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Critical Construction Activities of the Oil and Gas Projects in Malaysia

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ABSTRACT

The construction phase is a critical part of any oil and gas project. Thus, most project management companies managing Engineering, Procurement, and Construction (EPC) contracts are optimising the activities within the construction phase to expedite the project in general. Understanding the critical activities of the construction phase will enable the optimisation process for the project effectively. This paper aims to investigate the critical construction activities of the oil and gas projects in Malaysia. A systematic literature review (SLR) from various sources through books, conference proceedings, project management documents, and oil and gas industry journals were made to write this paper. Some studies classified the activities as direct activities linking to the actual discipline of the work done and some as indirect activities which form the actual construction phase. This early study is derived purely from literature review, cross referencing, and critical judging. The critical construction activities of the oil and gas projects in Malaysia should be further studied with focus only in the Malaysian projects and industry players.

Keywords:
Critical Construction Activities, Oil and Gas Projects, Malaysia

1. Introduction

The oil and gas industry in Malaysia started in 1910 with the first oil well managed by Shell drilled in Miri with a production of 83 barrels per day (bbls/d) and over the years it has maxed out at 15,000 bbls/d [1]. This also marked the start of the involvement of multinational corporations (MNCs) such as Exxon and Shell in the Malaysian oil and gas field where they were given rights to explore and produce in return for payment of royalty and taxes to the government under the Petroleum Mining Act 1966 (Act 95) [2]. The Petroleum Mining Act 1966 (Act 95) was changed to Petroleum Development Act (PDA 1974) under the New Economic Plan (1971) with the establishment of Petroliam Nasional Berhad (PETRONAS) to steward the governing of the resource [3, 4].

The oil and gas industry plays a major role in the energy sector in Malaysia because energy consumption in Malaysia comes primarily from oil, then followed by electricity and Liquid Natural Gas (LNG) [1]. The Malaysian Investment Development Authority (MIDA) [5] has stipulated that the oil and gas industry is an important sector that will continue its future growth due to the main factor that it contributes around 20 per cent to Malaysia's (GDP) currently. The development of this industry

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from the early stages has shown a huge potential in the growth of the Malaysian economy, taking the number two place as the largest producer of oil in South East Asia behind Indonesia [1].

An independent report from BMI (2017) on the current Malaysian oil and gas industry indicates a positive and strong growth in terms of forecasted production for raw products and for by-products. Backed by strong commitments from PETRONAS, the oil and gas industry in Malaysia is expected to continuously grow with a minimum stable increase of 5 percent from 2010 to 2020 [6]. Hence, it clearly shows the prominence of this industry in the economic front of Malaysia with continuous growth and possibility to steward the country's economy.

2. Literature Review

The oil and gas industry is divided into three main sectors namely upstream, midstream and downstream [7]. The upstream concentrates on exploration and production which covers facilities for production and processing of oil and gas; whereas midstream covers transportation, storage and marketing of the raw product; and downstream focuses on refining of the raw products and distribution of the by-products [7, 8]. The oil and gas projects falls under the upstream sector where it covers the construction of facilities such as subsea developments, offshore platforms, semi-submersibles, Single Point Anchor Reservoir (SPARs), Tension Leg Platforms (TLPs) and Floating Production Storage and Offloading (FPSOs) [9, 10]. However, the oil and gas projects also cover construction of pipelines for transportations, storage tanks, terminal and refineries which falls under midstream and downstream sectors.

According to the Malaysian Construction Industry Development Board (CIDB) (2016), the oil and gas projects is classified as part of the construction industry in Malaysia and is considered a major part of the construction industry in Malaysia where in 2015/2016 two of five largest private projects were oil and gas projects. The two projects were namely the Engineering, Procurement, Construction and Commissioning (EPCC) of Independent Deepwater Petroleum Terminal Phase at Pengerang, Johor and Piping and Associated Facilities (PAF) EPCC Contract at PETRONAS LNG Complex (PLC), Bintulu, Sarawak [11].

To attain the best output of any project, it's necessary to manage the oil and gas projects with sufficient project control and the right personnel from the early stages [12]. Project controls are mainly managed and executed with various contracts such as Engineering, Procurement and Construction (EPC), Engineering, Procurement, Construction and Installation (EPCI), and Lump Sum Turn Key (LSTK) [12, 13]. The personnel involved are normally the stakeholders and commonly in oil and gas projects, they are the project owner, Project Management Team (PMT), Project Management Consultant (PMC), contractor, subcontractor, equipment vendors and suppliers, insurance institute as well as financial institute [14, 15].

