturers, leading to delays in delivery and schedule impact.
4. Other major delays were commencing construction without all the engineering completed, land expropriation, inadequate documentation, failure to implement standards, cultural issues, poor cost estimates, insufficient data gathering, delay in mobilization, material delays, poor management, a lack of technical experience, change orders, coordination issues, poor planning, inappropriate contractor selection, and client interference. All of these were caused by a severe lack of communication and integration between client, design consultant, and construction contractor.
5. There are also client-related issues, such as design changes, delay in progress payments, and poor owner participation. Additionally, there are contract issues, such as quality issues, manpower issues, natural calamities/weather conditions, inappropriate project-delivery systems, difficulty in obtaining permits, delay in approvals, financial problems, inappropriate design or design errors, and inappropriate duration of estimates.

Upon completion of the categorization of delay factors from oil-and-gas-, power-, utility-, and pipeline-project-related literature and detailed understanding of the IPD approach, it was found initially that 34 out of 38 of the delay factors related to communication can be resolved during the concept/FEED phase if the stakeholders were integrated at the required time. Twenty-nine factors relating to design can be resolved if the required stakeholders are integrated at the required time, 16 of 18 planning-related factors can be resolved during the early design phase, and 14 out of 25 resource-related factors can be resolved during the design phase (Fig. 11).

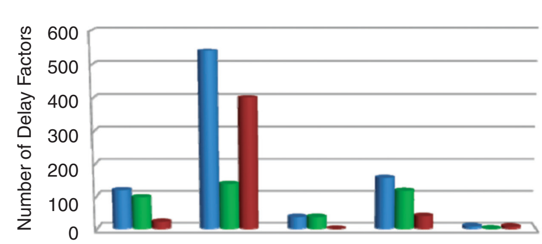
Local Experience

Contractors with the capability to execute design [front-end-engineering design (FEED)] have, in the past, designed and then participated in construction bidding. The strategy of contractor design followed by construction was stopped recently by some owners because the contractor either withheld critical information in the design (FEED) so that it was not released to competitors or sometimes inflated the requirements to mislead competitors. Alternatively, a contractor executing the design could have more details compared with other competitors, leading to the submission of a higher, but more inclusive, bid. This would lead to very low pricing from other bidders, and eventually, after the award of the engineering, procurement, and construction (EPC) to another bidder, change orders or disputes for



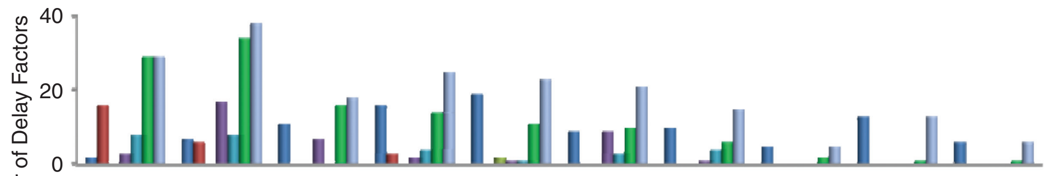
	All Phases	Execution	Concept and FEED	Concept, FEED, and Execution	Tendering
Total	40	98	25	28	2
Resolvable	38	34	25	25	2
Nonresolvable	2	64	0	3	0

Fig. 8—Delay factors resolvable on the basis of the occurrence phase—oil and gas.



	All Phases	Execution	Concept and FEED	Concept, FEED, and Execution	Tendering
Total Issues	120	540	37	158	8
Resolvable	98	139	37	118	1
Nonresolvable	22	401	0	40	7

Fig. 9—Delay factors resolvable on the basis of the occurrence phase—construction projects.



	Design	Commun-ication	Planning	Resources	Contract	Manage-ment	Quality	Regulation/Policy	Procure-ment	Environ-ment
Execution	2	7	11	16	19	9	10	5	13	6
Concept and FEED	16	6		3						
Tendering					2					
All Phases	3	17	7	2	1	9	1			
Concept, FEED, and Execution	8	8		4	1	3	4			
Issues Resolvable	29	34	16	14	11	10	6	2	1	1
Grand Total	29	38	18	25	23	21	15	5	13	6

Fig. 10—Delay factors that can be resolved during the design phase—oil and gas, power-plant, utility, and pipeline projects.

compensation would begin. This is the reason that participation of a single contractor during the FEED design is discouraged by owners.

