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Application of project management method in offshore engineering

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Application of Project Management Method in Offshore Engineering

By

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Research Paper: Application of Project Management Method in Offshore Engineering

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The research paper is a study of project management method in the application of offshore engineering projects, it adopts Analytic Hierarchy Process to analyze qualitative elements such as quality, time and cost.

The author uses investigation method to collect a number of the latest data, summaries worldwide oil and gas production areas and major offshore engineering markets, analyzes the current status and main content of China's offshore engineering market, and predicts the future development trends.

Meanwhile, it introduces the project management theory briefly, describes five processes, establishes analytic model, selects the overseas project BSP as an example and verifies its application in offshore engineering project management.

Lastly, the author rethinks the relationship among and between projects, human beings and the environment based on the engineering philosophy, proposes the existing problems and challenges, discusses the pollution problems in offshore engineering and puts forward practical and feasible solutions.

KEYWORDS: Project Management Method, Offshore Engineering Project, Analytic Hierarchy Process, Environment.

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LIST OF ABBREVIATION

ARCO	Atlantic Richfield Company
bbl	barrel
b/d	barrels per day
BP	British Petroleum
BSP	Brunei Shell Petroleum
CAGR	Compound Annual Growth Rate
CAPEX	capital expenditures
CAPP	Canadian Association of Petroleum Producers
cf	cubic feet
CNOOC	China National Offshore Oil Corporation
CNPC	China National Petroleum Corporation
COOEC	China Offshore Oil Engineering Corporation
COOECIC	China Offshore Oil Engineering Corporation International Company
COSL	China Oilfield Services Limited
EIA	Energy Information Administration (United States)
ENI	Ente Nazionale Idrocarburi (Italy)
EPCI	Engineering, Procurement, Construction and Installation
FID	Final Investment Decision
GoM	Golf of Mexico
IEA	International Energy Agency
IPMA	the International Project Management Association
ISO	the International Organization for Standardization
km	kilometers
KUFPEC	Kuwait Foreign Petroleum Exploration Company
NIOC	National Iranian Oil Company

OECD	Organization for Economic Co-operation and Development
OGJ	Oil & Gas Journal
OPEC	Organization of Petroleum Exporting Countries
PEMEX	Petroleos Mexicanos
PETROBRAS	Brazilian Petroleum Corporation
PMI	the Project Management Institute
PMP	Project Management Professional
SINOPEC	China Petroleum & Chemical Corporation
tcf	trillion cubic feet
UK	United Kingdom of Great Britain and Northern Ireland
U.S.	United States of America

CHAPTER I   INTRODUCTION

1.1 Background Information

Offshore oil and gas resources are natural wealth. They are scarce and nonrenewable. Humans must protect them reasonably and exploit them moderately. Nowadays, almost all of the offshore engineering projects adopt project management mode.

Since 1980s, China has been exploited offshore oil and gas resources, allowing foreign companies to participate in the offshore exploitation in the form of joint ventures and cooperation. Chinese companies have also engaged in offshore engineering activities. In cooperation with foreign companies, domestic engineering companies have gradually formed the basic concepts and perceptions of project management. Nevertheless, under the highly centralized planned economy system, the companies did not choose project management method and procedures at that time.

With the rapid growth of internationalization, China's offshore engineering companies continue undertaking overseas projects, and many problems have also arisen among them. However, current project management has the problems of extensive use of resources, low management level, and the negligence of the marine ecological environment during operations, which has destroyed the environment and caused the enormous waste of resources.

As the increase of the public awareness of environment protection and energy crisis, the situation must keep pace with the time. Project management can be introduced to solve the dilemma to achieve the balance of the environment protection and profits.

1.2 Objective of Research

There is only qualitative analysis, lacking quantitative analysis. As a result, it is not objective reflection of the project management performance (Wang, 2016). Therefore, based on the research background and demands, it is necessary to strengthen the management of the projects continuously, by training more professional personnel and drawing lessons from foreign experience to harmonize the requirements of environment protection in projects (Demirkesen & Ozorhon, 2017). We need to study the methods of offshore project management desperately, refine, adjust and improve the methods gradually. In the meantime, combining with domestic conditions, we must establish management procedures and patterns with Chinese characteristics. No safety accidents, the acceleration of progress and cost saving are the key to success, which adapt the increasingly fierce market competition.

1.3 Methodology

This article uses project management theory and analytic hierarchy process to conduct a more systematic research and analysis of offshore project management, utilizes judgment matrices to evaluate the main factors that affects the project, and provide theory and reference for the application of project management (Wang, 2012).

The factors that affect the success of a project are complex, with great uncertainty (Liu, 2013). Due to the lack of relevant data, it is difficult to identify major risk factors. The author conducts the survey of experts and questionnaire with project managers to find out the critical influences, constructs the structure model, compare and rank the weight of importance factors so as to list the major field and propose specific measures.

1.4 Structure of the Paper

Chapter II collects a large sum of data and information, summarizes worldwide oil and gas reserves, concludes global offshore engineering operation areas and activities, and analyzes the status of China’s offshore engineering market.

Chapter III gives a general introduction of project management theory, decomposes the project management processes, outlines the body of knowledge area, and describes the stakeholders in the project.

Chapter IV is the important and innovative part of this paper. It introduces Analytic Hierarchy Process and its application in offshore engineering project in detail. The paper establishes judgment matrixes, conducts consistency check, calculators the weight of the factors, and gets the conclusion of successful project management. By case analysis, the author shows that the project team manages and controls the project based on the theory and applies to these good practices in five processes so as to make the project successfully.

Chapter V is the summary and conclusion of this paper. It gives the criterion of a successful project. Furthermore, it discusses the thought about management philosophy, exposes the confronting problems, and provides the suggestion on environmental protection.

CHAPTER II. WORLDWIDE OFFSHORE ENGINEERING MARKET OVERVIEW

2.1 Overview of Worldwide Oil & Gas Reserves and Production Areas

2.1.1 Summary of Worldwide Oil & Gas Reserves

The below figure shows the distribution of worldwide oil reserves up to 2016. The darker the color is, the greater the reserves will be. We may conclude that the global oil reserves distributed unevenly, mainly concentrated in several major regions. The northern hemisphere has more reserves than the southern hemisphere. From the latitude, petroleum resources are mainly distributed in two latitude zones of Latitude 20 degrees to 40 degrees and 50 degrees to70 degrees.

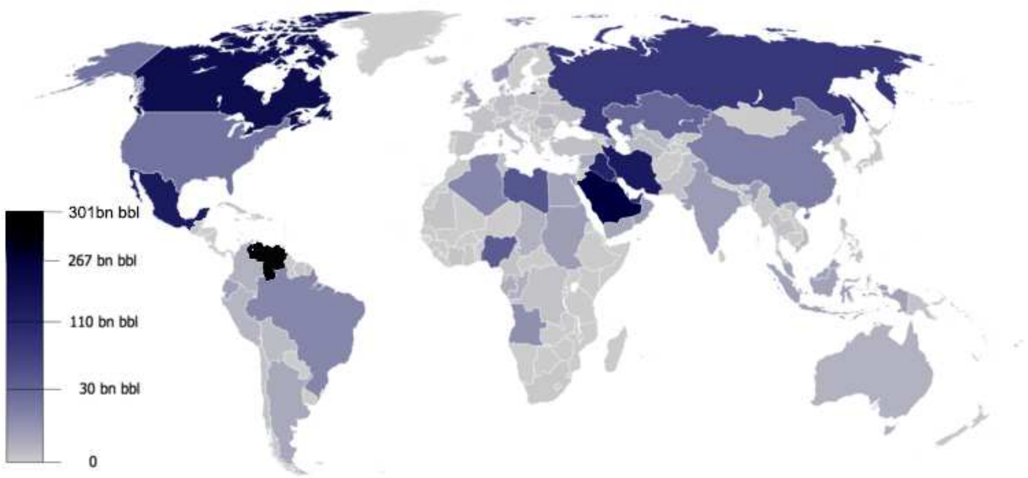

Figure 2.1: Countries by Oil Reserves 2016

Source: OPEC Annual Statistical Bulletin 2016

Table 2.1: Worldwide Oil Reserves and Oil Production

WORLDWIDE LOOK AT RESERVES AND PRODUCTION

	ESTIMATED PROVED RESERVES				OIL PRODUCTION		
	Jan. 1, 2018		Jan. 1, 2017		Estimated	Change	Actual
COUNTRY	Oil, 1,000 bbl[2]	Gas, bcf	Oil, 1,000 bbl	Gas, bcf	2017 1,000 b/d	from 2016 %	2016 1,000 b/d
ASIA-PACIFIC							
Afghanistan	—	1,750	—	1,750	—	—	—
Australia	1,821,000	70,230	1,821,000	70,230	269.0	-6.6	288.0
Bangladesh	28,000	6,560	28,000	7,253	12.0	—	12.0
Brunei	1,100,000	9,200	1,100,000	9,200	101.0	-7.2	108.9
China	25,627,320	192,108	25,620,000	184,419	3,877.0	-3.1	4,002.9
China, Taiwan	2,380	220	2,380	220	0.1	-14.7	0.2
India	4,494,504	45,548	4,622,323	43,344	730.0	-0.3	732.5
Indonesia	3,310,000	101,220	3,600,000	98,000	797.0	-2.9	821.0
Japan	44,115	738	44,115	738	11.0	—	11.0
Malaysia	3,600,000	41,765	3,600,000	41,765	645.0	-2.7	663.2
Myanmar	139,000	22,500	139,000	22,500	11.0	10.0	10.0
New Zealand	51,800	1,190	56,900	1,267	32.1	-7.5	34.8
Pakistan	332,166	20,794	350,630	19,158	91.2	7.6	84.8
Papua New Guinea	183,826	7,435	159,420	4,996	55.0	—	55.0
Philippines	138,500	3,480	138,500	3,480	12.5	33.0	9.4
South Korea	—	250	—	250	0.6	71.4	0.4
Thailand	349,390	6,830	396,360	7,304	240.0	-6.9	257.8
Vietnam	4,400,000	24,700	4,400,000	24,700	280.0	-7.4	302.3
Total Asia-Pacific	**45,622,001**	**556,518**	**46,078,628**	**540,574**	**7,164.6**	**-3.1**	**7,393.9**
WESTERN EUROPE							
Austria	41,200	230	43,000	247	14.6	3.1	14.2
Denmark	439,000	454	490,604	565	137.3	-1.8	139.8
France	65,970	297	72,347	304	15.3	-7.1	16.4
Germany	129,600	1,395	145,440	1,483	43.8	-4.9	46.0
Greece	10,000	35	10,000	35	2.3	-25.0	3.0
Ireland	—	350	—	350	—	—	—
Italy	487,792	1,346	556,720	1,735	69.0	-2.3	70.7
Netherlands	81,129	28,301	113,216	27,780	17.6	0.1	17.6
Norway	6,375,970	62,937	6,610,580	65,543	1,652.4	1.4	1,630.0
Spain	150,000	90	150,000	90	2.0	-25.0	2.7
Turkey	341,600	180	334,500	131	49.4	-0.1	49.4
United Kingdom	2,069,114	6,215	2,564,053	7,319	960.0	1.4	946.4
Total Western Europe	**10,191,375**	**101,830**	**11,090,461**	**105,582**	**2,963.5**	**0.9**	**2,936.1**
EASTERN EUROPE and FSU							
Albania	168,332	29	168,332	29	22.0	-4.0	22.9
Azerbaijan	7,000,000	35,000	7,000,000	35,000	774.5	-5.2	816.6
Belarus	198,000	100	198,000	100	32.0	-1.8	32.6
Bulgaria	15,000	200	15,000	200	1.0	—	1.0
Croatia	71,000	880	71,000	880	14.1	3.2	13.7
Czech Republic	15,000	140	15,000	140	2.0	-13.0	2.3
Georgia	35,000	300	35,000	300	0.4	—	0.4
Hungary	20,400	233	25,100	272	13.8	—	13.8
Kazakhstan	30,000,000	85,000	30,000,000	85,000	1,725.0	8.2	1,595.0
Kyrgyzstan	40,000	200	40,000	200	1.0	—	1.0
Lithuania	12,000	—	12,000	—	2.0	—	2.0
Poland	126,000	2,818	137,752	2,884	22.0	10.0	20.0
Romania	600,000	3,725	600,000	3,725	72.8	-3.6	75.5
Russia	80,000,000	1,688,228	80,000,000	1,688,228	11,001.0	0.7	10,924.0
Serbia	77,500	1,700	77,500	1,700	19.0	-5.0	20.0
Slovakia	9,000	500	9,000	500	—	—	—
Tajikistan	12,000	200	12,000	200	0.2	—	0.2
Turkmenistan	600,000	265,000	600,000	265,000	227.0	-1.3	230.0
Ukraine	395,000	39,000	395,000	39,000	45.0	-7.8	48.8
Uzbekistan	594,000	65,000	594,000	65,000	55.9	-6.4	59.8
Total Eastern Europe and FSU	**119,988,232**	**2,188,253**	**120,004,684**	**2,188,358**	**14,030.7**	**1.1**	**13,879.5**
MIDDLE EAST							
Bahrain	124,560	3,250	124,560	3,250	45.0	-8.2	49.0
Iran	157,200,000	1,190,830	158,400,000	1,183,019	3,797.0	6.9	3,550.8
Iraq	148,766,000	134,896	142,503,000	111,522	4,474.0	1.2	4,420.0
Israel	12,730	6,216	12,730	6,216	1.0	—	1.0