2.1 Construction Phase in Oil and Gas Projects

The construction industry plays an important role in the socioeconomic development of a country providing crucial infrastructures, employment opportunities and expansion opportunity for supporting industries [16]. It is clear that the construction industry is one of the vital sectors that contributes to the Malaysian economy and holds an important role in providing job opportunities as well as contributing to the development of various supporting industries [17].

The construction project life cycle which is commonly segregated to conceptual design, preliminary design, detailed design, construction and testing, commissioning and handover if grouped under the term of Engineering, Procurement and Construction (EPC), the conceptual design,

preliminary design, detailed design, are covered under the Engineering (E) and Procurement (P) category and the construction and testing, commissioning, and handover, is covered under the Construction (C) section [18, 19].

Even though all three aspects of EPC are crucial to the delivery of a successful project, past studies have linked the emphasis on the planning stage to ensure that the subsequent parts are executed without any issues [20, 21]. Major oil companies involved in the oil and gas projects are continuously optimising the processes to successfully complete oil and gas construction project by improving the different phases with emphasis on planning, human resources and monitoring performances [22]. Understanding the importance of the critical activities in the construction phase of the oil and gas project is important to optimise the outcome of the whole project to be delivered within schedule, budget and good quality.

2.2 Activities in the Construction Phase of the Oil and Gas Projects

Past studies or references have categorised the activities in the construction phase in various different ways. Some studies have listed the activities by the end product such as Floating Production Storage and Offloading (FPSOs), offshore platforms, subsea works, structural jacket and Tension Leg Platforms (TLPs) [9, 10, 23-25]. Some activities were common in most projects such as structural and piping works but some were specific to certain type of platform, such as fixed concrete base of structure which requires concrete premix and underwater concrete works [23]. Some activities were based on modification process such as revamp of an oil tanker hull for a new Floating, Storage and Offloading (FSO) facility [9].

Other studies emphasise on the direct activities by disciplines, such as piping installation, structural welding, electrical and instrumentation installation [26-30]. Some major oil and gas companies have categorised the activities in a procedural format or construction sequence which can be classified as indirect activities such as planning and scheduling, mobilisation of personnel, control and monitoring of progress and commissioning activities [19, 31-33]. Based purely on literature review, comparison of similar cases, cross referencing, and critical judging of the activities involved in the construction phase of the oil and gas projects, this paper will focus on the direct and indirect activities only as aforementioned.

According to Badiru and Osisanya [19], the construction phase of a project consists of various activities, starting from planning and scheduling, mobilisation of personnel and equipment, followed by execution of the work, management of resources/procurement, managing the quality with inspection activities, management of the progress with control and monitoring tools to the approval stage, and finally testing and commissioning works prior to handover and start-up. All these activities which are completed by different stakeholders having contractual responsibilities to finalise a particular section of the construction phase requires coordination to complete the project successfully to the required specification [19].

Some reference has shown that depending on the size of the project and duration of the activity based on contracting mechanisms, activities might vary due to the complexity of the work ranging from agreed day rates to lump sum prices [31]. According to Petroleum Development Oman L.L.C. (PDO) (2012), the key construction activities has been listed as follows:

(i) Input in design and confirmation of work scope.

(ii) Site establishment including offices, lay down, specialist storage, welfare facilities, local fabrication areas, workforce accommodation (for example onshore camp) supply base and staging points.

(iii) Set up and maintenance of material management system including tracking, receipt, handling, storage and preservation and installation.

(iv) Identification and recruitment of competent contractors and resources and where applicable the development of local content strategies and plans.

(v) Construction sequencing and planning and resource loading, including levels and competencies of personnel.

(vi) Job hazard analysis and development of construction methodologies, for example 'stick build' versus modularisation strategies.

(vii) Development of work packs and inspection and testing plans.

(viii) Fabrication of structures, piping and installation of major items of equipment, for example vessels, compressors.

(ix) Specification and procurement of specialised installation/construction equipment e.g. heavy lift equipment.

(x) Logistics associated with the mobilisation of personnel, equipment and materials.

(xi) Mechanical completion leading on to pre-commissioning of all utility and process systems

(xii) Commissioning and Start-Up (CSU) Team for live commissioning, start up and operations.

