Risk policy comparative review of offshore renewables and oil & gas installations

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Abstract: The development of adequate energy sources to satisfy the ever increasing energy demand in the world has led to the deployment of several offshore energy installations. Offshore Oil & Gas and renewable energy installations have had a lot of growth in recent years; this growth has led to an increase in the accompanying risks and challenges faced by these industries especially regarding policy implementation.

Thus, it is pertinent to assess all the risks in the offshore energy industry, to create a 'feed-in base' applicable to both offshore renewables and offshore oil and gas industries. This paper analyses all the risks in the offshore energy industry in relation to policy through Failure Mode and Effects (FMEA) analysis using Risk Prioritisation Numbers (RPNs).

1. Introduction

The offshore oil and gas sector generates around £20 billion of revenue per annum and £12.8 billion of Gross Value Added (GVA) whilst supporting induced, indirect and direct employment of more than 190,000 people; thus, making it one of the key sectors of the UK economy [1]. This scenario is true not only for the West but also for major emerging economies; for example, in Nigeria, offshore oil and gas earnings of over £18 billion per annum account for more than 98% of the country's export earnings, 83% of the federal government revenue, 14% of the country's Gross Domestic Product (GDP), 95% of foreign exchange earnings and 65% of the government's budgetary revenues, also making this sector the mainstay of the country's burgeoning economy [2].

Offshore oil and gas installations and processes around the world are 'converging' and becoming increasingly similar with major international oil companies participating actively in most exploration activities. However, this cannot be said of the offshore renewables industry, which is relatively 'young' compared to the offshore oil and gas industry and still has a lot of potential for growth especially in the West.

A huge number of elements such as offshore installations, risk management, personnel transfer, offshore operation and maintenance activities required to develop offshore renewable projects have already been developed by the oil and gas sector. This has made many oil and gas firms to start operating offshore renewable projects especially offshore wind, putting their expertise to use; using the same protocols and standards of the offshore oil and gas industry [3]. Skills transference from the oil and gas sector and incorporation of the oil and gas supply chain has the potential to reduce the cost of offshore renewable operations by 20% based on significant areas of crossover, application of similar knowledge and skills and favourable economies of scale [1]. However, despite these advantages; there are a lot of risks to be considered in the transition from offshore oil and gas to offshore renewables.

Therefore, the construction and quantification of an index of energy security is an important research issue, since it will enable the implementation and assessment of alternative policy measures in order to improve energy security and consequently enhance the mitigation of risks arising from the dependence of the European continent on external energy sources [4]; thus, the impact of risks on international markets and global energy supply remains of great importance [5].

Hence, a comparative analysis of the risks in offshore oil and gas installations and in the offshore renewables industry is done with the view of identifying, prioritising and comparing prevailing risks in order to derive recommendations for more efficient planning in future developments with respect to energy policies and security.

2. Risks in the Offshore Oil & Gas Industry

The petroleum industry drills for oil and gas wherever geologic conditions are conducive to find and produce commercial quantities of hydrocarbons. Operations are conducted on land and over water throughout the world, and, approximately 35% of world oil production is currently being extracted offshore from 60 countries.

Offshore operations present a unique combination of conditions not observed in other industries. Due to the remoteness of facilities and the challenges presented by a marine environment, drilling and construction projects are major undertakings which are significantly more expensive, uncertain, and riskier than onshore operations. Space constraints also make it difficult to mitigate hazards by separating equipment, personnel, and hazardous material. The availability and performance of service vessels and work conditions also result in delays, hazards, often with significant financial repercussions. [6]

Thus, increasing concerns about overall project 'life cycle cost' and 'safe operations' have made risk identification a key aspect of decision making with regards to embarking on offshore oil and gas projects. Proper risk identification also affects the feasibility of an adequate ROI (Return on Investment) for most offshore projects, which is increasingly becoming a major aspect of project investment decisions [7].These risks include: engineering, commercial, geological, operational, supply-demand, socio-economic, HSE (Health, Safety and Environment), asset damage, business interruption, compliance/non-compliance and security risks (including cyber threats) [7].

However, due to the world's increasing demand for energy, companies have to contend with these risks to have financial, operational and strategic success [8].

Ernst and Young in its business review of the energy sector highlights the major risks which oil and gas companies are prone to as: access to reserves and competition arising from political constraints; uncertain energy policies; cost containment; worsening fiscal times; HSE risks; human capital deficit; operational challenges; climate change concerns; price volatility and competition for new technologies [9].