COUNTRY	ESTIMATED PROVED RESERVES — Jan. 1, 2018 — Oil, 1,000 bbl[2]	Jan. 1, 2018 — Gas, bcf	Jan. 1, 2017 — Oil, 1,000 bbl	Jan. 1, 2017 — Gas, bcf	OIL PRODUCTION — Estimated 2017 1,000 b/d	Change from 2016 %	Actual 2016 1,000 b/d
Jordan	1,000	213	1,000	213	—	—	—
Kuwait[1]	101,500,000	63,000	101,500,000	63,000	2,707.0	-6.0	2,880.0
Oman	5,373,000	23,000	5,373,000	23,000	975.0	-4.1	1,016.6
Qatar	25,244,000	850,096	25,244,000	858,098	608.0	-6.3	649.2
Saudi Arabia[1]	266,208,000	304,382	266,455,000	303,284	9,965.0	-4.4	10,420.0
Syria	2,500,000	8,500	2,500,000	8,500	20.0	-30.1	28.6
United Arab Emirates	97,800,000	215,098	97,800,000	215,098	2,934.0	-3.8	3,050.0
Yemen	3,000,000	16,900	3,000,000	16,900	30.0	25.9	23.8
Total Middle East	**807,729,290**	**2,816,381**	**802,913,290**	**2,792,099**	**25,556.0**	**-2.0**	**26,089.0**
AFRICA							
Algeria	12,200,000	159,054	12,200,000	159,054	1,058.0	-4.8	1,110.8
Angola	9,523,000	10,880	8,273,000	10,880	1,649.0	-3.7	1,712.5
Benin	8,000	40	8,000	40	—	—	—
Cameroon	200,000	4,770	200,000	4,770	90.0	-3.5	93.3
Chad	1,500,000	—	1,500,000	—	98.0	-11.0	110.1
Congo (former Zaire)	180,000	35	180,000	35	20.0	—	20.0
Congo Brazzaville	1,600,000	3,200	1,600,000	3,200	303.0	-1.9	308.8
Egypt	4,400,000	77,200	4,400,000	77,200	628.0	-3.6	651.4
Equatorial Guinea	1,100,000	1,300	1,100,000	1,300	192.0	-15.4	227.0
Ethiopia	428	880	428	880	—	—	—
Gabon	2,000,000	1,000	2,000,000	1,000	200.0	-9.1	220.0
Ghana	660,000	800	660,000	800	166.3	65.3	100.6
Ivory Coast	100,000	1,000	100,000	1,000	30.0	—	30.0
Libya	48,363,000	53,144	48,363,000	53,144	760.0	94.5	390.8
Mauritania	20,000	1,000	20,000	1,000	5.0	—	5.0
Morocco	684	51	684	51	—	—	—
Mozambique	—	100,000	—	100,000	—	—	—
Namibia	—	2,200	—	2,200	—	—	—
Niger	150,000	—	150,000	—	—	—	—
Nigeria	37,453,000	193,351	37,062,000	186,610	1,520.0	3.4	1,470.0
Rwanda	—	2,000	—	2,000	—	—	—
Somalia	—	200	—	200	—	—	—
South Africa	15,000	—	15,000	—	2.0	—	2.0
Sudan and South Sudan	5,000,000	3,000	5,000,000	3,000	253.3	-0.7	256.0
Tanzania	—	230	—	230	—	—	—
Tunisia	425,000	2,300	425,000	2,300	43.8	-4.7	45.9
Uganda	2,500,000	500	2,500,000	500	—	—	—
Total Africa	**127,398,112**	**618,136**	**125,757,112**	**611,394**	**7,018.3**	**3.9**	**6,753.2**
WESTERN HEMISPHERE							
Argentina	2,162,207	11,889	2,184,554	11,174	478.0	-6.6	511.6
Barbados	2,534	5	2,082	4	0.7	—	0.7
Belize	6,700	—	6,700	—	4.0	—	4.0
Bolivia	211,450	10,450	211,450	10,450	58.2	0.2	58.1
Brazil	12,633,700	13,328	12,999,800	15,184	2,620.0	4.2	2,515.0
Canada	170,540,000	72,600	169,708,702	77,065	3,900.0	5.7	3,689.0
Chile	150,000	3,460	150,000	3,460	4.0	-9.1	4.4
Colombia	1,665,490	4,024	2,002,000	4,361	851.0	-5.2	897.5
Cuba	124,000	2,500	124,000	2,500	50.0	—	50.0
Ecuador	8,273,000	385	8,273,000	385	536.0	-1.9	546.6
Guatemala	83,070	—	83,070	—	9.5	5.9	9.0
Mexico	6,629,700	9,883	7,258,500	12,064	2,008.0	-6.8	2,154.0
Peru	434,900	16,100	473,000	14,090	43.0	6.6	40.4
Suriname	84,200	—	83,980	—	17.0	4.3	16.3
Trinidad and Tobago	242,982	15,800	242,982	10,600	72.6	1.5	71.5
United States	35,426,795	310,807	35,,230,000	307,730	9,230.0	4.2	8,857.0
Venezuela	302,250,000	202,692	300,878,000	201,343	2,010.0	-10.3	2,240.0
Total Western Hemisphere	**540,920,728**	**673,923**	**539,911,820**	**670,409**	**21,892.0**	**1.0**	**21,665.0**
TOTAL WORLD	**1,651,849,737**	**6,955,040**	**1,645,755,996**	**6,908,416**	**78,625.0**	**-0.1**	**78,716.6**
Total OPEC	**1,217,880,000**	**3,380,109**	**1,210,051,000**	**3,347,736**	**32,410.0**	**-1.5**	**32,887.7**

[1]Includes half of Neutral Zone production. [2]Includes crude oil, lease condensate and oil sands.

Source: Oil & Gas Journal, December 2017 – Special Report

According to the latest Oil & Gas Journal's annual survey of reserves, the worldwide proved crude oil and natural gas reserves grew moderately. The new estimation of worldwide crude oil reserves is 1,651 trillion bbl, and natural gas reserves is 6.95 quadrillion cf.

From the distribution, they can be divided into several blocks, OPEC, North America, Central America & Caribbean, Latin America, Europe & Russia, Africa and Asia-Pacific.

OPEC 2017 Annual Statistical Bulletin announced that 14 members share world's 73.7% oil reserves and 48.6% gas reserves. Total crude oil reserves is 1,217 billion bbl and gas reserves reaches 3,380 tcf.

In North America, the oil resources are distributed in Gulf of Mexico and Gulf of California, while Canada owns massive oil sands reserves. Crude oil & lease condensate reserves of United States was 35.43 billion bbl and dry gas reserves was 310 tcf. based on EIA 2017 reports. CAPP reported that the conventional crude reserves of Canada ran up to 5.14 billion bbl and proved oil sands reserves reached 165.4 billion bbl.

In Central America & Caribbean, Mexico and Venezuela are rich in oil resources. As the oil giant of Mexico, PEMEX estimates that oil reserves is 6.63 billion bbl and gas reserves is 9.88 tcf. Venezuela's oil reserves reached 302.24 billion bbl, and gas reserves increased to 202.69 tcf.

Brazil and Argentina are the countries with abundant oil reserves in Latin America. Brazil owns 12.63 billion bbl oil reserves and 13.32 tcf gas reserves. The Campos and Santos basins in the southeast of Brazil are the regions with the largest concentrations of crude oil. National Petroleum Agency of Argentina estimates that shale gas reserves ranks second position in the world and shale oil reserves remains fourth.

Western and Northern European countries, as traditional industrial powers, also share huge oil and gas resources. UK Oil & Gas Authority claimed that there are 2.07 billion bbl of oil and 6.2 tcf of gas around the North Sea. On December 2017, Norwegian Petroleum Directorate reported that proved oil and gas reserves is 6.37 billion bbl and 62.93tcf, respectfully.
Russia as the largest country in the world and has tremendous oil and gas resources. Different agencies gave different estimations about the reserves, from 60 billion bbl to 200 billion bbl. Although the official statement remains silence, the Union of Oil and

Gas Producers of Russia affirmed that the proven oil reserves stands 17.8 billion tons and category C2 reserves is 8 billion tons.

Africa, as emerging oil and gas reservoir continent, new fields have been discovered and exploited continuously. The proved oil reserves exceed 80 billion bbl. The gulf of Guinea in west Africa and the Mediterranean Coast can be seen as important oil and gas deposits. Libya, Nigeria, Algeria, Angola and Sudan ranked among the top five African crude oil reserves.

In Asia-Pacific region, the crude oil reserves is almost 45.62 billion bbl. The latest data for 2017 from China Mineral Resources Report shows that China's proved crude oil reserves is almost 25.63 billion bbl, and gas reserves climbed 4% to 192 tcf compared with 2016.

2.1.2 Worldwide Oil & Gas Production Areas Analysis

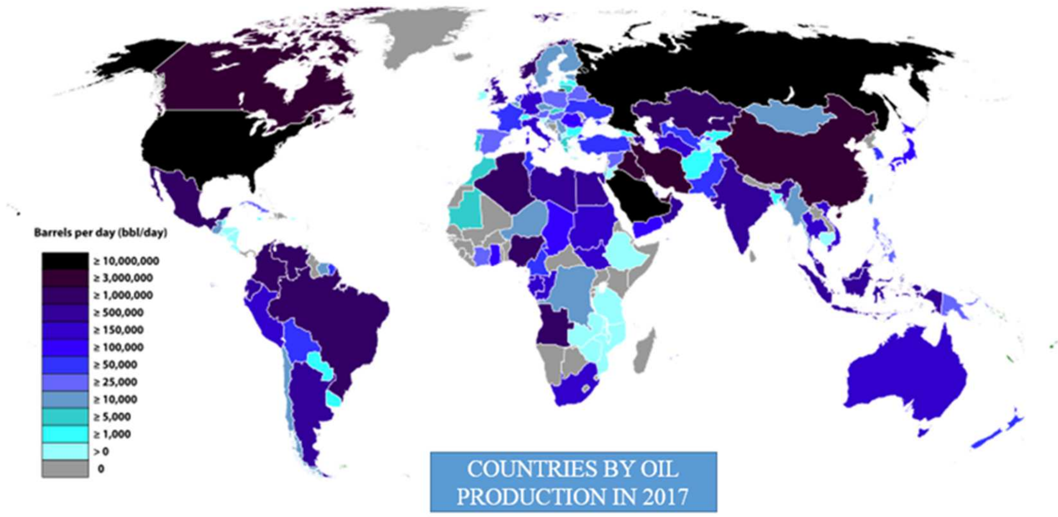

Figure 2.2: Countries by Oil Production 2017

Source: United States Energy Administration – Monthly Energy Review. 2017

According to preliminary statistics by OGJ, in 2017, due to worldwide crude oil and condensate production decreased slightly from a year ago. The number of OPEC crude oil production was 32.41 million b/d, oil supply shrank 13% from year to year.

From the above figure, we may easily find out that Saudi Arabia, Russia, and United States are the three largest oil production countries in first tier, which produce crude oil exceed 10 million b/d. The exports of Persian Gulf states account for 60% of the world's oil exports and are mainly exported to Western Europe, North America, and Japan.
According to EIA's data, in 2017, Russia exported 5.2 million tons of crude oil per day and exported 2.4 million tons of refined oil per day, which accounted for 70% of Russian oil production, of which 70% was exported to European countries such as the Netherlands, Germany, Poland, Finland and other OECD countries. In 2017, Russian exported 953,000 tons crude oil to China daily, accounting for about 18% of the oil exports.

Thanks to the development of shale oil and exploitation technology, United States changed from a major importer of crude oil to a net exporter. U.S. crude oil production reached the highest level in 2016. The ban on U.S. crude oil exports was officially lifted at the end of 2015, after which the country's crude oil exports increased substantially. In February 2017, China became the world's largest importer of U.S. crude oil.
Canada, China, Iraq and Iran follow closely, reach 3 million b/d of oil production. United Kingdom and Norway are major oil and gas producers in Europe. Despite considerable oil production, China has replaced the United States as the world's largest oil importer since 2015.

It is undeniable that Iran and Iraq are the major suppliers of oil to European countries. The crude oil from Iran and Iraq is also exported to India, China and other countries.

Latin-America countries like Brazil, Venezuela, Colombia and Mexico, African countries such as Algeria, Nigeria and Angola, and their oil production are more than 1 million b/d. Oil produced in Mexico, Brazil and Venezuela is mainly consumed in the Americas, while the oil produced in Africa is mainly exported to Europe.

2.2 Overview of Worldwide Offshore Engineering Market

From the perspective of geographical distribution, the offshore engineering market can be divided into seven major operation regions, North America, South and Central America, West Africa, North West Europe, Mediterranean, Middle East and Indian Sub-Continent, and Asia-Pacific. According to the depth of operation, it can be divided into shallow water, deepwater and ultra-deepwater operation areas. The oil industry generally believes that the depth below 500 meters is shallow water operation area, the depth more than 500 meters can be seen as deepwater operation area, and 1500 meters is regarded as ultra-deep water. Shallow water operations rely on fixed platforms for oil production, while deep-water and ultra-deepwater operations require sophisticated subsea trees and other equipment for oil production.

The final investment decision (FID) in the region is the focus of offshore engineering companies, which determines the value and amount of contracts, the amount of activities and duration of the operation. These factors will directly affect the strategic layout of the offshore engineering companies.

