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# EVALUATION OF THE APPLICABILITY OF SUBSEA WELLHEADS RUNNING BY JACK UP RIG FOR OIL AND GAS EXPLORATION PROJECTS IN SHALLOW WATER, OFFSHORE VIETNAM

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**Summary**

An overview of the oil and gas production in Vietnam reveals that certain major oil and gas projects, which account for large-scale operations and dominate the oil and gas production in the continental shelf of Vietnam, are entering a declining production phase. This affects not only the efficiency of individual projects but also the national energy security. Consequently, the research and application of new technical solutions to supplement and maintain oil and gas production become the most critical tasks in the current phase. However, based on the assessment of oil and gas potential in the basins on the continental shelf of Vietnam, few major offshore oil and gas prospects can be developed using conventional methods to achieve high economic efficiency. Therefore, two development concepts with the highest feasibility, both economically and technically, are: the development of marginal fields in shallow water conditions and the execution of exploration/production activities in new prospects at existing production projects by drilling additional infill wells and connecting them to the central processing platform (CPP).

The article evaluates the potential and proposes a solution using subsea wellheads & X-mas Tree, operated by jack-up rigs, to develop marginal oil and gas fields in shallow water conditions and existing oil and gas fields with potential prospects located far from the CPP. This approach aims to reduce operational costs and enhance the overall efficiency of the project.

**Key words:** Subsea wellheads, shallow water, X-mas tree, OPEX, CAPEX.

## 1. Introduction

The concept of "shallow water" in oil and gas exploration and production is defined based on the nature of work in each specific sector. For the scope of this article, shallow water is defined by the depth at which drilling and completion activities can be conducted using a jack-up rig with a maximum water depth of approximately 115 m in oil and gas fields  This depth is lower than the actual working specifications of jack-up rigs due to operational limitations related to the leg penetration during the rig positioning. In particular, the leg penetration at basins on Vietnam's continental shelf can vary between 3 m and 23 m, depending on the seabed's geological characteristics in each area.

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Based on this concept, current producing oil and gas fields and future potential development fields in shallow water are primarily distributed across the Cuu Long basin, Nam Con Son basin, Malay - Tho Chu basin and Song Hong basin. The distribution of these oil and gas fields is shown in Figure 1.

In these basins, oil and gas fields have been developed and continuously produced over long periods using conventional technical methods. The equipment structure consists of a central processing platform (CPP) and fixed production platforms without processing systems, which are connected to the CPP through an underwater pipeline network. The production wells are drilled directionally/horizontally from the fixed platforms to reach prospects located at a maximum horizontal displacement of approximately 4.5 km.