A lessons-learned workshop was conducted in 2013 to identify the major causes behind delays of the last five gigaprojects. Workshops included the majority of key stakeholders, including the project-management teams (PMTs) representing the owners, the PMTs representing the EPC contractors, project-management consultant teams, and major-vendor representatives. The main objective of the workshop was to allow the EPC contractors to express the delay factors caused by the owners. There was a consensus from three of the contractors that a lack of information during FEED, overdesign, and poor FEED led to major uncertainties and high-risk assumptions. It was also recorded that late document approvals by the owners were a major delay contributor. These collective delay factors were similar to the construction-project-delay factors; therefore, the workshop delay factors **(Table 3)** were added to the construction-project-delay factors. It was discovered locally that many factors that related to construction projects in literature also related to oil and gas projects; however, not all factors were mentioned in the oil and gas discussion, and therefore they were added to enhance the list.

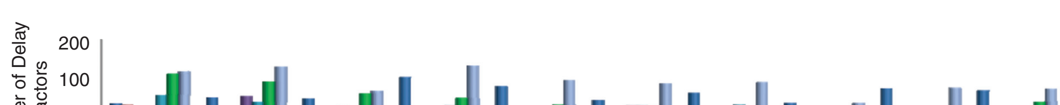
Various Oil and Gas Project Strategies in Literature

The StageGate® model is the most commonly used model for execution of oil and gas projects. It encourages collaboration across stages and underpins the process with appropriate system support (Barton 2013). Barton (2013) also extends his view on the benefits of StageGate, which are less rework in front-end engineering design (FEED), improved cycle time for certain stages, and reduced impact on the punch list from handoff to operations. The StageGate model is supported by each stage with clearly defined deliverables, thereby ensuring effective risk management. **Fig. 12** shows a typical StageGate model used in oil and gas projects.

The StageGate process ensures that the project passes through check posts or formal gates at well-defined milestones within the project's life cycle before receiving approval or funds to proceed to the next stage of work (Barton 2013). Each stage typically encompasses the elements outlined in the following.

The assess stage, with a duration of between 2 and 4 months (also called a feasibility study), is the stage during which option identification, construction methodology, screening studies, preliminary site investigation, field-development plans, process requirements, schedule and budget cost development, and the selection stage are all developed. The concept-selection stage, with a duration average of between 4 and 8 months, is used to develop site investigation, flow schematics, mapping, layouts and geographical information, selection of codes and standards, environmental and social consequences, risk assessments, project-cost estimates, and overall economics, and to define the stage.

The FEED stage, with duration between 8 and 14 months, is dependent on the available details from the owner and the scope details for the construction phase. A FEED consultant develops the project basis of design, process, hydraulic- and multiphase-flow



	Design	Commun-ication	Planning	Resources	Contract	Manage-ment	Quality	Regulation /Policy	Procure-ment	Environ-ment
Execution	28	44	41	99	74	36	57	29	69	63
Concept and FEED	24	3		6		1	1		1	1
Tendering					6	2				
All Phases	12	49	20	4	10	22	3			
Concept, FEED, and Execution	52	32	1	22	1	22	25			3
Issues Resolvable	107	87	56	42	25	18	17	5	4	32
Grand Total	116	128	62	131	91	83	86	29	70	67

Fig. 11—Categorywise delay factors that can be resolved during the design phase—construction projects.

Delay Factors From Lessons-Learned Workshop

Conflicts during construction	Improper construction-milestone definition
Conflicts of the drawing and specification	Improper technical study by the contractor during the bidding stage
Contract modifications	Inaccuracy of materials estimate
Contract negotiations	Inadequate progress review
Delay caused by contractor	Increase in quantities
Delays in construction	Lack of integration of skills at early stage of planning and design
Delays in site preparation	Liquidated damage
Design changes	Location
Disagreements or modifications on specifications	Material changes in types and specifications during construction
Excessive contracts and subcontracts	Overdesign
Failures	Poor qualification of consultant engineer's staff assigned to the project
Frequent change of project staff	Regulatory changes
Frequent change of subcontractors because of their inefficient work	Shortage of equipment
High performance or quality expectations	Time extensions
Improper codes used for design	Unrealistic client initial requirement
	Waiting for information

Table 3—Delay factors that were captured from the local lessons-learned workshop.