North America

North America is relatively mature market after several years exploration. During 2017 to early 2018, 10 shallow water and 19 deepwater blocks project contracts have been awarded to offshore engineering companies. The capital expenditure (CAPEX) in the region dropped significantly due to the plunging oil prices, compared with the peak in 2013, CAPEX in 2017 was only $7.9 billion. On the bright side, EIA announced that large discoveries in Mexico (Zama) and US (Whale) would be sanctioned by local authorities. The start-up of these projects will stimulate oil companies to increase investment, which is a positive sign for offshore engineering companies. Meanwhile, GoM is the frontier area of ultra-deepwater exploration, 41 discoveries which accounted for 19% of the global ultra-deepwater oilfields. It shows that the industry renaissance have built up momentum.

South and Central America

Latin America maintains significant growth treads for offshore engineering, There will be 39 offshore engineering projects with total CAPEX of $39 billion in the next two years. Brazil is the key driver of this growth. Petrobras, as state owned company of Brazil, issued $12.8 billion contracts for FPSO development projects in Lula Norte and Buzios fields. Also, nine projects with a total CAPEX of $23 billion will make positive contribution to offshore engineering companies, such as Liza project in Guyana, Sea Lion in Falklands. Colombia, Uruguay, Suriname and other countries in this region are conducting the seabed geological survey and feasibility analysis of the planned oilfields. These exploration activities provide potential opportunities for offshore engineering industry.

West Africa

Most of the oilfield blocks in West Africa are located in Atlantic Ocean, where the operation water depth are more than 500 meters. In 2017, only five FIDs of offshore projects were confirmed, with total CAPEX of $3.8 billion. The breakeven point of oil in West Africa is $70 per barrel. The higher exploitation costs and lower oil prices limit the pace of offshore development. Oil companies have taken many measures to control cost expenditures to improve their market competitiveness. Although West Africa is one of the most important regions for deepwater exploration and production (E&P), most of the investors remain pessimistic about sanctioned projects. In addition, the instability of political situation and corruption scandals obstruct the progress of development. ENI's Zohr project and BP's West Nile Delta project may bring dawn and hope.

North West Europe

Norway, Russia, UK, the Netherlands are significant countries for offshore E&P in this region. Over 90% of the oil fields are located in shallow water with depths less than 200 meters. Due to the harsh operating conditions and the requirements for environmental protection, the market threshold of offshore engineering companies is extremely strict.

In 2017, there were 22 offshore project FIDs with total CAPEX of $19.3 billion. Benefiting from the control of project cost deflation, investors have increased additional investment in oil and gas development projects. Clarksons estimates that 17 offshore project contracts with a total value of $15.8 billion will be awarded for the 2018-2019 biennium.

Oil companies such as Statoil and Lundin Petroleum have drilled several exploration wells since 2015. These high profile wells are planned into production in 2018. Frontier E&P in the region has genuine potential.

Mediterranean

Compared with oil resources, the Mediterranean region has an abundance of natural gas resources. Over 12 % of global offshore gas production come from Mediterranean. In 2017, the CAPEX of 15 offshore fields reached $15.8 billion. Due to the booming local demand, project economics have not been influenced by negative global energy price trends. There will be 11 projects with CAPEX of $13.78 billion in the next few years.

Middle East and Indian Sub-Continent

Middle East is the most important region for offshore production, which accounts for 29% and 36% of worldwide offshore oil and gas production respectively. In 2017, 12 offshore project contracts were awarded to offshore companies, and the total amount of the value was up to $15 billion. A large number of Iranian oilfields will be put into development because of the lifting of international sanctions. Total S.A. had reached an agreement with NIOC to operate South Pars Phase XI project jointly.

Meanwhile, India government make great efforts to promote the deepwater offshore development activities. Moreover, a great deal of companies compete on 15 offshore projects. The estimation of investments on these projects is around $ 63 billion, among which East African ultra-deepwater gas projects account for $ 34 billion.

Asia-Pacific

OGJ estimates that the offshore projects in Asia-Pacific region will account for 21% of global offshore investments. Especially in Australia, there were 34 natural gas development projects sanctioned by Australian Government in February 2018. The total amount of these projects exceeds $ 180 billion. Above all, driven by geopolitics, various deepwater development in India and China will be developed gradually.

Table 2.2: The Overview of Worldwide Oil and Gas Fields and Summary of Offshore Activities Description

Area	Oil and Gas Blocks	Operation Area / Water Depth	Offshore Activities Description
North America	Gulf of Mexico, Gulf of California	Ultra-Deepwater ≥ 1500 Meters	Oilfields Maintenance, New Discoveries Exploitation Exploration.
South and Central America	Brazil Lula Norte and Buzios, Guyana Liza, Falklands Sea Lion	Ultra-Deepwater ≥ 1500 Meters	New Discoveries Exploitation Exploration.
West Africa	Gulf of Guinea	Deepwater 500-1000 Meters	Support Services, Pipelaying, Exploitation
North West Europe	North Sea	Deepwater 500-1000 Meters	Oilfields Maintenance, Support Services, Exploitation in Norway.
Mediterranean	North Africa Coast	Deepwater, < 500Meters	Platform Maintenance, Support Services.
Middle East and Indian Sub-Continent	Persian Gulf Coast	Deepwater and Ultra-Deepwater, 500-1500 Meters	Subsea Services, New Discoveries Exploitation.
Asia-Pacific	Indonesia, Malaysia, Thailand	Deepwater, 500 Meters	New Discoveries Exploration, Subsea Services

Source: Created by the Author.

2.3 Status of China's Offshore Engineering Market

In China, the offshore engineering market is closely related to the oilfield development areas. The market mainly revolves around offshore oil and gas development industries. The operations include exploration and drilling of oil and gas fields, installation of modules, platforms and jackets, laying of submarine wires, cables, and pipelines, etc.

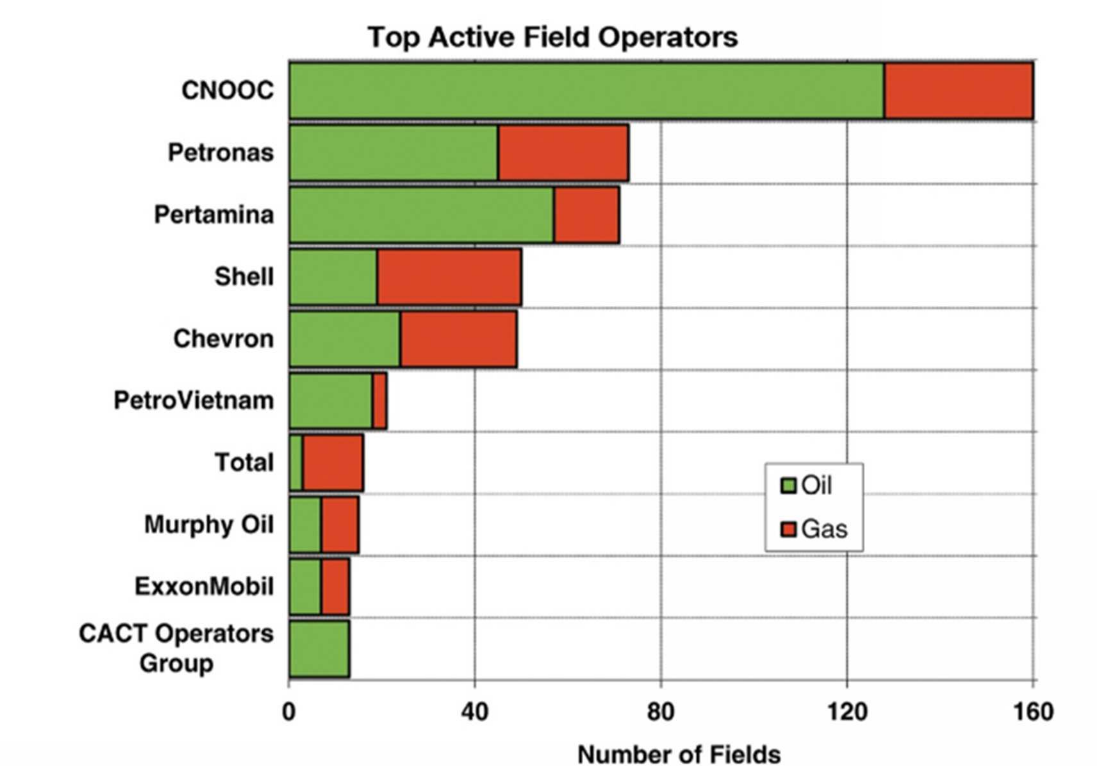

Figure 2.3: Top Active Field Operators in Asia-Pacific Region

Source: Clarkson Research Services LTD

From the above figure, we can see that CNOOC is the most active oil and gas field operator in the Asia-Pacific region, operating 130 oil fields and 160 gas fields.

China's offshore oil and gas fields are divided into four regions in the Bohai Bay, the East China Sea, the eastern South China Sea and the western South China Sea. The four branches of Tianjin, Shanghai, Shenzhen and Zhanjiang, which are subordinate to CNOOC, are responsible for the operation and development of the oil and gas fields.

COOEC is the subsidiary company of CNOOC, which is the largest and most comprehensive offshore engineering company in China and is responsible for the offshore construction, the installation of modules, platforms and jackets, and the laying of subsea pipelines.

2.3.1 The Bohai Bay Region

The region of the Bohai Bay covers the area of 58,527 square kilometers, which is the typical one of the Tertiary sedimentary basins. It is also the second largest oil-producing regions with 72 oil and gas discoveries in China. These oilfields are all in the shallow water.

Representative oil fields in the Bohai Bay include Chengbei oilfield, Bozhong oilfields cluster (Bozhong 28-1 oilfield, Bozhong 34-2 oilfield and Bozhong 34-4 oilfield), Boxi oilfield cluster (Qikou 17-2 oilfield, Qikou 17-3 oilfield, Caofeidian 18-2 and Qikou 18-1 oilfield), Bonan oilfield cluster, Jinzhou oilfields cluster, Suizhong 36-1 Phase I and Phase II oilfields cluster, Qinhuangdao 32-6 oilfield and Penglai 19-3 oilfield.

The Bohai bay region has the largest number of drilling and fixed production platforms, accounting for 90% of the total number of platforms in China. Among them, Chengbei oilfield always take the top spot on the offshore oil production.

The main offshore engineering business in this region includes maintenance of conventional oilfields, support services for oil extraction and the laying of new pipelines.

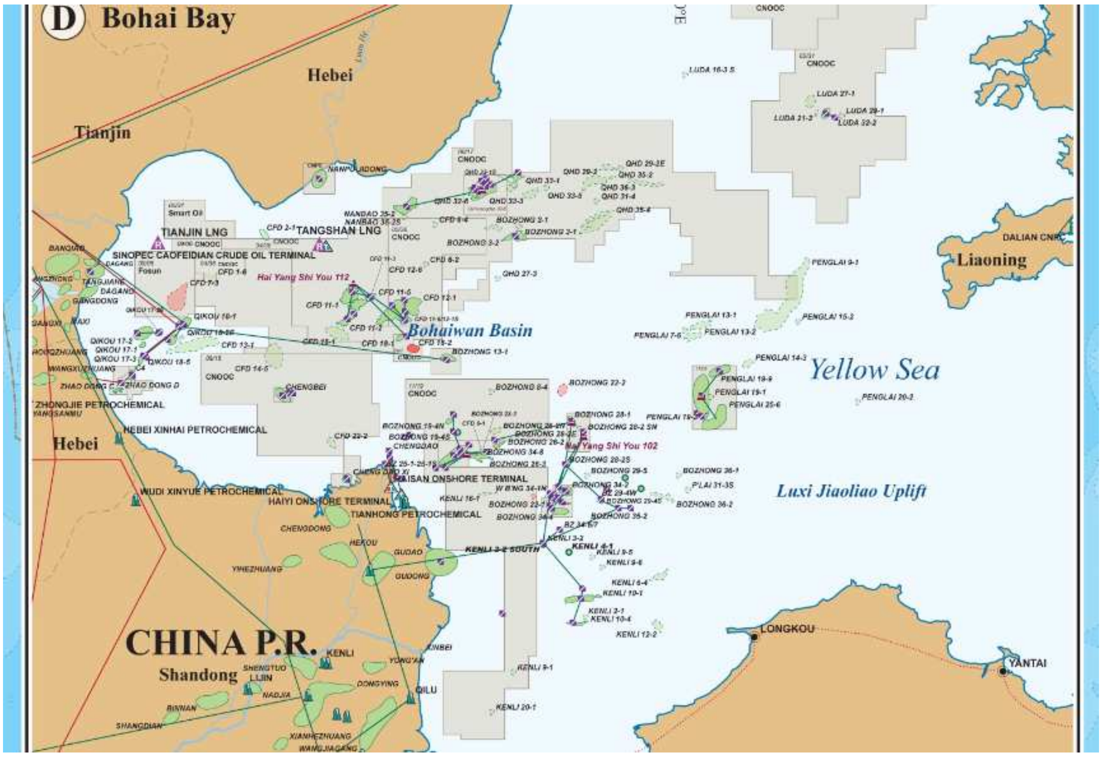

Figure 2.4: Oil and Gas Activity and Concession Map in the Bohai Bay 2017

Source: Clarkson Research Services LTD

2.3.2 The Eastern South China Sea Region

Fields in the eastern and western South China Sea are bounded by 113°10’E. The region of eastern South China Sea oilfields is approximately 131,000 square kilometers, which is divided in 7 blocks, such as Enping, Xijiang, Panyu, Huizhou, Liuhua, Lufeng and Liwan. Oilfields in this region have been developed earlier and have longer term exploration. Some oil fields have been continuously exploited for more than 20 years. The major oilfields consist of Huizhou oilfields cluster (Huizhou 21-1, Huizhou 26-1, Huizhou 32-2, Huizhou 32-3 and Huizhou 32-5), Panyu 5-1 oilfield, Xijiang 24-3 and 30-2 oilfields, Lufeng 13-1 and 22-1 oilfields.

