Deep-water oilfield development cost analysis and forecasting —— Take gulf of mexico for example

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Abstract. Gulf of Mexico (GoM) is the earliest offshore oilfield which has ever been developed. It tends to breed increasingly value of efficient, secure and cheap key technology of deep-water development. Thus, the analyze of development expenditure in this area is significantly important the evaluation concept of deep-water oilfield all over the world. This article emphasizes on deep-water development concept and EPC contract value in GoM in recent 10 years in case of comparison and selection to the economic efficiency. Besides, the QUE$TOR has been put into use in this research processes the largest upstream cost database to simulate and calculate the calculating examples’ expenditure. By analyzing and forecasting the deep-water oilfield development expenditure, this article explores the relevance between expenditure index and oil price.

1. The analysis of the major offshore development concept and EPC contract price in GoM.
By researching and counting the floating platforms which have been signed and built in recent 10 years in GoM, more than 90% deep-water oil and gas development uses the mode of floating platforms and subsea production systems (Figure 1). The main platforms include TLP, SPAR, Semi, etc. Because the construction capacity of deep-water floating platforms could meet the need of deep water development, the contractor is near to the market and the cost of transportation and installation is low, contributing the whole engineering more economical.

Based on the economic comparison of different oil and gas processing scale for newly built floating platforms in GoM in recent years, we use the investment of platform unit treatment scale as the evaluation and contrast index. Then fitting these indexes to a straight line (Figure 2). For the floating platforms, which were constructed in the same period and have similar processing scales, while have different types, semi-submersible platforms have the economic optimality. The amount of platform investment in the unit capacity scale is 10,000$ per bopd. Which means that if we want to add 1 bopd more capacity of oil and gas treatment, we should increase the cost at about 10,000 $. The next is SPAR and the lowest is TLP. Which means for each additional barrel per day on the processing capacity of Semi will cost more than 10 thousand dollars. In fact, the Semi has been used most in the new floating production facilities in recent 10 years in GoM since 2006.
2. Research on example cost of deep-water oilfields in GoM

To further study the economy of the floating working platform, taking the deep sea T field in GoM as an example, which was run by the software QUESTOR and calculated the planning stimulation of the offshore concept. For T oilfield using the “floating platform + subsea production system + pipeline” to develop and the floating platform using TLP, SPAR or Semi, the three development modes is stimulated and the calculation of CAPEX is analyzed. The CAPEX is formed by deepwater drilling and cost. The T-block’s main manufacturing parameters can be seen in table 1.

**Table1.** T-block’s main manufacturing parameters in GoM

| Recoverable reserve | Water depth | Water injection wells | Construction scale | Reservoir depth | Development period | Gas oil ratio | Surface water temperature | Distance from the shore | API° | Water temperature |
|---------------------|-------------|----------------------|-------------------|----------------|-------------------|---------------|---------------------------|------------------------|------|------------------|
| 490 mmbbl           | 1600 m      | 6                    | 70 kbopd          | 4000 m         | 20 years          | 320 m³/m³     | 32°C                      | 120 km                 | 31.6 | 10°C             |
The offshore engineering costs include platform costs, subsea production system costs, offshore pipeline costs, etc. And the platform costs account for 12-20%. The result shows TLP’s CAPEX is relatively high, reaching 4 billion 890 million dollars. SPAR’s CAPEX is about 4 billion 820 million dollars and the Semi is about 4 billion 290 million. That means the Semi platform could save 10% cost, compared with TLP and SPAR. And we can draw a conclusion that the Semi platform could get better economy in deep-water oil and gas development in GoM, which is in agreement with the conclusion from the analysis of the EPC contract price and the actual platforms in GoM in recent 10 years.

3. The analysis and forecast of offshore engineering cost
Analyzing the trend of offshore engineering cost indexes from 2000 to 2016 found all indexes go steadily up from 2000 to 2004 and to peak in 2013-2014. As the oil price drops in 2015, the sensitivity of Semi and SPAR platforms’ cost indexes were strong, dropping 31% and 39% in the past 3 years. The cost indexes of the TLP platform and the subsea production system declined 22% and 19% respectively by comparison.