Currently, the potential for large oil and gas fields that

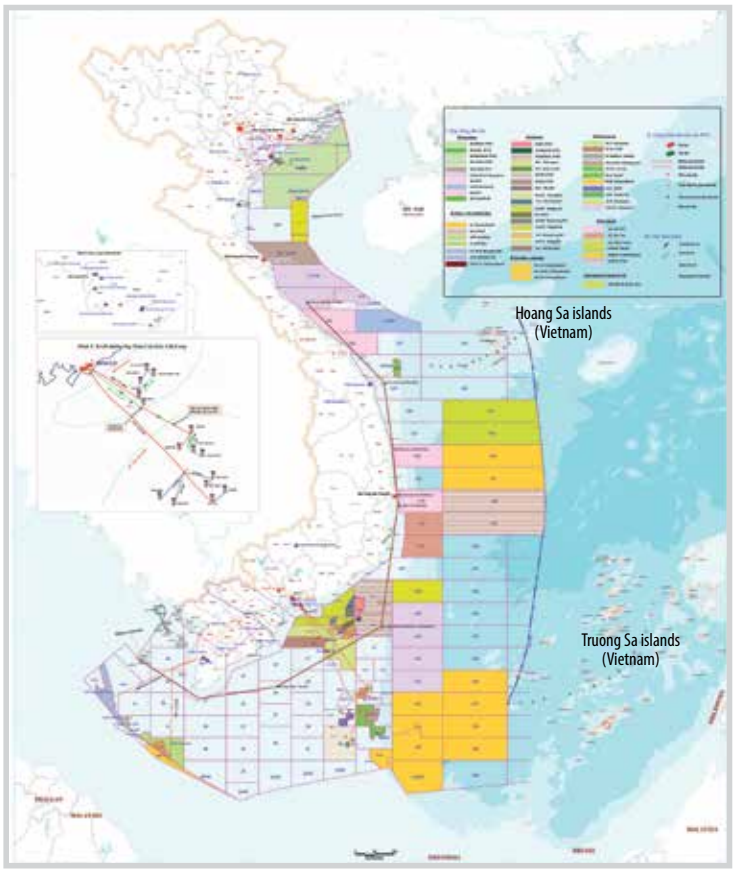



***Figure 1.*** *The distribution of oil and gas activities in Vietnam.*

could apply the conventional methodology for development phase on the Vietnam continental shelf has diminished. The in-place and recoverable reserves are not large, and high development costs, including drilling and production facilities, often result in project net present values (NPV) falling below expectations. Therefore, to increase oil and gas production, alternative approaches are necessary, focusing on the following aspects:

- Enhance exploration/production activities in ongoing projects by increasing the number of infill wells and constructing pipeline systems to connect to the CPP.

- Develop marginal fields using new technologies suited to the natural and geological conditions of the area to reduce capital expenditure (CAPEX).

In evaluating technological approaches, the authors identified that one promising solution for reducing drilling and CAPEX costs is the use of subsea wellheads and X-mas Tree systems installed with jack-up rigs. This method has demonstrated high efficiency in numerous global projects, yet it remains unimplemented in Vietnam.

## 2. Assess the development methodologies currently applied for oil and gas fields in Vietnam

Generally, development plans for oil and gas projects are established based on several key factors, including reservoir evaluation and feasibility, technology and equipment, the field's natural environment, offshore facility capacity, and innovative drilling and production techniques.

In Vietnam, most major oil and gas discoveries have been developed using conventional methods, including the construction of central processing platforms, fixed platforms, floating production storage and offloading (FPSO) units, and subsea pipeline systems for transporting oil and gas to shore. However, few oil and gas fields can efficiently apply this methodology. Meanwhile, the demand for oil and gas production continues to grow, highlighting the importance of developing marginal fields and exploring new prospects within ongoing production projects.

### *2.1. Exploration and development of new prospects in ongoing production projects*

For production projects experiencing declining production rates, technical approaches are being considered to maintain and sustain production, including:

a. Drilling additional infill/deviated wells from the fixed platform or CPP to reach the prospects within a drillable horizontal range (currently achievable with conventional technology at approximately 4,500 m).

b. With prospects located far apart, exploration/appraisal drilling of potential prospects beyond the reach of feasible deviated drilling is necessary. This involves installing lightweight wellhead platforms (with only the wellhead and X-mas Tree systems and connecting to the CPP via subsea pipelines).

It can be observed that this technical methodology is applied in most oil and gas projects in Vietnam. However, they also have limitations in terms of both technical factors and project efficiency, including the following:

- Some of CPPs or platforms have already reached the maximum number of wells per template slot; therefore, to drill a new development infill well, one of the existing wells must be abandoned and a sidetrack drilled to the new prospect. This will reduce the production rate along with additional drilling costs.

- The infill wells to be drilled from the platform will be designed with high inclination/complex well profile leading to prolonged operations time and higher risk of stuck pipe which may necessitate abandoning the well or drilling a new bore, thereby increasing project costs.

- The reservoir pressure is depleted after a production duration, resulting in reduced fracture gradient pressure while the pore pressure in the cap rock remains at its original values. This phenomenon leads to the risks of blowouts and fluid loss, significantly affecting the design and drilling operations

- The fixed costs for constructing new wellhead platforms (CAPEX) for new development wells are substantial, leading to a decreased NPV for the project (which will be specifically determined in the subsequent section).

- The preparation time for the installation of fixed platforms is lengthy, resulting in delayed first gas/oil production.

### *2.2. Development of maginal fields in shallow water areas*

- For marginal fields, factors affecting project feasibility include: recoverable reserves, geological conditions, natural conditions at the field site and drilling and facility costs. Fields with varying conditions require different development approaches, resulting in varied development costs. Thus, once recoverable reserves are established, CAPEX and OPEX costs become decisive factors. If a conventional development methodology is applied to marginal fields, the following limitations are observed: Independent development for marginal fields: In cases where prospects in the field are located far apart and beyond the feasible radius for deviated drilling, the concept of development involving the construction of CPP platforms and/or lightweight platforms is considered. However, that development concept incurs high costs, making in the project inefficient.