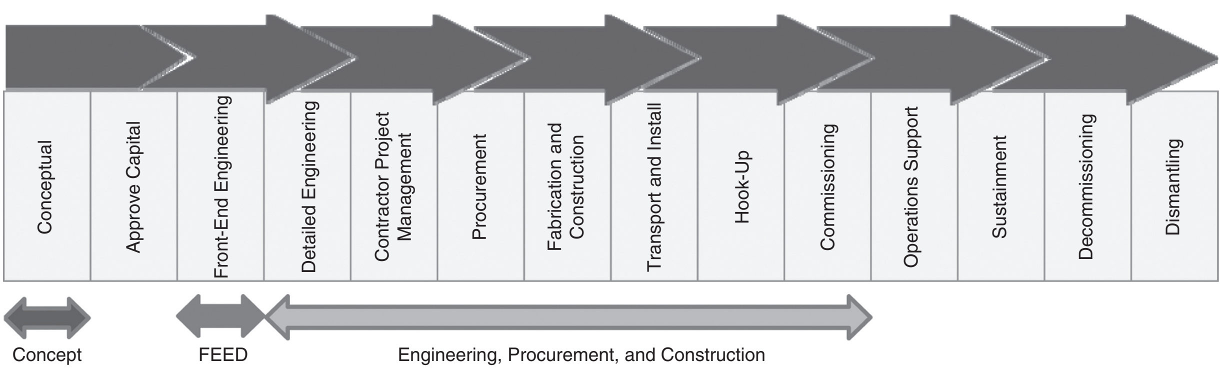


Fig. 12—StageGate® model for oil and gas projects (Barton 2013).

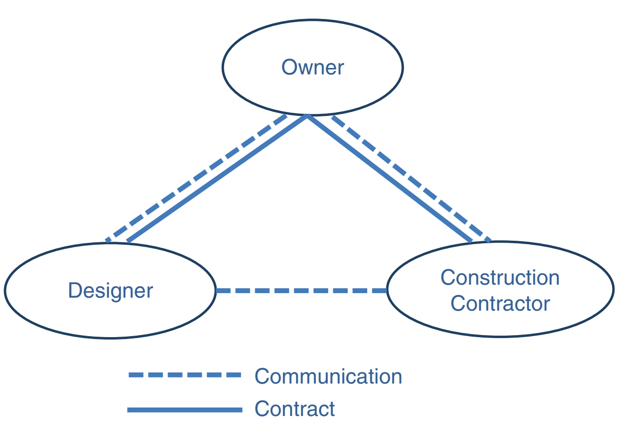


Fig. 13—DBB method [adapted from American Institute of Architects (AIA and California Council 1996)].

analysis, and operability, process, utility flow, piping and instrumentation diagram, hazardous operation, hazard-identification reviews, schedules, and cost estimates together with environmental-impact assessments; value engineering; authority liaison; quality assurance; and health, safety, and environment definition to finally produce a FEED package with an engineering, procurement, and construction (EPC) scope-of-work package. This allows the owner to float the EPC tender to contractors; the tendering duration is between 6 and 12 months depending on the size of the tender and the complexity of the work. After the EPC tender is completed, the EPC contractor commences the execution. The EPC stage is also called the execution stage. The contractor will have further detailed engineering and procurement roles in addition to his construction capabilities. The duration of this stage varies between 20 and 48 months. During this stage, the contractor produces a detailed design; final process- and utility-flow diagrams; final piping and instrumentation diagrams; civil, mechanical, electrical, control and instrumentation, telecommunications, specifications, and procurement packages; third-party reviews to produce project materials; and, finally, constructs the scope. The

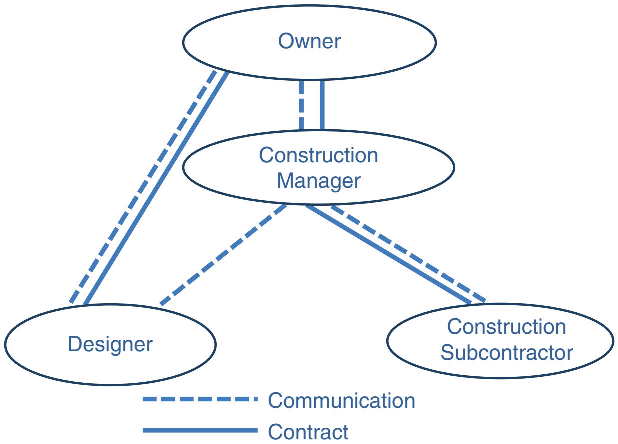


Fig. 14—CM@R method [adapted from American Institute of Architects (AIA and California Council 1996)].

last phase is the operating and maintenance phase, during which the project is handed over to the end users for production and operation.