An exhaustive analysis of the risk types identified from various literature show that they can be broadly classified into seven main groups which are: political; operational; economic; supply and demand; health and safety; environmental and strategic risk groups. A summary of the risks identified is presented in Table 1.

Economic evaluation of these risks is based on the 'most likely' results of variables that could be expected [10].

3. Risks in the Offshore Renewable Energy Industry

The world has seen an exponential growth in the offshore renewables industry. The UK has been at the forefront of Europe's exponential growth in renewables with new licenses awarded by the government, increasing generating capacity to 33GW by the end of 2020 [11]. However, a corresponding increase in risks and hazards is being associated with the growth trend in the industry and the offshore renewables industry is usually classified as a 'high' risk sector. The PESTLE (political, economic, social, technical, legal and economic) analysis approach is widely acclaimed as the best risk identification tool for the offshore renewables industry; because it maps individual risks to the multiple stakeholders involved in the offshore project development stages from design conceptualization to decommissioning [12], [13].

OREIs (Offshore Renewable Energy Installations) consist basically of offshore wind energy, tidal energy, marine current turbines and wave generators [14]. Offshore wind energy is more developed than the other three offshore renewable energy forms. Although, the offshore wind energy sector would benefit from a strengthening of existing, successful, legislation, there are concerns that a new legislative package could take years to adopt at a crucial time in the development of large scale wind power [15].

Hence, to reduce data gaps in the overall PESTLE analysis, it is anticipated that knowledge of the offshore wind sector would be transferred to the three other 'juvenile' offshore industries [12]. The PESTLE analysis thoroughly identifies all potential possible risks present in the offshore renewables industry based on stakeholder analysis.

Overlapping of project stakeholders occurred during the PESTLE analysis based on the relative importance and involvement of each stakeholder in the project development process [16]. A summary of these risks are also shown in Table 1.

4. The Relationship between Policy Planning and Risk Prioritisation for Offshore Energy Installations

Europe's dependence on imported energy has risen from 20% at the signing of the Treaty of Rome in 1957 to its present level of 50%, and the European Commission forecasts that imports will reach 70% by 2030. If energy trends and policies remain as they are, the EU's reliance on gas imports will jump to 84% of gas consumption and 93% of oil by 2030 [27].

According to the EWEA (European Wind Energy Association), a focus on the energy policy in Europe is becoming increasingly relevant to meet the increasing energy demands of the continent [28]. The imperatives of combating climate change and securing energy supply are becoming stronger, with globalisation demanding increasing levels of cost competitiveness.

The European Commission [29], also states that offshore renewable energy installations would become increasingly important over the next decade and as such, relevant energy policies would have to take into relevance the attendant risks inherent in not just the offshore renewables but also the offshore oil and gas industry. In order to achieve the three key objectives of the European Union's energy policy: reducing greenhouse gas emissions, ensuring security of supply and improving EU competitiveness; there is an increasing focus on finding ways to mitigate the impact of risks in the offshore energy industry in order to reach these targets.

A lot of importance is placed especially on the offshore wind energy industry as it has been estimated that, the potential for offshore wind energy is largely untapped: even excluding potential deep water deployments based on floating foundations, the potential exploitable by 2020 is likely to be about thirty times the current installed capacity and in 2030 it could be as high as 150 Giga Watts (575 TeraWatts Hour) [29].

The technology for offshore renewables is progressing fast, but it needs to be driven faster by a policy framework as positive as that which promoted the offshore oil and gas sector from the 1960s onwards [28]. A proactive policy is thus necessary to ensure that opportunities in this sector are maximized and risks mitigated.

An example in this regard is the designation of protected areas under the Habitats and Birds Directives in the marine environment by the EU member states which has also reduced the risk faced by offshore energy developers in being subject to excessive and expensive environmental assessment and monitoring [30]. Due to the importance of the offshore energy industry, risk identification and prioritisation are increasingly being considered in the enactment of policies.

5. Discussions

The offshore oil and gas FMEA high risk scenarios given in Table 2 show that the highest risks this industry is prone to are: exploration risks, unstable market conditions and uncertain energy policies. These results are a reflection of the current trend the industry is facing. Due to the demand for oil and gas, it is envisaged that offshore reserves would recede more and more into deep water facilities which would subsequently increase the levels of exploration difficulty. Unstable market conditions and energy policies also portend high levels of risk for the offshore oil and gas industry. As a result of shifting policies, and changing legislative views regarding the use of fossil fuels, policies change frequently and guarantees cannot be given for the continued use of fossil fuels (both onshore and offshore) in the energy market.