- Development of marginal fields based on adjacent field facilities: In this scenario, the lightweight platforms are selected for installation on the main reservoirs location. Oil and gas shall be transported to the adjacent field's CPP via a subsea pipeline system. However, for fields with low recoverable reserves, the cost of constructing lightweight platforms may reduce overall project efficiency.

## 3. Application of subsea wellhead system for shallow water areas

### *3.1. Geological conditions*

At this stage, the newest technology for sealing devices used to connect the subsea suspension system to surface equipment has not yet met the requirements for high - temperature and high - pressure (HTHP) conditions. Therefore, the subsea wellhead system for shallow water fields is only applicable to formations with the following conditions:

- Wellbore pressure P < 10,000 psi,
- Wellbore temperature T ≤ 150°C.

### *3.2. Field environment conditions*

As mentioned above, oil and gas fields in shallow water are developed using a jack-up rig solution under the following conditions:

- Water depth of approximately 115 m, which may vary based on the technical specifications of the rig and the penetration depth of the rig legs at the well location.

- Well location within a 10 km radius, which depends on the estimated cost of the subsea pipeline system from the well location to the central processing platform, or CPP.

### *3.3. Structure of exploration/development wells*

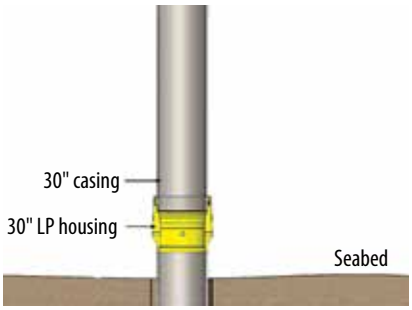
Depending on geological, pressure, and temperature conditions, the well structure is designed accordingly. However, the most common casing structure for exploration/development wells in shallow water basins in Vietnam is 30" x 20" x 13⅜" x 9⅝" x 7".

Additionally, the well structure may omit or add casing sizes. Following the design principles of the subsea wellhead system for shallow waters, the well structure only affects the configuration and scale of the system, without impacting functionality. Therefore, this document outlines the simplest structure with the applied casing schematics of 30" x 16" x 9⅝" x 7".

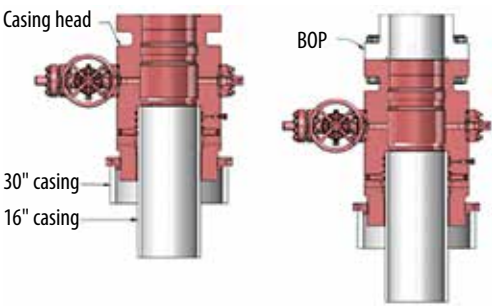
### *3.4. Use of subsea wellhead and X-mas Tree systems*

During the exploration phase, to reduce drilling and development costs, it is recommended to consider converting the exploration well into a development well by using the MLS (mudline suspension system) after completing the exploration stage.

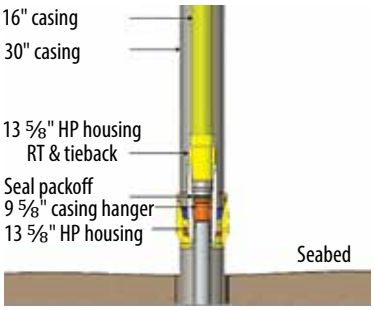
In general, the design of subsea wellhead and X-mas Tree should be based on the specific well schematic and well design. Therefore, in this paper, for economic evaluation purpose, the concept design and installation of the MLS are based on the casing scheme of 30" x 16" x 9⅝" x 7", as outlined in the running procedures and illustrated in Figure 2.