The current execution strategy has three project-delivery methods for owners: design/bid/build (DBB), construction manager at risk (CM@R), and design/build (DB) execution.

The DBB project-delivery method (also referred to as the traditional project-delivery method) was the most frequently used method for project execution during the early 1970s and 1980s. This delivery method focused on maintaining three separate phases: design, bid, and build/construction, with almost no overlap. There are three different entities in this type of project delivery: owner, designer (concept/ FEED), and construction (EPC) management. **Fig. 13** shows the typical DBB model.

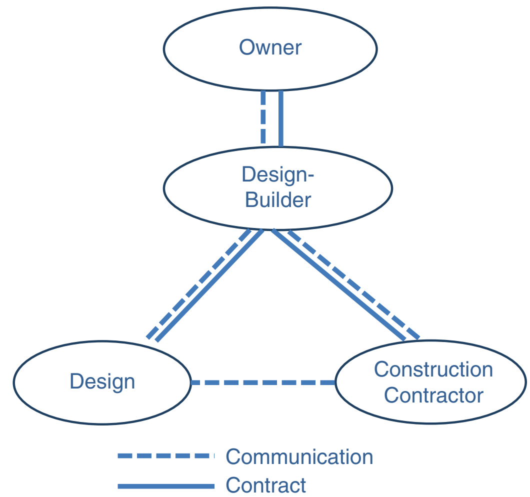


Fig. 15—DB method [adapted from American Institute of Architects (AIA and California Council 1996)].

CM@R allows the owner to nominate, during the design, a second party (also called the project-management consultant) with construction-related qualification and experience on a fixed-price or cost-plus-incentive basis. The second party that is nominated will be a firm or entity that will be represented as a "construction manager." This project-delivery model is a variant to the traditional DBB model in such a way that the responsibility of achieving the project schedule within the estimated cost lies with the construction manager, who will be nominated on the basis of experience and qualification by the owner to provide inputs during the design phase and to handle the construction phase with separate subcontracts. **Fig. 14** shows the typical CM@R model.

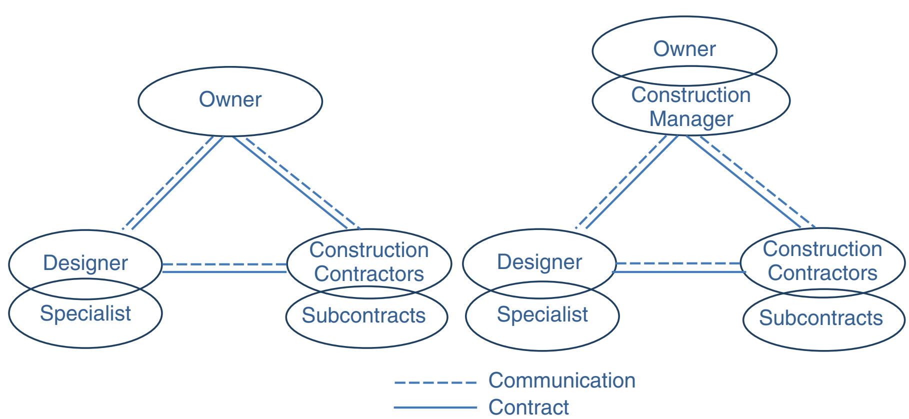


Fig. 16—Integrated-project-delivery method.

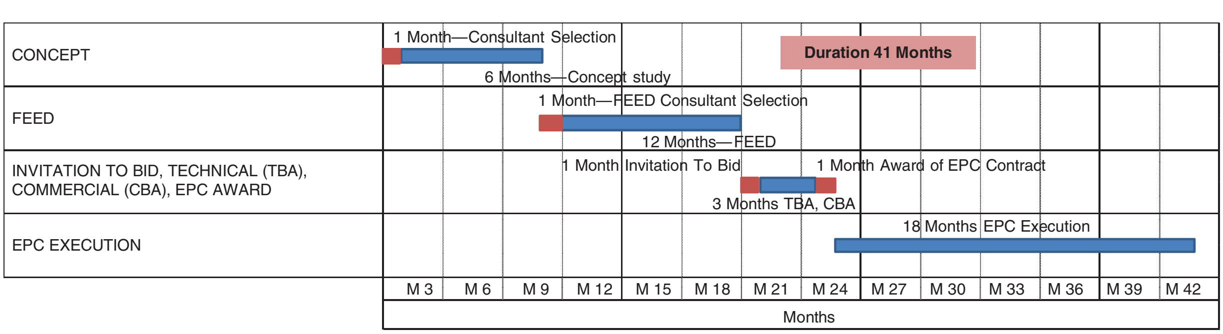


Fig. 17—Typical traditional project-execution schedule, including all phases and stages.