These activities listed by PDO [31] are only the key activities and it should be noted that the construction activities are not limited to only these activities. Other reference such as PETRONAS (2013) indicated that the fabrication and construction activities are based on the location of the development either onshore, offshore, or subsea and if it is a new development or modification. According to PETRONAS [32], the main construction activities includes the following:

(i) Management, planning and scheduling the fabrication or construction activities.

(ii) Review of design drawings and preparation of shop drawings, weight control and the final documentation.

(iii) Site survey, clearance, and preparation for the onshore construction project.

(iv) Fabrication of structural components at onshore fabrication yards for the offshore part of the project.

(v) Pre-fabrication of process system packages at the vendors' worksites.

(vi) Installation of system packages at the fabrication yards.

(vii) The maximisation of systems and equipment pre-commissioning at the onshore fabrication yards.

(viii) Load out and fastening of fabricated components.

(ix) The coating of linepipes at the onshore coating yards.

Another criterion of activities used for this study is the direct activities, which is based on discipline. Brown and Potts [26] mentioned control system, electrical, fire and gas, instrumentation, mechanical, piping, steel and telecom (communication) as some of the disciplines involved in the activities. Similarly, Saadawi [27] as well as Constant and Ramat [29] also mentioned some of the same activities. Schmidt [28] claimed similar activities but had additional activities such as Heating, Ventilation, and Air-Conditioning (HVAC) and surface protection. Likewise, Al Yabhouni and Harrison [30] proposed an additional activity which is in regards to concrete.

3. Methodology

The method of content analysis via a systematic literature review (SLR) was conducted to identify and classify the list of critical activities by combining results from relevant sources [34]. This initial study is based purely on literature review, cross referencing, and critical judging which does not require primary and complex data collection via survey method. A content analysis was conducted

by conceptual analysis, focusing on specific code in the literature review and collecting them to be tabulated [35], where for the purpose of this study, construction activity of oil and gas project is selected as the code.

The activities listed from Badiru and Osisanya [19], PDO [31], PETRONAS [32] is classified as indirect activities for this study. The compiled list of indirect construction activities from the three resources is shown in Table 1 portraying them under the same construction stage since most of the activities imply the same meaning even though it is described with a bit of difference. The indirect activities in construction phase listed are proposed by this study to be segregated into planning and execution stage of construction in order to further add value to Table 1.

Table 1
List of indirect activities in the construction phase

Badiru and Osisanya [19]	PDO [31]	PETRONAS [32]	Construction Stage
Planning and scheduling	Input in design and confirmation of work scope	Management, planning and scheduling the fabrication or construction activities	Planning
Mobilisation	Site establishment including offices, lay down, specialist storage, welfare facilities, local fabrication areas, workforce accommodation (such as onshore camp) supply base and staging points	Site survey, clearance, and preparation for the onshore construction project	
	Identification and recruitment of competent contractors and resources and where applicable the development of local content strategies and plans.	X	
Management of resources or procurement	Set up and maintenance of Material management system including tracking, receipt, handling, storage and preservation and installation	X	
	Logistics associated with the mobilisation of personnel, equipment and materials	X	
Execution of work	Construction sequencing and planning and resource loading, including levels and competencies of personnel	Review of design drawings and preparation of shop drawings, weight control and the final documentation	Execution
	Fabrication of structures, piping and installation of major items of equipment, namely vessels and compressors	Fabrication of structural components at onshore fabrication yards for the offshore part of the project	

	X	Pre-fabrication of process system packages at the vendor's worksites	
	X	Installation of system packages at the fabrication yards	
	X	Maximisation of systems and equipment pre-commissioning at the onshore fabrication yards	
Control and monitoring	Job hazard analysis and development of construction methodologies, namely 'stick build' versus modularisation strategies	X	
	Development of work packs and inspection and testing plans	X	
X	Specification and procurement of specialised installation/construction equipment, namely heavy lift equipment	Load out and fastening of fabricated components	
X	X	The coating of linepipes at the onshore coating yards	
Quality and inspection activities	Mechanical completion leading on to pre-commissioning of all utility and process systems	X	
Approval, testing and commissioning works	Commissioning and Start-Up (CSU) Team for live commissioning, start up and operations	X	

(Source: Edited from Badiru and Osisanya [19]; PDO [31]; PETRONAS [32]

Since the direct activities are based purely on discipline, the direct list of activities or types of discipline is extracted from various source namely Brown and Potts [26], Saadawi [27], Schmidt [28], Constant and Ramat [29] and Al Yabhouni and Harrison [30] as shown in Table 2. This list of direct activities is sorted by this study in accordance with similar activities since the different references used different terminology to indicate the same type of activities.