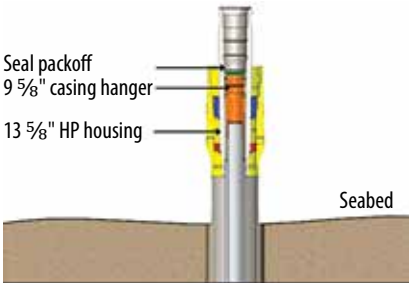

*1. Drilling 36" x run 30" casing*



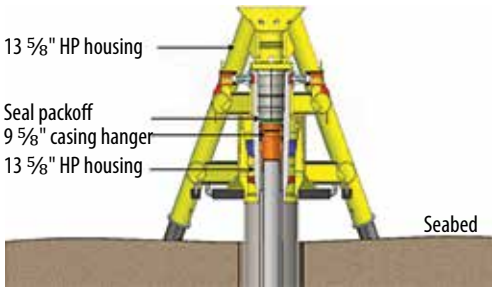

*2. Installation of surface WH and BOP*



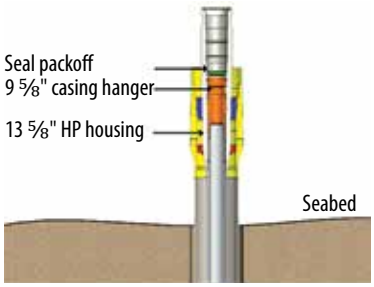

*3. Drilling and running 16", 9⅝" and 7"*



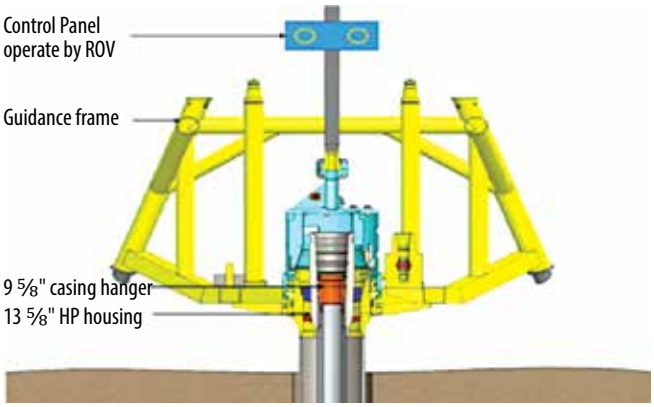

*4. Recovery of landing strings*



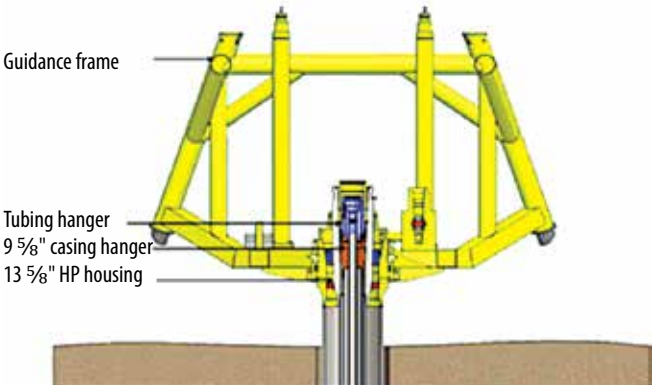

*5. Installation of protection frame for MLS*



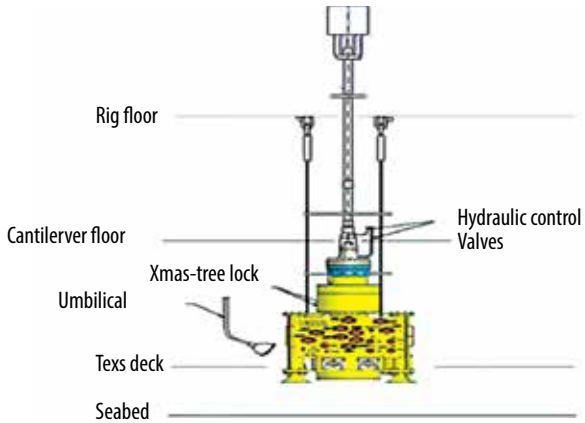

*6. Recovery of protection frame*



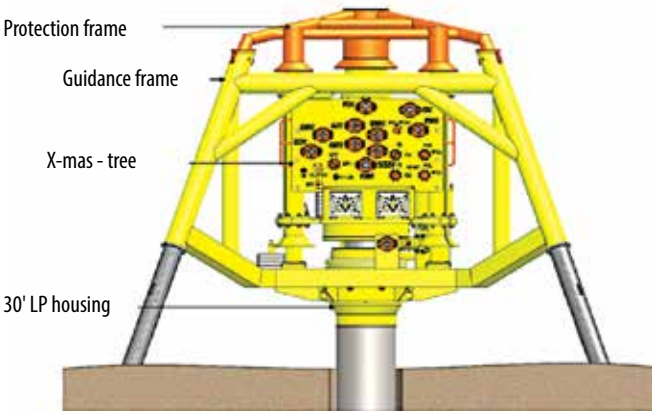

*7. Installation of guidance frame systems*




*8. Lower and upper completion*




*9. Installation of the X-mas tree*




*10. Installation of X-mas tree protection frame*

***Figure 2.*** *Running procedures of subsea wellhead and MLS systems.*

### *3.5. Structure of subsea facilities utilizing subsea wellhead and X-mas Tree systems*

Essentially, the structure of subsea facilities utilizing subsea wellhead and X-mas Tree systems in shallow water conditions is similar to that in deep water. The production wells are positioned based on the evaluation results of prospects. Three main types of structures are designed and constructed, including (Figures 3 - 5).

Applicable for prospects with small reserves, a single well wellhead and X-mas Tree shall be connected to the central processing platform or a lightweight platform via a subsea pipeline system (Figures 3).