Code	Finding (All Project Types)	Code	Finding (All Project Types)
Communication		Communication	
C1	Client participation	C13	Joint ownership of project
C2	Conflicts/disputes	C14	Lack of communication between engineers/stakeholders
C3	Delay in approval during construction	C15	Lack of effective managing and controlling subcontractors
C4	Delay in approval of major changes	C16	Lack of integration of skills at early stage of planning and design
C5	Delayed approval of design documents	C17	Lack of IT use in communication and information management
C6	Delayed design information	C18	Lack of mechanism for recording, analyzing, and transferring project lessons learned
C7	Excessive bureaucracy in owner's organization	C19	Owner interference
C8	Improper documentation of project objectives	C20	Poor documentation
C9	Inadequate design-team experience	C21	Poor site management and supervision
C10	Inappropriate overall organizational structure linking all project teams	C22	Slow decision making and lack of staff involvement
C11	Insufficient team building	C23	Social and cultural factor
C12	Issues regarding permissions/approvals from other stakeholders	C24	Unforeseen ground conditions or insufficient site data
Design		Design	
D1	Delay in preparation of shop drawings and material samples	D15	Improper technical study by the contractor during the bidding stage
D2	Change orders	D16	Inadequate design-team experience
D3	Conflicts/disputes	D17	Inadequate project-scope definition
D4	Conflicts of the drawing and specification	D18	Incomplete drawings/specifications/documents
D5	Delayed approval of design documents	D19	Inconsistency of technical specifications
D6	Delayed design information	D20	Increase in quantities
D7	Delays in producing design documents	D21	Insufficient design information
D8	Design changes	D22	Material changes in types and specifications during construction
D9	Design complexity	D23	Megasized projects
D10	Design variations or changes in client requirement	D24	Mistakes and discrepancies in design
D11	Disagreements or modifications on specifications	D25	Obsolete technology
D12	Engineering clear roles and goals	D26	Overdesign
D13	Improper/outdated design software	D27	Rework
D14	Improper codes used for design	D28	Unforeseen ground conditions or insufficient site data
Planning		Planning	
P1	Improper construction-milestone definition	P6	Incomplete or inaccurate cost estimate
P2	Improper planning	P7	Lack of effective management
P3	Inaccuracy of materials estimate	P8	Poor estimation of labor productivity
P4	Inadequate or improper planning	P9	Time extensions
P5	Inappropriate overall organizational structure linking all project teams		

Table 4—Resolvable factors; all projects—communication, design, and planning.

The DB project-delivery method has gained popularity more recently because of the single contract between the owner and the design builder. The guaranteed maximum price (GMP) is provided early by the design builder on the basis of the design inputs from the designer nominated. The DB model is in a way more suitable for a risk-averse owner, wherein the contract between the owner and design builder is formed on the GMP, and the entire liability of adhering to the schedule and cost commitments are on the design builder. The DB model is also different from the CM@R model in that there is no direct communication or contract between the owner and the designer or between the owner and the construction contractors/suppliers/specialists. **Fig. 15** shows the typical DB delivery method. The IPD model enables a direct communication and multiparty contract between all stakeholders. **Fig. 16** shows a typical IPD model for project delivery (AIA 2007).

The typical schedule for a traditional delivery method is approximately 41 to 56 months **(Fig. 17).** The duration depends on various