Table 2
List of direct activities in the construction phase

Brown and Potts [26]	Saadawi [27]	Schmidt [28]	Constant and Ramat [29]	Al Yabhouni and Harrison [30]
X	X	X	X	Concrete
Control System	Control System	X	Control System	X
Electrical	Electrical	Electrical	Electrical	Electrical
Fire and Gas	Fire and Gas	Fire and Gas	Fire and Gas	X
X	X	HVAC	X	X
Instrumentation	X	Instrumentation	Instrumentation	Instrumentation

Mechanical	Mechanical	Mechanical Process Equipment	Mechanical	Mechanical Process Equipment
Piping	Piping	Piping	Piping	Piping
Structural/Steel	X	Structural/Steel	Structural/Steel	Structural/Steel
X	X	Surface Protection	X	Surface Protection
Telecom	X	X	X	X

From Table 2, the direct activities for this study is determined as concrete, control system, electrical, fire and gas, HVAC, instrumentation, mechanical/process equipment, piping, structural/steel, surface protection and telecom.

4. Results and Findings

Based on the previous two tables (Table 1 and Table 2) with direct and indirect activities that were populated, a complete list of direct and indirect activities was developed as per Table 3 with the direct and indirect marking. The indirect activities were made into smaller components to capture every aspect of the indirect activities.

Table 3
Lists of direct and indirect construction activities

Construction Activities - Indirect	
CI1	Planning and Scheduling - Contract Details
CI2	Preparation - Work scope/Work packs/Job cards
CI3	Mobilisation - Site Preparation/Location/Area
CI4	Mobilisation - Equipment
CI5	Mobilisation - Personnel
CI6	Logistics Management - Material/Procurement
CI7	Logistics Management - Personnel
CI8	Construction Study - Documents, Drawings, Datasheet, Analysis, Risk Document
CI9	Construction Study - Methodologies, Plans, Procedures, Risk Mitigation
CI10	Onshore Fabrication - Structural/Piping/Equipment/Mechanical
CI11	Onshore Fabrication - vendor equipment
CI12	Onshore Installation - Equipment
CI13	Onshore - Surface protection - Coating, Personnel Protection, Passive Fire Protection
CI14	Onshore - Quality inspection
CI15	Onshore - Commissioning/Factory Acceptance Test (FAT)
CI16	Transportation - Load-out and sea-fastening
CI17	Offshore installation - Structural/piping/equipment/mechanical
CI18	Offshore installation - Vendor equipment
CI19	Offshore installation - Equipment
CI20	Onshore - Surface protection - Coating, Personnel Protection, Passive Fire Protection
CI21	Offshore - Quality inspection
CI22	Offshore - Mechanical completion/pre-commissioning
CI23	Offshore - Commissioning/Site Acceptance Test (SAT)
CI24	Offshore - Livening-up system
CI25	Offshore - Start-up
CI26	Offshore - Handover - Construction to operations
CI27	Indirect - Miscellaneous
Construction Activities - Direct	

CD1	Concrete
CD2	Control system
CD3	Electrical
CD4	Fire and gas
CD5	HVAC
CD6	Instrumentation
CD7	Mechanical/Process Equipment
CD8	Piping
CD9	Structural/steel
CD10	Surface protection
CD11	Telecom
CD12	Direct - Miscellaneous

CI – Construction-Indirect, CD – Construction-Direct

The new list of construction activities that were developed in Table 3 has 27 indirect activities and 12 direct activities. The list of direct and indirect activities was coded to be used for the purpose of questionnaire survey in later stages of continuation of this study.

5. Conclusion

This paper is based purely on literature review, comparison of similar cases, cross referencing and critical judging via a systematic literature review (SLR). The initial findings concluded that the activities involved in the construction phase can be divided into two main category, namely indirect activities and direct activities. None of the indirect or direct activities of the construction phase has been identified as critical at this point of the research of this study and will be further reviewed with questionnaire survey. The critical activities of the construction phase specific to the oil and gas projects in Malaysia should be further researched with focus only in the Malaysian projects and industry players. The understanding from this paper will assist in researching the critical activities of the construction phase of oil and gas projects in Malaysia.

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