In cases where prospect have big reverser or prospects are located relatively close to each other, drilling can be carried out using a subsea template or an independent drilling location through the cantilever system of a jack-up rig (Figures 4).

Applicable to large prospects or those located close to each other, the wells are drilled from various locations and connected to a flow manifold, which is then linked to the central processing platform (Figures 5).

## 4. Assessment of technical and economic eficiency

The subsea wellhead system used in shallow water has been designed and deployed with jack-up rigs in several major field areas worldwide, such as the Gulf of Mexico, the North Sea, and the Black Sea. These projects have demonstrated that the system meets both technical and economic efficiency requirements. However, it has not yet been applied in Vietnam, underscoring the need to evaluate the feasibility of using a subsea wellhead system for exploration and development. This

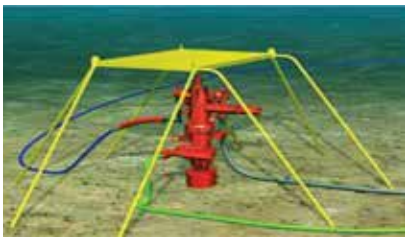


***Figure 3.*** *Single production well [1].*

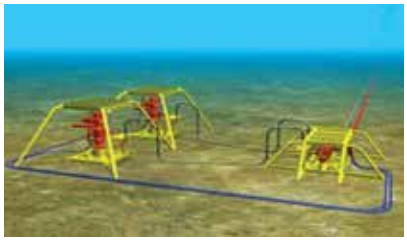


***Figure 4.*** *Structure of the well cluster [1].*

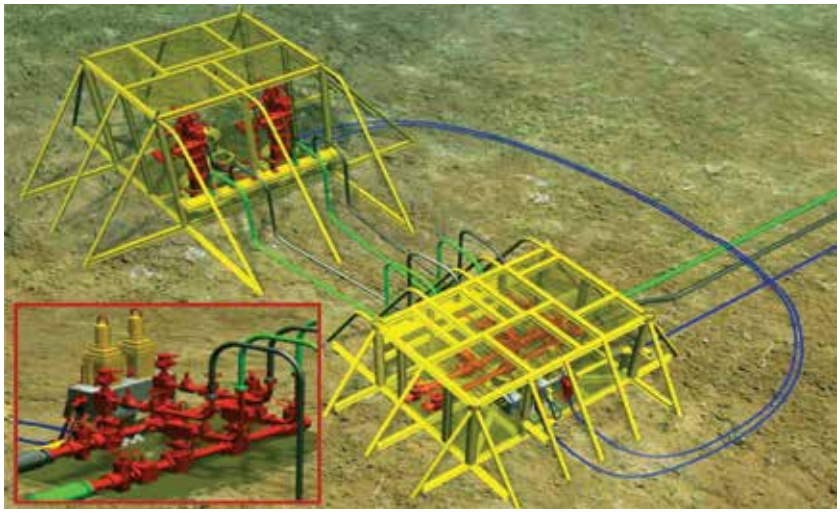


***Figure 5.*** *Structure of the well series [1].*

approach aims to supplement production in declining fields or to develop marginal fields in shallow water conditions.