The requirements of Semi platforms and SPAR platforms have fallen sharply since 2014 because only Korean contractors’ construction capacity could meet the overall construction requirements of the two platforms in the world. With the recovery of the oil price, the average increase in the offshore engineering cost indexes of the Semi and SPAR will be 3.1% in the future and the Subsea and TLP’s will be 4.2%, which will be the level of 2013 in about 2022. The offshore engineering cost indexes of the Semi and the SPAR will grow slowly in the future. Although subsea production systems’ cost index will grow steadily, it is hard to recover to the level of 2014, which is at its peak. It is can also be seen that the Semi working platform+subsea production system can be a priority selection of the deep-water oil and gas development based on the offshore engineering market and polices.

The changes of deep-water’s CAPEX and OPEX show that they have a delay-time relative to oil price and the trend of OPEX always maintain the rising tendency. While the trend of CAPEX was twists and turns: before and after 2008, the increase-smooth tendency made the investment index transit smoothly within the next 3 years; before and after 2014, the increase-decrease tendency shows that the sharp fall of oil price drug the high level index down; the investment index will rebound with the recovery of the oil price and it will recover the level of about 2019 to 2013. Controlled by the fluctuations of the oil price, the OPEX keeps the rising trend as a whole.
4. The analysis and forecast of CAPEX/OPEX

According the historical trends of drilling and offshore engineering cost, we can make forecasts that there is a consistency between the trend of CAPEX’s deep-water oil and gas development and OPEX’s in GoM. And the change of CAPEX shows the trends of CAPEX and OPEX lag behind oil price obviously (Figure 5). Although the development cost fell with the oil price fluctuation in 2009 and 2014, CAPEX and OPEX are always on the rising trends at the whole. In views of the above, the CAPEX and OPEX’s forecast region may rebound slowly with the oil price rising over next 3-5 years and in the year of 2019, the CAPEX will recover the level which is in 2013.

5. Conclusions

(1) The most used development concept in GoM is “floating platform+ subsea production system.” In recent ten years, semi-submersible platform has been used most frequently. Local contractors of GoM have the ability to integrate the construction of floating platforms. The suppliers are near the operating area and the transport cost is low. The Semi platform has relatively economy and operability under the conditions of deep-water, offshore climate in GoM.

(2) Looking forward to the future, some projects that using "FPSO + subsea production system" in the development and utilization of oil and gas fields in GoM will be used more widely. The series concept will bring revolutionary progress for world’s deep-sea oil and gas scale development and utilization.

(3) The cost and economy of deep sea platforms are subject to multiple factors. Normally, the larger the scale of oil and gas treatment we will plan, the higher the platform cost of unit processing scale we
shall consider. Therefore, we need more production rate, stable and long-term oil and gas fields production to ensure the deep sea oil and gas development period to maximize the economic benefits. 

(4) The variation trend of deep sea investment shows a trend of "twists and turns". It shows a relatively "lagging" variation trend to compare with the overall change in oil prices.

References
[1] Wei Wang. 2015. Four challenges of deep water oil and gas development. Petroleum Knowledge.(6): 5-7
[2] Lichen Wang. 2014. Global investment trend exploration and development of oil and gas. International Petroleum Economy. (9): 34-37
[3] Yaxing Liu. 2012. The thinking of South China Sea oil and gas exploration and production according to the status of the resource exploration of Gulf of Mexico [J]. China Mining Magazine.21 (9):17-19.
[4] Chenggao Yi. 2016. The new technique and tendency of global oil and gas development [A]. 14th National College Academic Communication of Oil and Gas Storage and Transportation.(7): 1-7.
[5] Wood Mackenzie. 2016. Mexico’s Round One deepwater exploration: big Gulf of Mexico opportunities. WoodMackenzie : 1-4.
[6] Wood Mackenzie. 2015. Deepwater Gulf of Mexico Briefing 2015. WoodMackenzie:1-2.