Table 3 shows the high risk scenarios according to the FMEA classification for the offshore renewables industry as: inconsistent energy policies, fluctuating energy standards and global energy market uncertainties. These three high risk scenarios all border on energy policy issues. This shows the fact that much more than the offshore oil and gas industry; energy policy considerations would have a higher impact on offshore renewable operations.

Compared to the well-established offshore oil and gas industry, offshore renewables are more dependent on energy policies and fluctuating market conditions. Government interventions and political ideologies regarding the use of renewable energy have helped boost this industry in the past decade; however, a shift in this may lead to uncertainties in the growth of the industry.

Market uncertainties, fluctuating policies, environmental risks and price volatility are common risks for both the offshore oil and gas and offshore renewables industries. An assessment of these risk categories further gives credence to the fact that adequate energy policies have a high potential of leading to a more successful offshore energy sector because, adequate energy policies can help reduce supply-demand risks which lead to market uncertainties and price volatility. Also, environmental risks can be mitigated with the enactment of the right policies acting as guidelines for the offshore energy industry.

6. Conclusions

The risk prioritisation of the offshore renewables and the offshore oil and gas industry show that with the adequate policies and the use of a strategic coordinated approach, both industries can be effectively managed simultaneously to enhance Europe's energy sustainability in the decades to come thereby reducing reliance on imported energy. Hence, practical steps and policies based on actual, sectorial needs should be considered to enable the offshore energy industry operate at a high level.

Furthermore, the monitoring of offshore energy installations with a minimal impact on the environment should be encouraged by the Government. Cooperation between both the public and private sectors should be encouraged to further facilitate the approval of offshore energy sites and the construction of offshore grid systems for effective energy transmission and distribution. Policies and favourable regulatory conditions for investments in offshore grids and adequate offshore energy research should also be encouraged to mitigate the risks and encourage the growth of offshore energy in Europe.

Risk Prioritisation Methodology

According to the FMEA (Failure Mode and Effect Analysis) pocket handbook: 'FMEA analyses and ranks risks associated with various processes systematically including their existing and potential failure modes; prioritizes the risks based on ranking results, processes the highest ranked risks, evaluates and re-evaluates the risks, and loops through the prioritization process until marginal returns are achieved'. It is a systematic tool which identifies, prevents, eliminates and controls potential errors in a project [17]. Reliability is also enhanced by recognizing failures before they occur using FMEA [18].

The overall FMEA process which includes failure finding, prioritization and minimization makes it applicable to a wide range of processes including energy analysis; to aid in the application of adequate corrective and preventive maintenance actions. FMEA manages the documentation and implementation of 'error causing scenarios' [19].

Based on the review conducted in previous sections, the various risk groups in the offshore oil and gas and offshore renewables industries as summarized in Table 1, were ranked using the FMEA method to enable the evaluation of possible effects of failure modes.

The major advantage of the FMEA method is its 'action' not 'reaction' approach to dealing with failure [20]. Thus, FMEA is performed before the project design stage because costs due to damages are much higher if discovered after project design.

The main tasks of FMEA analysis used in this paper are information collection on risk causing activities and processes for offshore renewables and offshore oil and gas installations which have been done in preceding sections.

This also includes the formation of a combined risk register (Table 1). The severity, occurrence and detectability rates were assigned to each risk to calculate the RPN (Risk Priority Number). Severity of the risk considers its overall effect; Occurrence deals with the frequency at which a potential error would occur and Detectability is a qualitative assessment that identifies the cause mechanism of the risk event [20].

Thus, priority ranking is achieved based on the assignment of a requisite RPN which is defined as:

$$RPN = S \times O \times D$$

Where: S = Severity; O = Frequency of occurrence and D = Detectability

Surveys were created for both industries; based on responses from professionals and doctoral researchers with research interests peculiar to each of the offshore industries. The RPN values were chosen to vary between 1 and 1000 leading to the prioritization of the risks according to their RPN values.

The development of a risk-based methodology helps to focus on risk-significant areas and operational practices. One of the main goals is to concentrate on critical components. A 'critical' component is a component mostly contributing to the risk; [21] which in the sense of this paper is classified as a high risk scenario.