Platform maintenance, workover services, cementing services and subsea pipelines replacement are the main operations for offshore engineering companies.

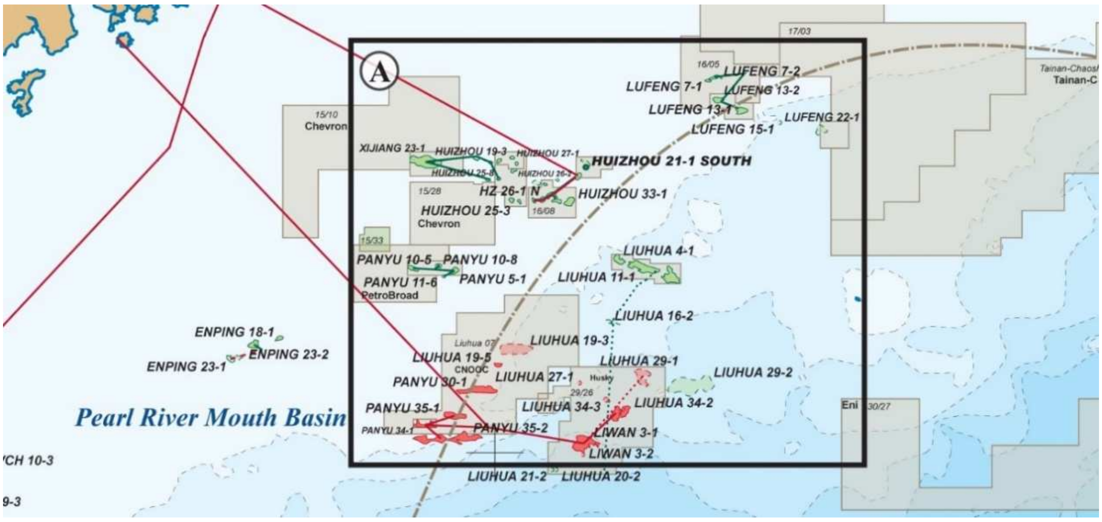

Figure 2.5: Oil and Gas Activity and Concession Map in the Eastern South China Sea 2017

Source: Clarkson Research Services LTD

2.3.3 The Western South China Sea Region

Oil and gas exploration projects in the northern South China Sea region are distributed in four basins, including the Beibuwan Basin, the Yinggehai Basin, the Qiongdongnan Basin, and the Pearl River Mouth Basin.

Weizhou oilfield cluster (Weizhou 10-3 oilfield, Weizhou 11-4 oilfield, and Weizhou 12-1 oilfield) is the largest oilfield cluster in the South China Sea. It is composed of 14 oil fields, 25 platforms, 164 km submarine cables and 336 km subsea pipelines. Weizhou 10-3 oilfield is the first oil field developed by Sino-foreign cooperation with TOTAL. Weizhou 11-4 oilfield produces 900,000 tons of oil annually.

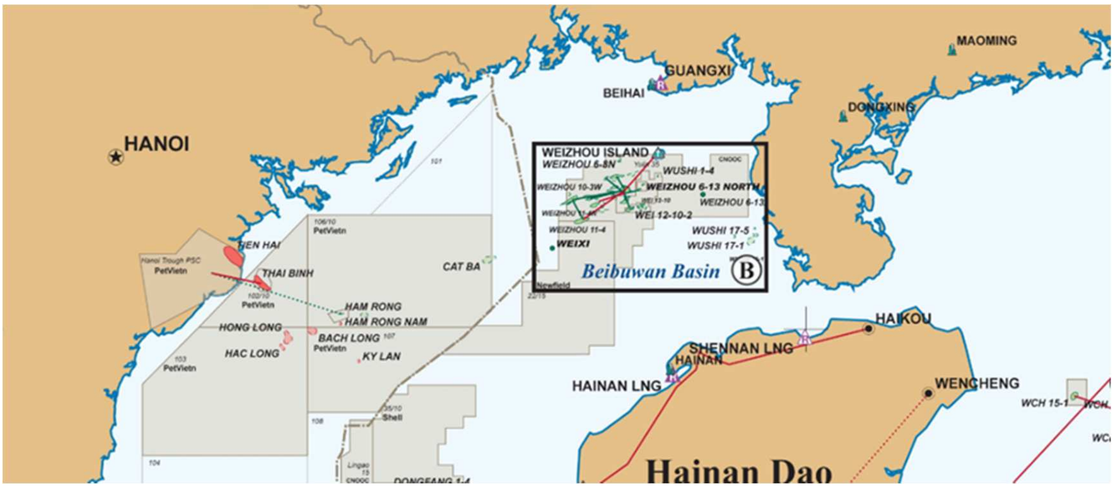

Figure 2.6: Oil and Gas Activity and Concession Map in the Western South China Sea 2017

Source: Clarkson Research Services LTD

Dongfang, Ledong, Yacheng, and Lingshui block are located in the southern sea of Hainan Island sequentially. All the fields in these blocks are gasfields with water depths around 100 meters.

Dongfang 1-1 gasfield transports 2.6 billion cubic meters of natural gas produced by 22 production wells through the central platform through 110 km submarine gas pipeline to Dongfang City year after year.

The annual production of Yacheng gasfield cluster is 3.4 billion cubic meters, of which 2.9 billion cubic meters are sent to Hong Kong. The world's second-longest, 778 km gas pipeline from Yacheng to Hong Kong has suffered the highest working pressure in the world. Yacheng 13-1 gasfield is China's first offshore gasfield jointly developed by CNOOC, ARCO and KUFPEC.

Lingshui block consists of Lingshui 17-2 deepwater gasfield, Lingshui 25-1 deepwater gasfield and Lingshui 18-1 deepwater gas field with average operating depth of 1500 meters. The maximum drilling depth of the Lingshui 17-2-2 well reached 1547 meters. Wenchang gasfields cluster is located in the eastern part of Hainan Island and includes

Wenchang 9-2 gasfield, Wenchang 9-3 gasfield and Wenchang 10-3 oil and gas field. The water depth of the Wenchang gasfield cluster is about 130 meters.

Dongfang 1-1 gasfield, Wenchang gilfield, and Ledong 11-1 gasfield are still under construction and bring tremendous opportunities to offshore engineering enterprises. Expenditure in this region will also be supported by these deepwater and ultra-deepwater projects.

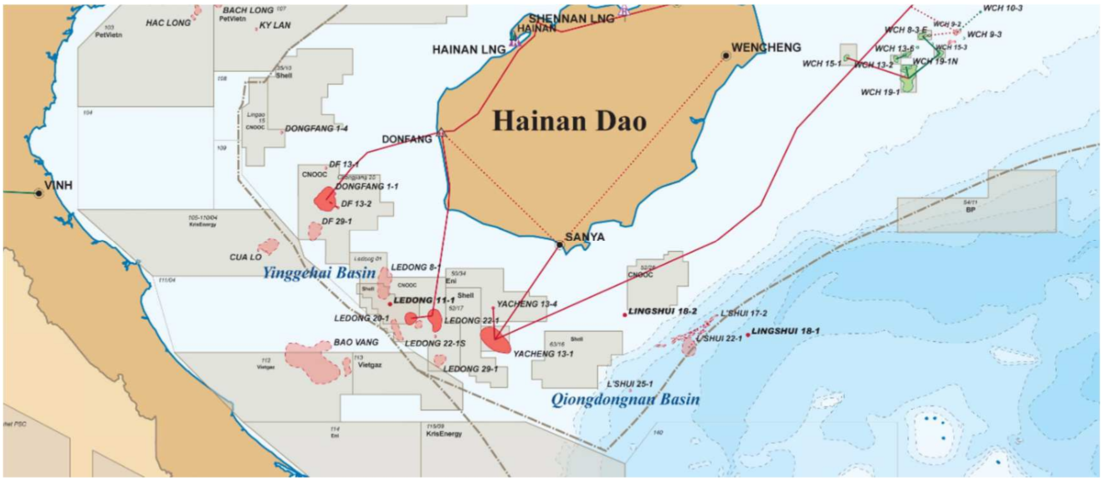

Figure 2.7: Oil and Gas Activity and Concession Map in the Western South China Sea 2017

Source: Clarkson Research Services LTD

2.3.4 The East China Sea Region

Oilfields in the East China Sea are located in the Xihu Trough of the East China Sea Shelf Basin. CNOOC and its partner SINOPEC have exploited Pinghu, Chunxiao, Tianwaitian, Duanqiao, Canxue, Baoyunting, Wuyunting and Kongqueting oil and gas fields successively. The most famous field in the East China Sea is the Chunxiao, which consists of four oil and gas fields (Li, 2007). Huangyan Phase I oilfield project developed by CNOOC includes two natural gasfields and 11 production platforms. The East China Sea region is in the disputed area between China and Japan. Therefore, the Huangyan Phase II project, including the exploitation of seven new oil and gas fields, moves slowly due to Japanese disturbance.

Table 2.3: The Overview of China's Oil and Gas Fields and Summary of Offshore Activities Description

Area	Oil and Gas Blocks	Operation Area / Water Depth	Offshore Activities Description
The Bohai Bay	Chengbei, Bozhong, Boxi, Qikou Caofeidian, Bonan, Jinzhou, Suizhong, Qinhuangdao, Penglai.	Shallow Water, $<$ 100 Meters	Oilfields Maintenance, Support Services, Pipelaying
The Eastern South China Sea	Enping, Xijiang, Panyu, Huizhou, Liuhua, Lufeng Liwan.	Deepwater, and Ultra-Deepwater, 500-2000 Meters	Platform Maintenance, Subsea Pipelaying.
The Western South China Sea	Dongfang, Ledong, Yacheng, Lingshui.	Shallow Water, Deepwater and Ultra-Deepwater, $<$ 100 Meters, 500 Meters and $\geq$ 1500 Meters	New Discoveries Exploitation Exploration,.
The East China Sea	Chunxiao, Huangyan	Ultra-Deepwater $\geq$ 1500 Meters	Exploration, Exploitation.

Source: Created by the Author.

From the shallow water to the ultra-deepwater, offshore engineering faces higher investments, more difficulties and greater risks. However, the exploitation of offshore engineering projects in the deep sea is an irreversible trend in the future. The management becomes more complicated than ever. The traditional project management is not suitable for the modern operation and management and has many problems in implementation process, such as imperfect organization, unqualified standards of personnel and the negligence of safety and quality. Therefore, we should form thinking innovation and adopt new management theory to manage the project.

CHAPTER III. PROJECT MANAGEMENT ANALYSIS

3.1 Overview of Project Management Theory

Project management theory is an advanced management theory. It originated from the Second World War and has been well developed since 1970. Project management theory takes specific project as the research object, through qualitative and quantitative analysis methods, it introduces some advanced management concepts and methods into daily project management, which improves the efficiency of project management significantly. As a discipline, project management theory has mature theoretical basis and method system and has played an important role in many practical project management processes.

With the increasing of global competition, project activities are becoming more and more complex, the number of projects has increased dramatically, the scale of project teams has continued to expand, the conflicts of project stakeholders have increased, and the pressure of reducing project costs has continued to rise (Lampert & Kim, 2018). These current conditions force government departments and companies, who are project owners or project implementers, to invest a great deal of manpower and material resources to study and understand the basic principles of project management and the specific methods for the development and use of project management.

The academic community generally regard project management before the 1980s as traditional project management, and traditional project management mainly focuses on the fields of architecture, civil engineering, and national defense industry. After entering the 21st century, project management needs to pay more attention to dealing with cross-regional and cross-domain complex issues so as to achieve more operational efficiencies. The project management area extends to the telecommunications, information technology, financial, software, pharmaceutical and biotechnology, and energy industries. Due to the characteristics of flexibility and adaptability to the dynamic changes, the project management approach can improve the efficiency of middle level managers and fully utilize internal and external resources. Project management method has become a significant management tool for enterprises and has been widely used. In this context, modern project management has formed its own theory and method system gradually (Torbjørn & Andreas, 2018).

Meanwhile, different types of projects in different fields have immensely enriched the contents of project management, and new project management tools and methods have been continuously developed and applied. The influence of project management is increasing day by day, The project management science is also growing rapidly and improving progressively, which has become one of the core competence of the company. Project management centres on customer needs, which responses quickly to customer demands and solves the problems efficiently with lower costs (Sun, 2006).

The matrix organization is more flexible than the traditional hierarchical personnel organization, which generated for specific customer needs, and can be disbanded after the project task is completed, so as to respond to the changes of the market demand promptly. Different project teams can also collaborate with each other to solve problems in different fields. Especially in the transnational corporation or in an international collaborative project. For example, there is an oilfield exploitation project in Southeast Asia, the equipment suppliers are from Japan, the integrated manufacturing bases are in China, and the operating center is in Singapore, the matrix management organization is the optimal mode for the project.

Nowadays, there are two mainstream of project management research systems, one is the International Project Management Association (IPMA) led by European countries, the other is the Project Management Institute (PMI) led by the United States.