Considering the current circumstances of Vietnam's oil and gas industry, the author presents an option for a development plan for oil and gas fields in shallow water areas, focusing on technical and economic efficiency as follows:

### *4.1. Technical efficiency*

- Shortened time to first oil/gas [2]

In principle, once a field development plan (FDP) is approved by the authorities, the project will proceed through the stages of preparing bidding documents, signing contracts, manufacturing, handover, and equipment installation.

With projects using the conventional development methodology, the preparation and installation of the production platform require approximately 24 - 30 months, with drilling and completion taking about 3 months. Therefore, the total time from project approval to first oil and gas flow is around 27 - 33 months. An alternative approach involves pre-drilling with a subsea template before installing a wellhead platform to shorten project time. However, this method can be delayed due to the waiting period for the wellhead platform installation, after which the jack-up rig must return for well connection and completion. Additionally, this method carries higher risks related to positioning the production platform onto the well template.

In contrast, applying a subsea wellhead system in shallow water can achieve first oil/first gas approximately 14 - 16 months after project approval. Essentially, this approach shortens the time to first oil/gas flow by about 12 - 17 months, depending on the scale of the project.

- Simplified facility structure [2]

For fields with multiple prospects located 8 - 10 km apart and with moderate reserves, the simplest operational approach is to use a structure with single wells or well clusters, operated with direct hydraulic control. In cases where clustered well structure is applied, a jack-up rig with cantilever movement can be used for drilling and completion without requiring frequent rig repositioning.

In addition to these advantages, applying a shallow-water subsea wellhead approach with a simple profile for production well can penetrate prospects located in areas that can not be reached by drilling from the production platform. This increases both production rate and overall project efficiency.

- Reduced drilling risks

The design of wells in shallow-water subsea wellhead systems typically features simple schematic and trajectories, avoiding wellbore penetrating through abnormal geological conditions. Consequently, using a jack-up rig for drilling in these wells minimizes operational risks, such as stuck pipe, hydraulic issues while also shortening drilling time.

### *4.2. Economic efficiency*

- Minimized drilling expenditures

For conventional development plans, the lightweight fixed platforms with wellhead systems installed on the surface require the deck to be elevated above sea level to withstand storm conditions. Consequently, the length of the legs of the jack-up rig must be longer, leading to higher specifications and, therefore, higher daily rental rates (USD/day). In contrast, using a subsea wellhead system enables the use of a rig with lower specifications, thereby reducing daily rental costs.

According to current market surveys of jack-up rigs, the rental price of a rig with a leg length of 477 ft is approximately 10 - 20% lower to compare to a rig leg length of 517 ft (or longer). Additionally, the well strategy design is simplified when applying a subsea wellhead, thus shortening construction time by approximately 5%, thereby reducing drilling costs.

- Reduced CAPEX

The value of CAPEX for each project is determined based on the scale of offshore facilities and drilling methodology, which depends on the scope of each project. With the exploration/development projects by drilling infill wells in ongoing production fields or developing marginal fields, the following costs will decrease to compare to conventional methodology:

+ Subsea wellhead/tree systems and pipeline connections to the CPP: Costs include operational equipment and vessel chartering for pipe laying, which are lower than the design, construction, and installation costs of lightweight fixed production platforms.

+ No cost for surface wellhead/tree systems.

+ Costs for supporting services, including service vessels, logistics bases, transportation, and import/export activities.

- Reduced OPEX

The value of OPEX for a project primarily includes items such as chartering security vessels, maintenance, upkeep of equipment and platforms, and periodic surveys. Therefore, using a subsea wellhead system can affect costs for the following items:

+ No annual maintenance costs for surface equipment, as with fixed platforms.

+ Lower logistics costs, including service vessels and personnel for maintenance and repairs of equipment throughout the field's life, compared to fixed platforms.

+ Higher well intervention costs, as a jack-up rig must be mobilized for each individual well repair task.

Nevertheless, in overall comparisons, using a subsea wellhead system results in lower OPEX than lightweight fixed production platforms.