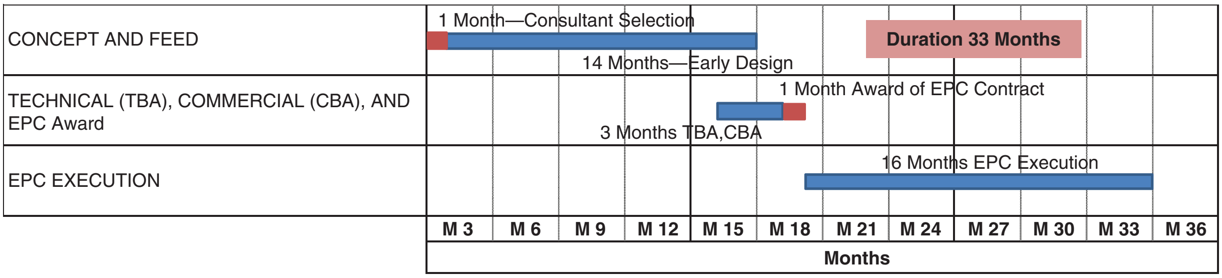


Fig. 18—Typical IPD project-execution schedule, including all phases and stages.

factors and elements. The EPC execution (construction phase) is considered the longest phase during the project life cycle.

Strategy for Integrated Project Delivery (IPD)

The proposed IPD strategy will ensure that necessary stakeholders are involved during the design phase and that each possible delay factor will be tackled with a solution by integrating them at the required time and event during each project phase, mainly during the concept/FEED phase (early phases), before any contractual obligation restricts the possible mitigation measures to overcome the problems that may arise during construction. The same approach can be extended during the concept phase to bring the owner with other required stakeholders. As examples, the concept-design consultant and the owner will be collaborating along with the end user at a very early stage, such as the design-concept phase, during which the owner will ensure that the ultimate objectives of the project are communicated and documented clearly and the concept-design consultant will ensure that these objectives are captured and defined and that the requirements are well-developed. In addition, the end users (operating and maintenance stakeholders) will be involved and integrated with the team at the concept stage to ensure that all concerns are captured with the buy-in from the owner. As explained previously, the contributions of contractors and manufacturers during the FEED design will capture the concerns of the stakeholders. The initial framework will take each possible delay factor that could be resolved within the identified time frame and with involvement of related stakeholders.

On the basis of the data sampling, the factors related to design, communication, and planning have been analyzed separately because most authors have listed the delay factors under these three categories as the highest-rated factors causing delays in projects. The resolvable delay factors under design, communication, and planning have been listed in **Table 4.**

From the initial study, it can be seen that during the design phase, other delay factors that occurred at various phases/stages can also be resolved and reduced at early phase during the design.

Involving all EPC bidders and major vendors during the design will reduce the uncertainties for the executors (EPC contractor) and will allow them to propose alternative solutions if they are feasible and cost effective to them. This means that all the involved parties will have the opportunity to express their concerns at an early stage (FEED) and may drive the design and client to accept the change if feasible. The same could be accomplished with the major vendors (manufacturers); they will have the opportunity to present their concerns and propose their new ideas before freezing the design. At the end of the design, all parties will accept the proposed design and understand the client decision on the selected design and technologies.

With more information available during early design because of the involvement of construction contractors, more-precise work can be performed in the design detailing. With a reduction in the number of assumptions, more-realistic schedules can be developed. A 3D model can be developed with such detailed information. In addition to the preceding, the tendering phase will be shortened because the same will be implemented during early design. The time float generally estimated for the execution phase is lesser because the design is performed with all procurement- and constructability-related information from stakeholders, thereby the number of changes/variations in design or changes in stakeholder expectations is fewer. The impact of implementing IPD strategy is presented in **Fig. 18.**

Conclusion

Despite the advancement in research and technology in renewable energy sources, fossil fuels still top the chart with 78.2% of global consumption. Approximately 70% of energy-supply investment today is related to fossil fuels (IEA 2014). With the depleting reserves of oil and gas worldwide and the rising cost of material and manpower, the cost of oil and gas recovery, refining, and transportation has increased greatly. Also, with the increasing complexity of the projects, there have been substantial delays in oil and gas projects worldwide (EY 2014). The existing project-delivery methods have their own limitations and could not improve the project performance, and they raise the need for more-collaborative project-delivery methods to meet the challenges of reduced budget and time constraints and high-quality safety and reliability standards. Even though integrated project delivery (IPD) has not been implemented on a large scale in oil and gas projects, it has been implemented successfully in several building projects with measurable benefits. Even though it is too early to commit on the level of collaboration possible in oil and gas projects and the extent of contractual modification that can happen between the hundreds of entities in oil and gas gigaprojects, with more investment for research and study of the IPD method, more-quantified and -structured implementation methods can be developed and the project performance can be measured quantitatively. With the rising complexity and the growing demand for better and reliable project outcomes, IPD can evolve to suit the needs of the oil and gas sector.

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