As early as 1965, Europe established the International Project Management Association. Its members are representatives of project management research organizations from various countries. Each national project management organization is responsible for the specific needs of localization, while IPMA is in charge of coordinating common issues among countries. IPMA also provides a wide range of services, including training and education, standardization and certifications. Professionals are graded by qualification authentication, from level A to level D. IPMA introduced the knowledge system *ICB-IPMA COMPETENCE BASELINE*, which covered 40 quality requirements and 28 core elements for project managers.

Based on the core ideology of meet the requirements of stakeholders, the United States also established the Project Management Institute in 1969. Its members are mainly experts from companies, universities, and research institutes.

PMI formulated industry standards and developed the *Project Management Body Of Knowledge* (PMBOK), which divided project management into ten knowledge areas. The International Organization for Standardization (ISO) also adopted the PMBOOK framework to formulate the ISO10006 standard for project management.
PMI pays more attention to the evaluation and assessment of personnel knowledge. In combination with the review of the management capabilities, relevant practitioners may obtain the certification of *Project Management Professional* through PMP examination. As of December 2017, there were 800,000 PMPs worldwide.

The project management method described in this paper is based on the PMI system.

3.2 Project Management Process Decomposition

Project management theory is a comprehensive discipline that covers ten major fields of knowledge areas, including integration management, scope management, time management, cost management, quality management, human resources management, communication management, risk management, procurement management and stakeholder management (Lückmann & Färber, 2016).

Divided from the phase of project, it can be divided into five major processes, such as initiating process, planning process, executing process, controlling process and closing process. The project team can only start the next phase of work after completing current phase of the work.

Table 3.1: Project Management Body of Knowledge

PROJECT MANAGEMENT BODY OF KNOWLEDGE		Five Process/Performance										
		Initiating Process		*Planning Process*		*Executing Process*		*Controlling Process*		*Closing Process*		Total
1	**Integration Management**	1.1	Develop Project Charter	1.2	Develop Project Management Plan	1.3	Guiding and Managing Project Work	1.4	Monitor & Control Project Work	1.6	Close Project or Phase	6
								1.5	Integrated Change Control			
2	**Scope Management**			2.1	Plan Scope Management			2.5	Scope Verification			6
				2.2	Collect Requirements							
				2.3	Scope Definition			2.6	Scope Control			
				2.4	Create WBS							
3	**Time Management**			3.1	Plan Schedule Management			3.7	Schedule Control			7
				3.2	Define Activities							
				3.3	Sequence Activities							
				3.4	Estimate Activity Resources							
				3.5	Estimate Activity Durations							
				3.6	Schedule Development							
4	**Cost management**			4.1	Plan Cost Management			4.4	Cost Control			4
				4.2	Estimate Cost							
				4.3	Budgeting							
5	**Quality Management**			5.1	Plan Quality Management	5.2	Quality Assurance Implementation	5.3	Quality Contorl			3
6	**Human Resource Management**			6.1	Plan Human Resources Management	6.2	Acquire Project Team					4
						6.3	Develop Project Team					
						6.4	Manage Project Team					
7	**Communication Management**			7.1	Plan Communication Management	7.2	Manage Communication	7.3	Communication Control			3
8	**Risk Management**			8.1	Plan Risk Management			8.6	Risk Control			6
				8.2	Risk Identification							
				8.3	Perform Qualitative Risk Analysis							
				8.4	Perform Quantitative Risk Analysis							
				8.5	Plan Risk Response							
9	**Procurement Management**			9.1	Plan Procurement Management	9.2	Conduct Procurement	9.3	Procurement Control	9.4	Close Procurements	4
10	**Stakeholder Management**	10.1	Identify Stakeholders	10.2	Plan Stakeholder Management	10.3	Manage Stakeholder Engagement	10.4	Control Stakeholder Engagement			4
Total		2		24		8		11		2		47

Source: Summarized and created by the author.

3.2.1. Initiating process

Initiating process is an accreditation procedure, which refers to the phase of starting a new project or entering into the new stage of an existing project. In this phase, the company shall develops the project chapter, authorizes the initiation of the project, appoints the project manager, establishes the project team, and identifies project stakeholders.

The project team must have a clear understanding about the project, such as internal organizational structure of the project, the project objectives and major tasks (Yu, 2007). It is necessary to determine the technologies and methods applied in the project. The environment in which the project is implemented is also very important. Only after the project team fully understands the relevant circumstances, the project can be started smoothly and lay a solid foundation for the next process.

Generally speaking, the initiating process of the project starts after the completion of bidding or contract signing.

3.2.2. Planning process

The project planning process is one of the most complex and important phases in the project management, which involves ten fields of the management and runs through the entire project cycle. In this phase, The project team needs to develop a project schedule, determine the scope of the project, allocate project human resources, formulate project risk management plan, prepare project budget, establish project quality assurance plan, draft project communication plan, and formulate the procurement plan.

Once significant changes occur, the project team must take stakeholders' opinions and review the previous plan. After the project plan is completed, it must be monitored and implemented strictly during the implementation phase. When there is a deviation between the plan and the actual situation, it must be adjusted timely. If necessary, the project manager should apply for the change of plan. Change applications must strictly abide by the approval process to maintain the seriousness of the plan.

3.2.3. Executing process

When the initial conditions required for project initiating and planning are met, the project will be executed. The work in this phase takes up large amounts of resources and is full of uncertainties and risks (Zoufa & Ochieng, 2018).

In the executing process, these uncertainties may lead to the changes of the plan and the reconstruction of the criterion, which may result in the adverse impact on project resource productivity, availability, and the time of activities (Cheng, Wang, Liu & Zhao, 2015). In order to avoid the occurrence of these risks, the project team must ensure that there are no deviations in the executing process. If deviations come out, the project team must analyze and find out the root causes timely, and take appropriate countermeasures, such as revising the project plan or baseline reasonably. Besides, the project manager should provide the project task book to the key personnel before the implementation of the project. Because the project task book lists the requirements of the project and describes track record of the progress, quality standards, working content and scope of work, which can supervise and urge the project to implement as required effectively.

3.2.4. Controlling process

The project controlling process is a specific, selective, and active dynamic process, which monitors and evaluates the project deviations, and takes corrective action when necessary, so as to ensure the implementation of project plans and achieve project objectives (Bagchi, Kirs, Udo, & Cerveny, 2015).

Project management personnel track and review the project executing process, adjust the progress and performance of the project, and initiate the corresponding response measures if changes occur. The project manager also analyze the progress and evaluate the performance of the project periodically in order to identify and correct deviations.

In this phase, the project team should not only monitor the ongoing activities within a process group, but also the entire project. It is important to coordinate the relationships between various project phases effectively and take corrective actions to prevent the deviations timely.

3.2.5. Closing process

When the project enters the final stage, it means that all the processes of the project have been completed and the entire project has ended officially. Namely, project stakeholders take over the project products from the project team.

In this phase, the project team need to finish the following handover works.

1. The project team needs to obtain the acceptance of the project deliverables by the relevant stakeholders and transfer the ownership to the authorizer in accordance with the project management plan, so as to close the project formally.
2. The project team evaluates each completed project phase, sums up experiences, and reappraises and updates the organizational assets.
3. The project team should finish all procurement activities and ensure that all agreements related to procurement activities are completed. The project manager should acquire the financial, legal, and administrative closings in order to transfer the responsibilities and obligations.
4. According to the project communication management plan, the project manager should prepare and provide the final project report, record and report project performance information, and assist the evaluation of the project. Meanwhile, the archivist should place the documents and original records on file to demonstrate the compliance with legal requirements. These documents can be used for future projects and audits.
5. In accordance with the stakeholder management plan, the project manager should use appropriate tools and techniques to assess stakeholders' satisfaction by obtaining feedback from relevant stakeholders.

3.3 Analysis of Stakeholders in Offshore Engineering and Construction Project

The offshore engineering and construction industry involves many stakeholders, including owners, contractors, subcontractors, commercial banks/investment and financial institutions, insurance companies, and governments.

The project team must design communication plan and influence strategies based on the analysis results. The high-efficiency scheme helps to harmonize stakeholders, invest resources for the same goal, and achieve the success of the project. Thus, effective stakeholders management is the key to project success (Chen & Qiang, 2008).

Owner: In the offshore engineering and construction project, the owner is normally the national government or oil companies, who is the most significant stakeholder (Lei, 2007). The owner awards the contract of oilfield exploitation and construction to the contractor. The contractor completes the project operation so that the oilfield can produce oil as soon as possible. The main interest of the owner is to provide funds and make decisions.

Contractor: The contractor needs to combine all kinds of different factors to integrate the project complete the project on time and deliver the deliverables on schedule. Nowadays, the most popular contract in offshore engineering field is EPCI contract. The contractor shall design the structures, procure the necessary materials, undertake construction and transportation, and install the platforms and equipment at the offshore site. The deliverables or services provided by the contractor must meet the owner's needs and requirements. The contractor takes the primary responsibility for project management.

Subcontractor: Due to the consideration of capital turnover, the complexity of the project, and the business risks reduction, the contractor often decompose the project into several individual projects and select third parties with technical expertise to execute the contract, after the contract signed with the owner. These third parties are called the subcontractors. Certainly, the owner has strict requirements on the subcontractors selected by the contractor. Only after passing through the qualification review and getting approval from the owner, subcontractors may provide services to the contractor (Li, 2016). Providing satisfactory products or services and obtaining project returns are the concerns of the subcontractors.

Commercial banks/investment and financing institutions: The long-duration offshore engineering projects need huge expenditure, offshore engineering companies must obtain loans or investments through banks or investment and financing institutions. The bank loans are important sources of funds for contractors. The project team needs to strengthen the creditor's confidence and obtain loan support. The creditors always hope that the project goes smoothly and gain profits so that their claims can be guaranteed. Therefore, commercial banks/investment and financing institutions pay attention to the security of the funds and debt paying ability of the companies.

Insurer: In project management, the four major measures to deal with risks are avoidance, acceptance, transfer, and insurance. It is impossible for offshore oil exploration operations to adopt risk avoidance strategies. Similarly, as the exclusive offshore engineering and construction operator, they cannot transfer the risks to others. Therefore, insurance is undoubtedly the best choice for offshore engineering companies. In practice, the owners and the contractor often transfer risks to insurer through the purchase of insurance so that they can get compensation from risk accidents. The premium is essential expenditure for project team. Both of the insurer and insured share the same interests, that is the safety of the project.

Government: The administrative macro-control policies, such as monetary policy, fiscal policy and taxation policy, also play a crucial role on the project processes. Economic law and environmental protection law are binding on companies and companies must follow and obey the relevant laws and regulations.

The approval and supervision of the project are the concerns of the government. The project team must minimize the interference of the project so as to lower the negative impacts on the environment.

The purpose of stakeholder analysis is to identify those decision-makers and organizations that influence the project, and to formulate communication strategies so as to make it conducive to the advancement of the project. It is impossible for stakeholders to agree on all the issues, some of whom are more influential than others. How to balance the interests of all parties has become a critical issue for strategic planning. Thus, we should list the concerns and focus of different stakeholders, find out their relationship among safety, environment and efficiency, distinguish the stakeholders in different stages, and take effective measures.

CHAPTER IV. ANALYTIC HIERARCHY PROCESS IN OFFSHORE ENGINEERING PROJECT MANAGEMENT

4.1 General Introduction of Analytic Hierarchy Process

The analytic hierarchy process abbreviated as AHP, which was formally proposed by an American operations researcher T.L. Saaty in the mid-1970s. It is a systematic and hierarchical analysis method that combines qualitative and quantitative analysis. Due to its practicality and effectiveness in dealing with complex decision-making issues, it has been highly regarded around the world (Jiang, 2011). Its application has covered areas such as economic planning and management, energy policy and distribution, behavioral science, military command, transportation, agriculture, education, human resources, medical care, and the environment.

Analytic hierarchy process is a quantitative method , which is wildly used by the project managers. By means of analytic hierarchy process, project managers can derive the weight of each indicator, identify the critical factors that affect the success of the project, propose improvement measures, and control key areas so as to make the project successful (Nascimento, Majumdar, Ochieng, Schuster & Studic, 2016). The author of this paper interviewed 37 project managers on 100 domestic and overseas projects in the form of questionnaire survey. These managers are mainly from COOEC Project Management Center, SINOPEC Shanghai Offshore Petroleum, COSL, and CNPC Offshore Engineering Company. The main content of the questionnaire is to score the weights of several major indicators in project management, including quality, time and cost, etc. Due to the trade secrets concerned, COOEC requested that the format of the questionnaire and the contents filled in the paper shall not be disclosed. But the provided data, average value and weight are all true and effective.

4.2 Application of Analytic Hierarchy Process in Offshore Engineering Project Management

We should analyze and summarize all the relevant factors, establish hierarchy structure and judgment matrix through analytic hierarchy process, verify the values of consistency ratio, find out the various weights of the factor respectively, and obtain the order of indicators (Shen, 2012).