The computation of RPNs also allows focus on risk events with high RPNs based on their higher priority ranking compared to other risks as shown in Tables 2 and 3.

Events with high RPN values are thus classified as 'high risk'. The RPN is basically used as a metric for classifying risks as 'acceptable' or 'unacceptable'. The values of S, O and D which were for FMEA in this paper are be ranked on a scale of 1 to 10 similar to the scale given in Towler and Sinnot, [22].

Due to the possible uncertainties existing in the FMEA evaluation process, RPNs representing 'crisp numbers' which are used in conventional FMEA methods are being replaced with linear programming methods, fuzzy and weighted RPNs. This paper takes into account the major shortcomings of the RPN method during the FMEA, however; the errors which these shortcomings might present to the overall data analysis results are considered negligible. According to Lui et al [23] and Gilchrist [24], the major shortcomings of the FMEA cum RPN approaches are:

- Only three risk factors mainly in terms of safety are considered when the RPN method is used.
- The RPN elements have a lot of duplicate numbers.
- RPN calculations are highly sensitive to variations in risk factor evaluations.
- Various interdependencies occur among failure modes and effects and these are not taken into account by the RPN.
- RPNs are not continuous values and thus, have many 'holes'.
- The effect of corrective actions cannot be measured by RPNs.
- Score conversion is different for each of the three risk factors considered in FMEA.
- A lot of controversy abounds concerning the mathematical formula for performing RPN calculations.

- Evaluation of the three risk factors cannot be carried out precisely.
- Equal values of RPNs can occur from different combinations of occurrence, severity and detectability; but with totally different risk implications.

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S/N	Offshore oil and gas industry risks	Offshore renewables industry risks
1.	Access to offshore reserves	'Blade throw' risks
2.	Climate change concerns	Collision risks
3.	Competition for proven reserves	Commissioning risks
4.	Competition from offshore renewables	Competition from offshore oil and gas
5.	Construction risks	Construction and installation risks
6.	Contractual risks	Contractual risks
7.	Decommissioning risks	De-commissioning risks
8.	Environmental risks	Engineering design uncertainties
9.	Exploration risks	Environmental risks
10.	Expropriation and nationalization risks	Fluctuating energy standards
11.	Fluctuating fiscal terms	Global energy market uncertainties
12.	Geological risks	Grid connection and integration risks
13.	Governmental regulations	Investment risks
14.	Health risks	Inconsistent energy policies
15.	Human capital deficit	Insurance risks
16.	Installation risks	Legal risks
17.	Insurance risks	Licensing risks
18.	Investment risks	Offshore communications interferences
19.	Legal risks	Political instabilities
20.	New operational challenges	Price fluctuations
21.	Political instabilities	Project approval risks
22.	Price volatility	Public and private sector partnership risks
23.	Processing and separation risks	Public disapproval of projects
24.	Safety risks	Reduction of subsides and tariffs
25.	Supply chain glitches	Regulatory compliance risks
26.	Taxation risks	Structural failure risks
27.	Transportation risks	Structural maintenance risks
28.	Uncertain energy policies	Supply chain fluctuations
29.	Unfamiliar environment risks	Taxation risks
30.	Unstable market conditions	Technology maturity level risks

Table 1: Combined risk register of offshore oil and gas and offshore renewables

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S/N	Risk	Rank	RPN
1	Exploration risks	1	409
2	Unstable market conditions	2	391
3	Uncertain energy policies	3	388
4	Environmental risks	4	337
5	Safety risks	5	336
6	Political instabilities	6	302
7	Price volatility	7	298
8	Fluctuating fiscal terms	8	268
9	Geological risks	9	251
10	Expropriation and nationalization risks	10	228

Table 2: Offshore oil and gas FMEA high risk scenarios

S/N	Risk	Rank	RPN
1	Inconsistent energy policies	1	448
2	Fluctuating energy standards	2	442
3	Global energy market uncertainties	3	421
4	Price fluctuations	4	367
5	Reduction of subsidies and tariffs	5	276
6	Supply chain fluctuations	6	234
7	Environmental risks	7	214
8	Investment risks	8	202
9	Structural failure risks	9	198
10	Regulatory compliance risks	10	195
11	Decommissioning risks	10	194

Table 3: Offshore renewables FMEA high risk scenarios