- Overall project economic efficiency

For oil and gas projects globally and in Vietnam, economic efficiency is primarily evaluated using the Net Present Value (NPV) of the entire project. Furthermore, based on the assessment results of oil and gas potential on Vietnam's continental shelf, the use of a subsea wellhead systems are often utilized for developing moderately scale. This makes the NPV a key factor in determining whether to proceed with project implementation.

In this article, the authors aim to evaluate the

***Table 1.*** *Comparision of overall costs for development of gas project in Vietnam*

| Descriptions | Estimated cost of project applied the lightweight platform (Million USD) | Estimated cost of project applied subsea wellhead methodology (Million USD) |
|---|---|---|
| Estimated cost of drilling and completion | 124.5 | 118 |
| Estimated cost of wellhead and X-mas Tree | 1.5 | 2.8 |
| Estimated cost of building a fixed lightweight platform (unmaned) | 51.5 | 0 |
| Estimated costs of subsea pipelines, control and ubmblical systems and vessel subsea pipe layer | 90.5 | 95 |
| Estimated value of CAPEX | 268 | 215.8 |
| Estimated value of OPEX and well intervention | 415 | 181 |
| Abandonment expenditure | 50 | 34 |
| Net profit of partners | 145 | 145 |
| Net profit of contractor | 432 | 432 |
| Total income of government | 650 | 650 |
| Taxes | 85 | 85 |
| Other fees | 20 | 20 |
| Total CAPEX, OPEX | 2,333 | 1,978.6 |
| Revenue from the sale of products | 2,427 | 2,427 |
| **NPV** | **39.5** | **222.3** |

economic efficiency of a gas field case study in Vietnam. The scope of work is defined as follows:

- The gas field is currently in production, with facilities including a central processing platform and a development plan that involves drilling infill wells to maintain the gas production rate.

- Total 4 production wells designed with TD @ 4,000 m TVD SS with casing structure 30" x 20" x 13⅜" x 9⅝" x 7" and 5½" completion for a field life of 15 years.

- Jack up rig 10,000 psi BOP shall be utilized for drilling activities, the daily rate 130,000 USD/day [3].

- The light fixed unmmaned platform including jacket and topside with estimation of weight 1,700 MT and 1,400 MT respectively.

- The gas is transported to the central processing platform over a distance of 30 km.

- Production is expected to decline gradually over 15 years, with a total output of 5,500 million $m^3$.

- The estimated gas price under the contract is 12.5 USD/MMBTU.

The economic efficiency of the proposed development project is assessed through a comparison of various development methodologies, based on the estimated costs associated with a gas project in Vietnam. The key cost components and their details are outlined in Table 1.

Note:

The estimated costs listed in Table 1 for a specific gas project are assumed based on the following criteria:

- Estimated costs for each item are based on the average values of gas projects in Nam Con Son basin, offshore Vietnam.

- Costs are estimated for a project with the following scale:

+ Service costs are estimated based on market prices for the year 2023.

+ The discount rate - 10%.

Estimated costs are calculated in detail for each specific project, using the estimated service prices at the time the project is executed.

Based on the estimated NPV table for the two options, it is evident that with the same production volume, the option using the subsea wellhead/tree system incurs lower total costs, resulting in a higher NPV compared to the option using lightweight fixed platforms.

## 5. Conclusion

Based on the assessments of oil and gas reserves on Vietnam's continental shelf to date, the fluctuations in the market for services related to the exploration and development of oil and gas fields, the preliminarily evaluation of technical and economic efficiencies, and the

results demonstrating effectiveness in several projects worldwide, the application of the subsea wellhead/tree system for development in shallow water is a feasible option for fields with the following characteristics:

- Currently producing fields that plan to increase production rates by drilling infill wells to access distant prospects located far from the central processing platform.

- Marginal oil and gas fields with natural environmental conditions suitable for operations using jack-up rigs.

However, during the development planning process, oil and gas operators need to consider several issues related to the operation of production wells, including:

- Assessing potential reserves and prospect locations to select the optimal development structure, maximizing operational efficiency and minimizing CAPEX costs.

- Selecting appropriate service providers with the necessary capabilities and experience in executing similar projects.

- Evaluating the technical options and equipment used for well intervention to minimize risks and project costs.

- Utilizing data collected during production to update the production plateau for each specific formation, enabling a reasonable well-opening strategy.

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