4.2.1 Establishment of Judgment Matrixes

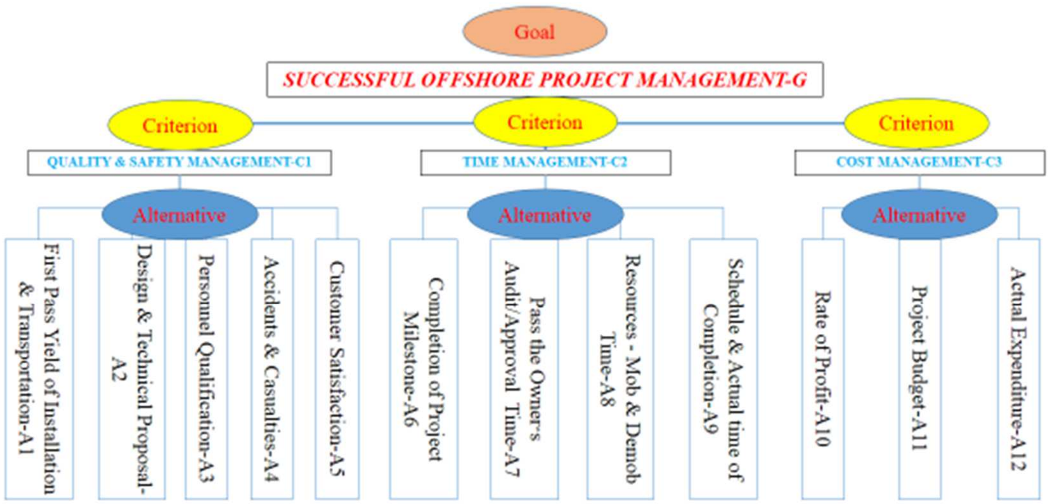

Figure 4.1: Successful Offshore Project Management - Judgment Matrix.

Source: Created by the Author.

A successful project is a comprehensive systematic engineering with completeness, including three criterions of quality and safety management, time management and cost management. Each criterion consists of several alternatives. Through questionnaires and combined with the actual situation of the projects, the author integrates the evaluation system of 12 alternatives in three levels, as shown in the above figure.

4.2.2 Single Hierarchical Arrangement, Consistency Check and Overall Ranking

After establishing the hierarchical analysis structure model, it is necessary to compare the importance of each alternative with respect to the upper level, and construct a comparison judgment matrix. The construction of the judgment matrix adopts 1-9 scales method, describes the relative importance of each alternative qualitatively, and score each alternative with accurate figures (Wei, 2013).

Table 4.1: Judgment Matrix Scale and Its Meaning

Scale	Meaning
1	Comparing the two elements, they have the same importance.
3	The former element is slightly more important than the latter.
5	The former element is much more important than the latter.
7	The former element is obviously more important than the latter.
9	The former element is absolutely more important than the latter.
2, 4, 6, 8	Intermediate values of adjacent judgments above.
Reciprocal	$a_{ji}=1/a_{ij}$

Source: Created by the Author.

By using expert evaluation method, we can get four judgment matrices as below.

Table G – C1-C3 judgment matrices

G	C1	C2	C3
C1	1	1	2
C2	1	1	1
C3	1/2	1	1

From the above table, we can get the conclusion that quality and safety management C1 and time management C2 are more important than cost management C3, while quality and safety management C1 is as important as time management C2.

Table C1 – A1-A5 judgment matrices

C1	A1	A2	A3	A4	A5
A1	1	1	1/2	1/2	4
A2	1	1	1/2	1/2	4
A3	2	2	1	1	5
A4	2	2	1	1	5
A5	1/4	1/4	1/5	1/5	1

Table C1 – A1-A5 judgment matrices

C2	A6	A7	A8	A9
A6	1	1	1/2	2
A7	1	1	1/2	2
A8	2	2	1	3
A9	1/2	1/2	1/3	1

Table C3 – A10-A12 judgment matrices

C3	A10	A11	A12
A10	1	1	1/2
A11	1	1	1/2
A12	2	2	1

Then we conduct single hierarchical arrangement and consistency check. Single hierarchical arrangement is to calculator the factor weight of this layer relative to the factor of upper layer based on judgment matrices. The root method is widely used to calculator the relative importance of factors in judgment matrices (Liu, 2014).

First of all, we can calculator $\overline{W_i}$ (the n-th root of the product of factors in each line). For example,

$$\overline{W_1} = \sqrt[3]{\prod_{j=1}^{n} b_1j} = \sqrt[3]{1 \times 1 \times 2} = 1.2599;$$

$$\overline{W_2} = \sqrt[3]{\prod_{j=1}^{n} b_2j} = \sqrt[3]{1 \times 1 \times 1} = 1.0000;$$

$$\overline{W_3} = \sqrt[3]{\prod_{j=1}^{n} b_3j} = \sqrt[3]{½ \times 1 \times 1} = 0.7973;$$

In the formula, b_{ij} is the factor of judgment matrices, n is order of judgment matrices, $\overline{W\iota}$ is the n-th root of factor product of lane i.

By the calculation, the numerical number are $\overline{W_1}$ = 1.2599, $\overline{W_2}$ = 1.0000, and $\overline{W_3}$ = 0.7973.

Secondly, we should normalize the vector $\bar{W}$. $\bar{W} = (\overline{W_1}, \overline{W_2}, \ldots\ldots, \bar{W_n})$. For instance,

$$W_1 = \frac{\overline{W_1}}{\sum_{i=1}^{n} \overline{W_i}}, = \frac{1.2599}{1.2599+1+0.7937} = 0.413$$

$$W_2 = \frac{\overline{W_2}}{\sum_{i=1}^{n} \overline{W_i}}, = \frac{1}{1.2599+1+0.7937} = 0.327$$

$$W_3 = \frac{\overline{W_3}}{\sum_{i=1}^{n} \overline{W_i}}, = \frac{0.7937}{1.2599+1+0.7937} = 0.260$$

$W = (W_1, W_2, W_3)^T = (0.413, 0.327, 0.260)^T$, this is the factor weight of G – C1-C3.

And then, we should figure out the value of λ_{max} (G – C1-C3).

$$\lambda_{max} = \sum_{i=1}^{n} \frac{Bi\,W}{n\,Wi} = 3.0536$$

In the formula, B_i is row vector of G – C1-C3 in the judgment matrix.

Next, in order to verify the consistency of these judgment matrices, we should compare the consistency index CI with random index RI, then get the values of consistency ratio CR. The value of CR is the smaller the better. If $CR < 0.1$, it assumes that the judgment matrices meet the requirement of consistency check, otherwise the judgment matrices need to be corrected.

$CI = \frac{(\lambda max - n)}{(n-1)}$, $CI = 0.0268$

Because the dimensionality $n = 3$, we can derive that $RI = 0.58$.

$CR = \frac{CI}{RI} = \frac{0.0268}{0.58} = 0.046 < 0.1$

The result shows that G – C1-C3 meet the requirement of consistency check. We can use the same principle for single hierarchical arrangement of judgment matrices, the results list as below:

Judgment Matrix	Index Weight *W*			Consistency Check
	C1	C2	C3	$\lambda_{max}=3.054$, $CI=0.027$ $RI=0.58$, $CR=0.046<0.1$
G – C1-C3	0.413	0.327	0.260	

Judgment Matrix	Index Weight *W*					Consistency Check
	A1	A2	A3	A4	A5	$\lambda_{max}=5.035$, $CI=0.009$, $RI=1.12$, $CR=0.008<0.1$
C1 – A1-A5	0.168	0.168	0.306	0.306	0.052	

Judgment Matrix	Index Weight *W*				Consistency Check
	A6	A7	A8	A9	$\lambda_{max}=4.010$, $CI=0.003$, $RI=0.90$, $CR=0.004<0.1$
C2 – A6-A9	0.027	0.027	0.423	0.423	

Judgment Matrix	Index Weight *W*			Consistency Check
	A10	A11	A12	$\lambda_{max}=3.000$, $CI=0$, $RI=0.58$, $CR=0<0.1$
C3 – A10-A12	0.25	0.25	0.50	

Finally, we can get the results of total evaluation index and ranks. (The figures are accurate to two decimal point.)

No	Index Weight			Combination Weight	Ranking List
A1	0.17	/	/	0.07	3

A2	0.17	/	/	0.07	3
A3	0.31	/	/	0.13	2
A4	0.31	/	/	0.13	2
A5	0.05	/	/	0.02	5
A6	/	0.23	/	0.08	3
A7	/	0.23	/	0.08	3
A8	/	0.42	/	0.14	1
A9	/	0.12	/	0.04	4
A10	/	/	0.25	0.07	3
A11	/	/	0.25	0.07	3
A12	/	/	0.50	0.13	2
$CR = \frac{0.413\times0.010+0.327\times0.003+0.26\times0}{0.413\times1.12+0.327\times0.90+0.26\times0.58} = 0.005 < 0.1$					

4.2.3 The Analysis of the Successful Offshore Project Management

Analysis 1: The importance of criterion level: Quality and Safety Management C1 > Time Management C2 > Cost management C3.

From the above table, we can draw the conclusion that quality and safety management is the most important among three managements. For project managers, the control of time and schedule is more important than cost.

Analysis 2:

The importance of alternative level: Customer Satisfactory-A5 > Personnel Qualification-A3 = Accidents Casualties-A4 > First Pass Yield of Installation & Transportation-A1 = Design & Technical Proposal-A2 .

In terms of alternative level, the pursuit of customer satisfaction is the goal in quality and safety management. Then, the project should strictly control the personnel qualification so as to prevent the accidents and casualties. It is critical for the project to achieve success in transportation and installation at first time. The approval of project documents by the owner is also the premise of the management, such as technical proposal and design scheme. These measures can avoid making time-consuming corrections and unnecessary rework.

Analysis 3:

The importance of alternative level: Resources - Mob & Demob Time-A8 > Completion of Project Milestone-A6 = Pass the Owner's Audit/Approval Time-A7 > Schedule & Actual time of Completion-A9 .

In the aspect of time management, the availability of relevant resources, especially the arrival time of working vessels is the most important factor in ensuring the progress of project. The completion of works in accordance with milestone and the time of acceptance by the owner are chasing closely behind. Having above guarantees can make the project accomplish various tasks on schedule.

Analysis 4:

The importance of alternative level: Actual Expenditure-A12 > Rate of Profit-A10 = Project Budget-A11.

In regard to cost management, the project must pay special attention to the actual expenditure. Only in this way can increase the profit margin and match the budget.

The results of these quantitative analyses can help the project managers weigh the pros and cons for better management of the projects.

4.3 Case Analysis - Project Management of COOEC

Traditional industries focus on repetitive and standardized activities. Offshore engineering projects are not very clearly defined and involve interdisciplinary issues with complexity. Each project has its own specificity and uniqueness. It requires the use of internal and external resources to operate flexibly. Project management methods are the key point to achieve flexibility. It breaks the methods and boundaries of traditional management, and realizes integrated application. It is an innovation of management methods. Therefore, most of the worldwide offshore engineering projects are operated based on a project management mode. Project management methods can achieve standardization and high efficiency, which meet the demands and requirements of the owners preferably. As a result, the application of project management methods has gradually become one of the core competencies of offshore engineering companies.

4.3.1 General Introduction of COOEC

China's offshore oil development has a history of nearly 40 years. Through years of external cooperation and self-development, China National Offshore Oil Corporation (CNOOC) has introduced and mastered international popular project management concepts and methods. It acquires a great many of achievements in management by objectives, especially in time management, cost management, quality management and safety management. China Offshore Oil Engineering Corporation (COOEC) established in 1982, which is the subsidiary company of CNOOC. COOEC is a leading marine energy service contractor rooting in Asia-Pacific region, which delivers world-class services and integrated EPCI (engineering, procurement, construction, and installation) solution to the clients in offshore industry. It is able to provide various services such as oil & gas exploitation engineering, platform design, on-shore manufacturing, offshore/underwater platform installation, platforms decommissioning, maintenance and integrated logistics & transportation. Notably, COOEC adopts project management methods in its overseas and domestic engineering projects.

4.3.2 Analytic Hierarchy Process Theoretical Application in BSP project

In November 2014, COOEC got the contract from Brunei Shell Petroleum Co Sdn Bhd. The location of BSP project is in Brunei Champion Oilfield, which accounts for about 40% of Brunei's oil reserve and produces 50,000 barrels of oil per day. The duration of the contract is 12 months starting from 2014 December, and the scope of work includes the transportation and installation of offshore structures and subsea facilities. BSP project is divided into two sub-projects, CPID project and CWF B2/3 project. CPID project is transportation and installation of one 1,200T six-leg jacket and one 1,364T module, while CWF B2/3 is transportation and installation of seven modules with weights varying from 760T to 1,300T. The contract value is USD 40 million.

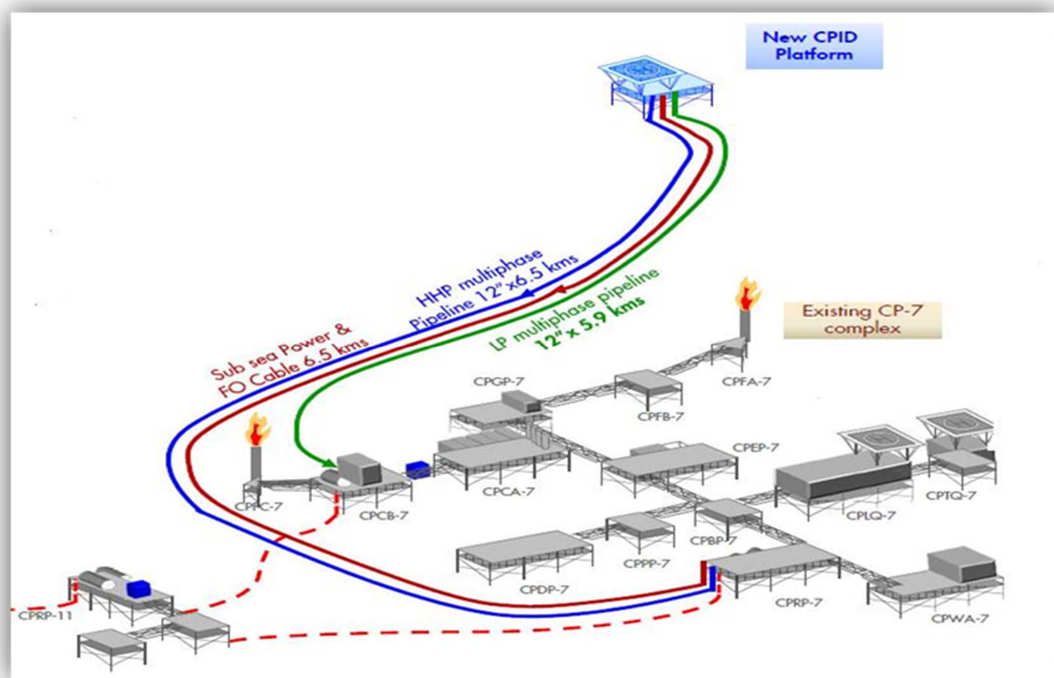

Figure 4.2: Sketch Map of Completion – BSP CPID Project

Source: COOEC – Installation Company.

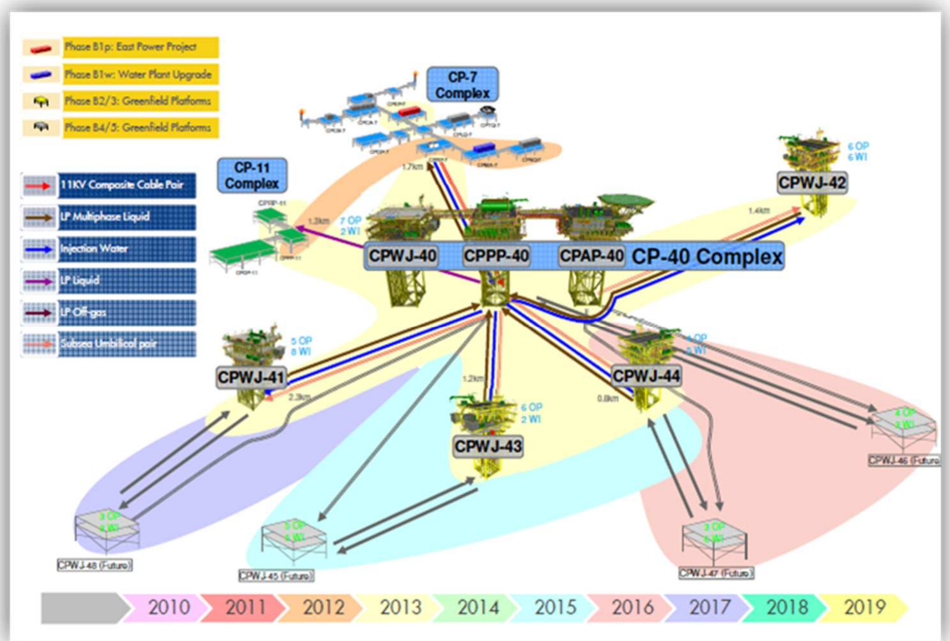

Figure 4.3: Sketch Map of Completion – BSP CWF B2/3 Project

Source: COOEC – Installation Company.

Initiating Process

In the project bidding process, COOEC established a project team and appointed the project manager. After the award of contract, the project team entered into the initiating process immediately, set up the project charter and conducted a detailed interest demand analysis of various stakeholders. The project team was solely responsible for follow-up tracking, implementing and controlling the project. In project charter, the success of project was to satisfy the customers by providing quality services.

Planning Process

The project team developed a project operation schedule in accordance with project management methods. In the planning process, three major management and control objectives covering quality and safety, time and cost were proposed.

In terms of **safety management**, the goal is to ensure that there are no fatal accidents, occupational injuries and major safety accidents (Rui, 2017). There is no marine loss accident with direct economic losses exceeding USD 100,000 and liability accident for machinery or equipment with direct economic losses exceeding USD 80,000.

In terms of **quality management**, the project team proposed that the engineering design, offshore structure loading, transportation, and offshore installation should be completed in the first time, without major defects and quality accidents (Bucelli, et al., 2018). The passing rate of design scheme and compliance of technical documents reached 100%.

In the past, the duration of similar project was more than 18 months. However, BSP project lasted only 12 months. In terms of **time management**, all milestones must be completed in accordance with the contract, and the entire work of the project should be handed over to the client before December 31, 2015. The project team defined each activity according to the requirements of milestones, divided the time required for the activity, distinguished between the immediate preceding time and the following activity time, discussed the possibility of the simultaneous constructions on land and at sea, estimated the required resources and formulated the project schedule (Liu, Shang & Wang, 2015).

In the aspect of **cost management**, COOEC implemented the project economic responsibility system, put forward 6% as target profit, estimated the cost of its own resources and outsourced resources, and completed the preparation of budget.

Executing Process

Based on the *PM BOOK* knowledge system, in the executing process, the project team placed emphasis on quality assurance implementation, which was divided into the several aspects, including shore-based qualification assurance, on-shore and offshore operating personnel assurance, ship resources assurance, certificate qualification assurance (personnel and ships), logistics assurance, etc.

According to the project contract and the requirements of Brunei Energy Department and Labor Department, any foreign company must establish a local company to conduct business. COOEC coordinated with the partner and set up a subsidiary in Brunei so as to carry out follow-up offshore project activities.

The on-site project team consisted of 39 people, including 26 Chinese employees and 13 foreign employees. The project manager developed integrated organizational framework, covering human resources, QHSE, financing, procurement, and marketing. The project team and QHSE manager attached great importance to on-shore and offshore operating personnel qualification assurance, dealt with 540 workers' application and applied for 694 work permits in Brunei.

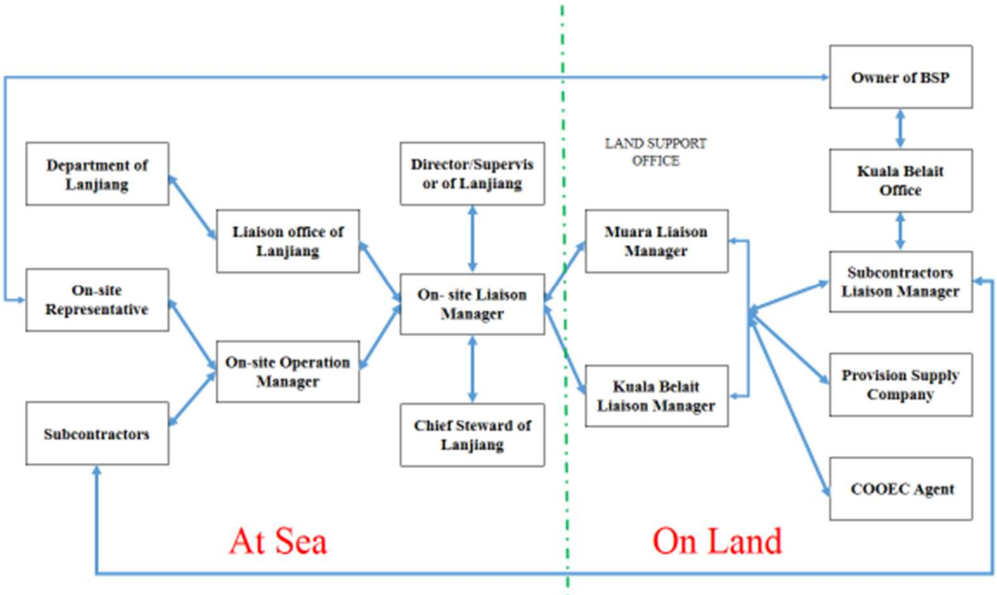

Figure 4.4: Organizational Framework Chart of BSP Project

Source: COOEC – Installation Company and Compiled by the author.

All foreign vessels working in Brunei waters must get the permits and handle import and export formalities. During construction period, 20 different types of ships has been put into the operation, consisting of 1 floating crane, 8 barges, 9 tugboats/AHTS and 2 traffic support vessels. The total ship working days are 1,459 days. Except 1 floating crane and 1 barge from COOEC, the other 18 vessels were chartered vessels. The project team made appropriate arrangements to ensure that the ship resources are put into the project on time (Abdussamie et al., 2018).

In the aspect of certificate qualification assurance, the owner of the BSP project required the operators working onboard to hold the certificate of professional training for seafarers issued by the Training Organization for Offshore Oil Industry (OPITO). Through continuous communication, the owner approved the new version of certificate issued by China Maritime Safety Administration eventually.

All ships working in Brunei waters must pass Offshore Vessel Inspection Database inspection (OVID), BSP Pre-hire checklist inspection and marine warranty survey. Then, the project team submitted rectification reports and closed down defective items to meet the requirements.

Controlling Process

In this phase, the project team strengthened the control of quality, safety, time and cost.

Quality Control

The project team clarified the responsibilities and duties of inspectors in quality control. The organization chart indicated the minimum requirements in regards to QC Manning levels (Zuo, 2017). All inspection personnel should be familiar with the QA/QC audit procedures, standardizations and improvements.

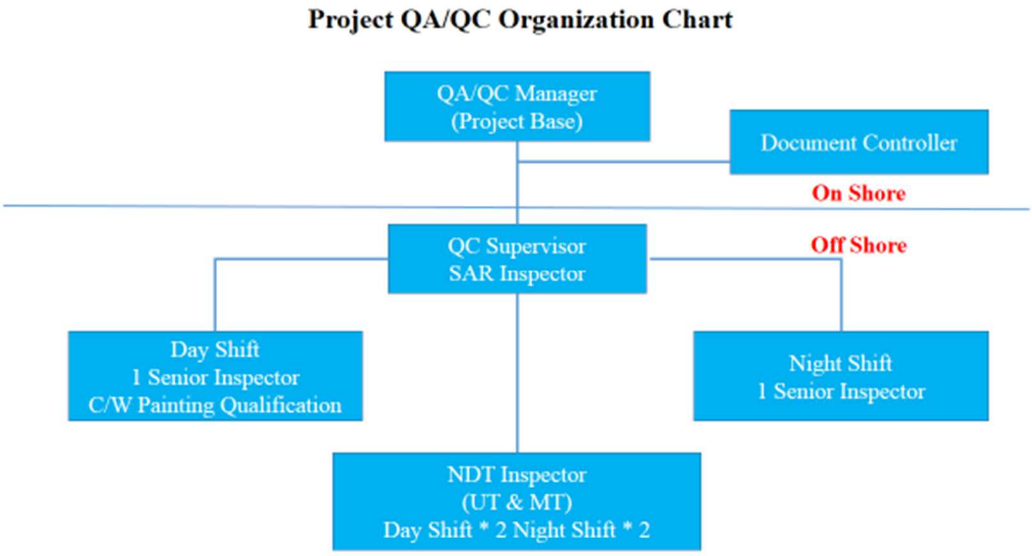

Figure 4.5: Project QA/QC Organization Chart of BSP Project

Source: COOEC – Installation Company and Compiled by the author.

Process management and closed-loop management were the quality control methods adopted by the project team. They paid special attention to the engineering design and construction quality control. Project engineers developed 27 construction procedures, 51 calculation reports and 137 construction drawings.

In the engineering design quality control period, the project team strictly implemented the regime of documents signing and reviewing, strengthened the program audit, summarized experience and learned lessons from experts. The project team reviewed and audited quality documents periodically, corrected non-conformities timely, and solved the problems in its infancy. In addition, engineers used 3D methods for engineering design to improve design accuracy and quality.

In the construction quality control period, the project team divided the quality control into three parts, namely the quality control of the jacket, transition section and module/structure. On-site personnel controlled the accuracy and levelness of the jacket, the installation quality of the transition section, the lifting of the structure, welding quality and measurement quality. The aim was to complete the transportation and installation task in the first time (Gao & Song, 2017).

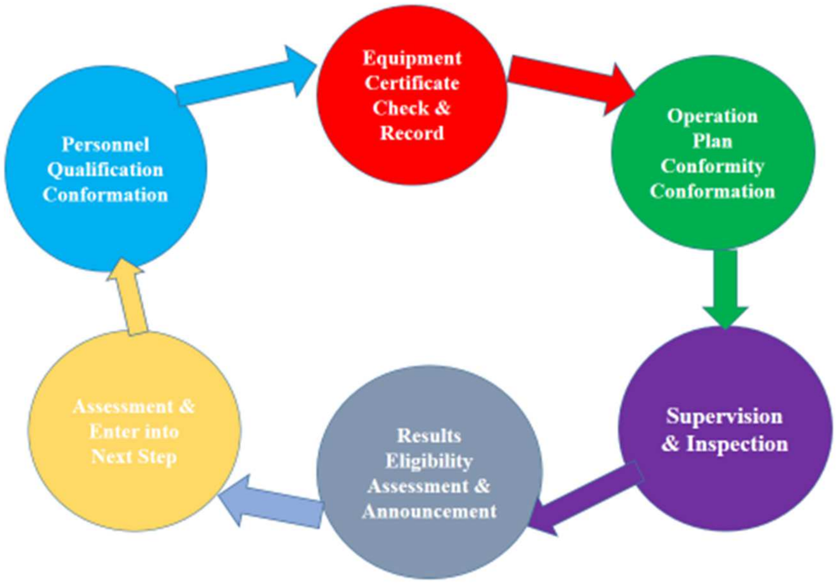

Figure 4.6: Project Quality Control – Close Loop Management

Source: COOEC – Installation Company and Compiled by the author.

Safety Control

The project team conducted safety control by the behavioral measures, implemented on-site safety behavior assessment, exercised personnel training and drills, enforced routine spot inspections, and took precautions against unsafe behavior and operations at the source. Project quality manager accompanied the owner to embark on vessels for on-site safety inspections for 15 times, organized 84 safety trainings, held 39 abandon ship drills, fire drills and boat drills, checked 25 routine safety inspections, and found 309 unsafe operations and habits. All the deficiencies have been rectified.

Time Control

The project team adopted various control measures to ensure that the project and all engineering activities started as scheduled (Sanchez & Terlizzi, 2017). They recorded the start & end time and the completion of each project activity during the project process (Chen, 2010). Comparing the level of completion of each activity with the plan, they determined the level of completion of the entire project, and combined the indicators such as duration, production results, labor efficiency, consumption, etc.

Project schedule engineers evaluated the progress of the project, analyzed the problems, and took corrective measures (Wang, 2013). Meanwhile, they made arrangements for the next stage of work, estimated the remaining time of some activities, proposed measures to adjust the progress, made new arrangements and plans based on the completed status, reanalyzed the network, forecasted new duration of the project and reported to the project manager. Then, the project manager reviewed the adjustment measures and set up the new plan, analyzed the effect of the adjustment measures, and evaluated the new duration (Musawir, Serra, Zwikael & Ali, 2017).

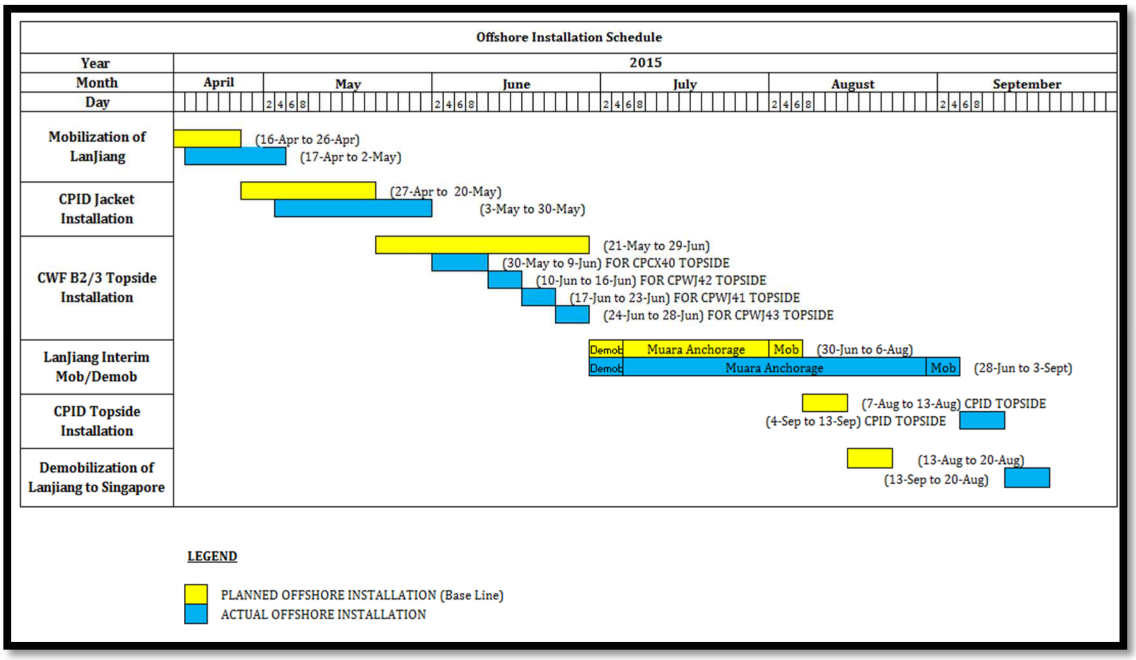

Figure 4.7: Comparison Chart of Actual and Planed Schedule

Source: COOEC – Installation Company and Compiled by the author.

Cost Control

The project team controlled expenditures strictly, arranged the ship resources reasonably, and compressed the standby time of ships as much as possible. By this way, the project team reduced the actual expenditures of chartered freight and fuel, and saved a great deal of cost.

<u>Closing Process</u>

The project team completed all activities in accordance with the milestones, passed the audits by the owner and the third party, and handed over ownership back to the owner. The profit margin reached 8%, exceeding the desired target.

4.3.3 Results

Based on the calculation of Chapter 4.2, we get the importance of project is that Safety ＞ Time ＞ Cost. This can be used in decision-making to optimize the choice of projects in project management. When there are multiple standards that can be used to evaluate the quality of project management, how to weigh the merits of these standards and identify the major issues, and achieve optimal choices is a multi-objective decision-making issue.

Analytic hierarchy process is a simple and feasible method for multi-criteria goal decision making. It integrates macro goals and complicated data effectively. By embodying the evaluation objective and then decomposing it layer by layer, the target becomes realizable indicators gradually. This method integrates the experience of expert team members. In terms of indicator weight determination, the experience and reasonable suggestions from team members can be combined into the indicator weight judgment effectively to ensure the scientificity of weights. In the process of weight calculation, this method can verify the validity and consistency of expert evaluations, which insures the scientificity and rationality of subjective judgments, and combines the qualitative judgment with quantitative researches perfectly.

Analytic Hierarchy Process provides qualitative analysis of quantitative events. The evaluation results are visual, and can be applied extensively in offshore engineering project management.

CHAPTER V. SUMMARY OF PROJECT MANAGEMENT AND CONCLUSIONS

5.1 Success Criteria of Project Management

Quality, cost and time are the three key elements to measure the success of a project. The project's success criteria can be quantified, such as whether the deliverables have been achieved, the difference of indicators between the project outcomes and the pre-set goals, and the summary of the implementation processes in the fields of time, cost and quality. The final deliverables submitted to the owner should meet the operating requirements, and are able to be operated economically, safely and efficiently.

The project should be completed within the budget, and meet the demands of project economy and safety. As a result, the project team should try their best to reduce the cost, accelerate turnover rate of funds and shorten the time of capital occupation (Nie, 2017). Besides, the project should be completed on time in an orderly manner, and no accidents and losses occur during the entire period (Lin, Shen, Ma & Chen, 2008).

Above all, the project should have the ability of sustainable development and excellent prospect, which maintains the harmony with the environment (Zhou, 2012).

The highest level of project management is to satisfy all project stakeholders.

5.2 Philosophy and Thinking of Project Management

In a highly organized society, people must not only emphasize the efficiency of the organization and the technical methods of management, but also pay more attention to the human factors in management. Management activities should be conducive to improving human values, developing human potential, and liberating human creativity. Philosophy is the spirit and direction of project management, and project management is the practice and embodiment of philosophy. The philosophical understanding and thinking of project activities is an inevitable choice for the development of human society and world civilization (Floricel, Bonneau, Aubry & Sergi, 2014).

5.2.1 To Maintain a Rational Growth of the Project

Human beings should avoid the situation of expanding the scale of project blindly, regardless of the rule of social development and economical capacity. There is no doubt that the increase of development projects improves social civilization and material life of human beings. However, because of the increase of the project quantity and their complexity as well as the expansion of their scales, the relations between and among the projects, the nature, the economy and the society have become extremely complicated. The philosophy of project management must prioritize all the aspects referring to the project management (Bai & Wang, 2009).

5.2.2 To Seek the Balance Between Environment and Development

The socio-economic development has made tremendous achievements, but humans have also paid painful costs such as ecological balance destruction and environmental pollution. If the development patterns do not change, they will jeopardize the stability and development of the social economy. The harmonious development must maintain a relatively stable and dynamic balance. Human beings should neither sacrifice the environment for economic growth, nor give up the exploitation natural resources for the protection of environment (He & Wang, 2008).

Project management should focus on the comprehensive utilization of resources, energy conservation, and consumption reduction. It should also make reasonable planning to achieve the development goals of circular economy and green economy so as to coordinate the harmony between humans and nature.

5.2.3 The Value of "Putting People First"

The basic requirement of project management is to raise the level of management and improve the efficiency and productivity continuously (Yan, 2013). Project management is multi-objective management, and we must regard the law of development dialectically. Except for the pursuit of schedule and quality optimization, project management must strive to minimize resource consumption, reduce environment impacts, and achieve the aim of the best integrated benefits.

Human beings are the most active factor in social production (Wang, 2014). We must inspire the creativity of people, improve their comprehensive quality, transform advanced technologies and scientific achievements into productivity and promote the development of project management so that the whole society can share the achievements of development.

5.2.4 To Conserve and Protect the Natural Resources

Natural resources, especially oil and gas resources, are not inexhaustible. While maintaining the growth of social wealth, we must also satisfy the needs of human beings rationally (Shi & Xiang, 2001). Therefore, humans should exploit and utilize natural resources reasonably by means of efficient project management.

5.3 Problems and Challenges

5.3.1 The Lack of Samples

Project management is a theoretical system, which lacks the quantifiable indicators. Analytic Hierarchy Process compensates this deficiency by analyzing qualitative elements quantitatively. However, it is short of combination of theory and practice. In order to analyze and evaluate qualitative elements accurately, it is necessary to enlarge the number of samples and conduct further researches.

5.3.2 Imperfect Evaluation Mechanism

Although similar indicator evaluation systems of other industries are available for reference, offshore engineering project management has not formed a mature system yet. The indicators for the evaluation of offshore engineering project management are limited to relatively simple indicators such as financial data and scheduled plan, and lack comprehensive evaluation of the overall project (Cao, 2014).

5.3.3 Public Concerns about Environmental Protection

The activity chain involved in the offshore oil exploitation engineering includes geophysical prospecting, drilling, logging, down-hole operations, installation of offshore platforms and jackets, underwater pipe-laying, oil production, gathering and transportation. These operations will cause negative impacts on the marine environment (Halim, Janardanan, Flechas & Mannan, 2018). The factors that affect the environment in offshore engineering include ecological environment (hydrographic environment, submarine geology and geomorphology, and ecological organisms), air pollution, noise, vibration, liquid/solid waste, oil spill and other related factors (Wang, 2017).

The drill fluid and cuttings generated during the drilling phase will affect the seawater quality and marine sediment environment (Almeida & Medeiros, 2017). These kinds of pollutants will damage marine life resources such as plankton, benthic organisms, roes and larvae. In addition, sewage, oily water, garbage and production waste from ships and platforms will affect the environment. Since offshore oil and gas exploration and development facilities are far away from the shore, the air pollution and noise pollution during the offshore construction are easily overlooked, which will also affect the environment and human beings (Kandasamy et al., 2016).

Offshore engineering companies use the method of water injection to exploit some shallow oil-gas reservoirs and oil fields with complex geological structure. Due to improper water injection, the weak parts of the stratums are under excessive pressure, resulting in new oil and gas channels that link with the seabed, which leads to uncontrolled leakage of reservoir fluids, also known as "geological oil spills."

5.4 Suggestions as to Strengthen Environmental Protection Measures

According to the foregoing analysis, in different stages of project management, various environmental protection measures shall be taken in project planning, executing, controlling and closing, respectively.

5.4.1 In Planning Process

The project team should set up QHSE(Quality, Health, Safety and Environment) leading group for the project, who is responsible for the overall environmental protection during the entire project. The QHSE group must verify and determine the status and characteristics of environmental sensitive points within the execution area, and identify important environmental factors in the construction process.

Meanwhile, the project team should estimate the probability of oil spill accidents caused by unexpected events or accidents during the project construction and production period, predict the path and scope of oil spill drifting and the amount and residual of spilled oil, analyze the environmental impact on the surrounding sensitive areas, provide reasonable and feasible precautions and mitigation measures for oil and gas leakage accidents, and formulate corresponding emergency plans.

5.4.2 In Executing Process

The QHSE department must strengthen the education of operators and improve civilization quality and awareness of marine environmental protection continuously. When the project is in progress, it is necessary for corresponding responsible persons to make full use of various risk identification tools and organize experts in various fields to carry out hazard identification, risk analysis, and safety assessment at each step. Moreover, the project team should take compensation measures on ecological protection, such as avoiding the sewage discharge within the spawning season of major economic fish, and proceeding the artificial propagation and releasing to increase the diversity of marine organisms.

Once industrial accidents or emergencies occur, the designated engineering representative shall find out the causes of the accidents immediately, prepare analysis reports, develop solutions for reducing the impacts on the environment, which will be submitted to the owner for approval, and implement the approved solutions. The project team need to review, update, adjust and revise the original emergency plan promptly according to changes in internal and external conditions after the accident.

5.4.3 In Controlling Process

Each individual should implement the environmental protection work and take corresponding responsibilities. The project manager should evaluate the effectiveness of environmental protection measures and conduct performance assessments, reinforce the management of subcontractors, and supervise operation vessels.

During the construction process, patrol boats and the safety manager should patrol the operation area regularly and fill in the inspection logbooks. Once the pollution problems found, the inspectors shall report to the project manager and the owner without hesitation. No matter who caused the pollution, the project team shall deal with the pollutant unconditionally and take environmental remediation at once to minimize the effects of pollution and mitigate the risks of pollutant dispersion.

5.4.4 In Closing Process

After the completion of the project, the project team can compare the actual assessment values based on post-evaluation analysis with those in the original Environment Impact Assessment report, come up with measures to improve environmental protection, and increase environmental economic benefits. It is also the verification to the original EIA predictions, from which they can summarize experiences, learn lessons, and propose more effective measures.

Also, the project team should consult with the stakeholders and the public about the project, ask for advice, and examine the comprehensive and long-term benefits of the project. For the errors or missing items in the original report, the project team can review the operation processes, and assess the effectiveness of environmental protection measures combined with monitoring data obtained from the site to make corrections or supplements.

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