Analytical Hierarchy Process to Determine Minimum Attractive Rate of Return for Exploration and Production Projects in Oman

By Saaed Al-Shehhi

Abstract

In Oman, the oil and gas regulator is the Ministry of Oil and Gas (MOG) and all concessions are awarded by this entity. MOG has completed several projects in collaboration with various government sectors and they also oversee all oil and gas Exploration and Production (E&P) activities. E&P is conducted by companies that are either national or overseas corporations.

Economic evaluation of E&P projects is based on single hurdle rate which actually represent project's Minimum Attractive Rate of Return (MARR) which should include risks related to the opportunities.

The purpose of this paper is to find whether single hurdle rate is appropriate to evaluate investor's project economic evaluation and to find out appropriate range of MARR.

In this paper, Analytical Hierarchy Process (AHP) is used to find out range of project risks, that cover activity type, location, reservoir type and drilling type, which is then plugged into the MARR equation. The paper concludes that a range of 11 to 15% covers most cases and, therefore, single interest rate is inappropriate.

1. Introduction

1.1 Oil and Gas Reserves and E&P Companies[1]

Total oil and condensate reserves in the Sultanate of Oman is estimated to be 5151 million barrels by the end of 2013, the year that saw 3.5% augment in reserves, compared with 4197 million barrels in 2012. Production also increased by 2.5%, from 918.5 to 941.9 thousand barrels per day (bpd).

Gas reserves in Oman increased by a whopping 39.8%, from 17.82 trillion cubic feet (tcf) in 2012 to 24.91 tcf in 2013. Main attribution to this increased in new agreement signed, on December 16, 2013, between MOG and BP Oman to develop the Khazzan field in Concession Block No.61. During the next 15 years, BP will drill 300 wells to increase its net production to 1 billion cubic feet of gas per day and 25 thousand barrels of condensate per day, at an estimated cost of 16 billion US Dollars.

Over 2012, the Sultanate's gas production amounted to 101.8 million cubic meters per day, a growth of 3.6%. Majority of gas produced, more than 77%, is non-associated gas. Figure1 shows estimated gas reserves by companies.

[1] Ministry of Oil and Gas, Annual Report 2013, Retrieved on July 22, 2014, from http://www.mog.gov.om/Portals/0/pdf/MOG-Book-2013-eng.pdf

Figure 1: Expected Natural Gas Reserves of the Producing Companies by the End of 2013 (Source: Ministry of Oil & Gas, Annual Report)[2]

It can be seen from Figure2 & 3 that there are more blocks in exploration stage, 18, than in production stage, 11, and there are 15 blocks that are either opened, in marketing stage or negotiation phase and this means there are yet multi-billion dollars to be invested in the country.

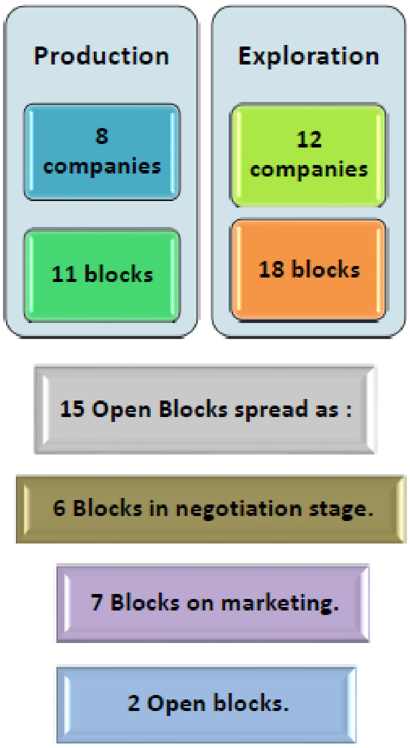

Figure 2: Exploration and Production Companies (Al-Riyami, Ahmed, Presentation)[3]

[2] Ministry of Oil and Gas, Annual Report 2013, Retrieved on July 22, 2014, from http://www.mog.gov.om/Portals/0/pdf/MOG-Book-2013-eng.pdf

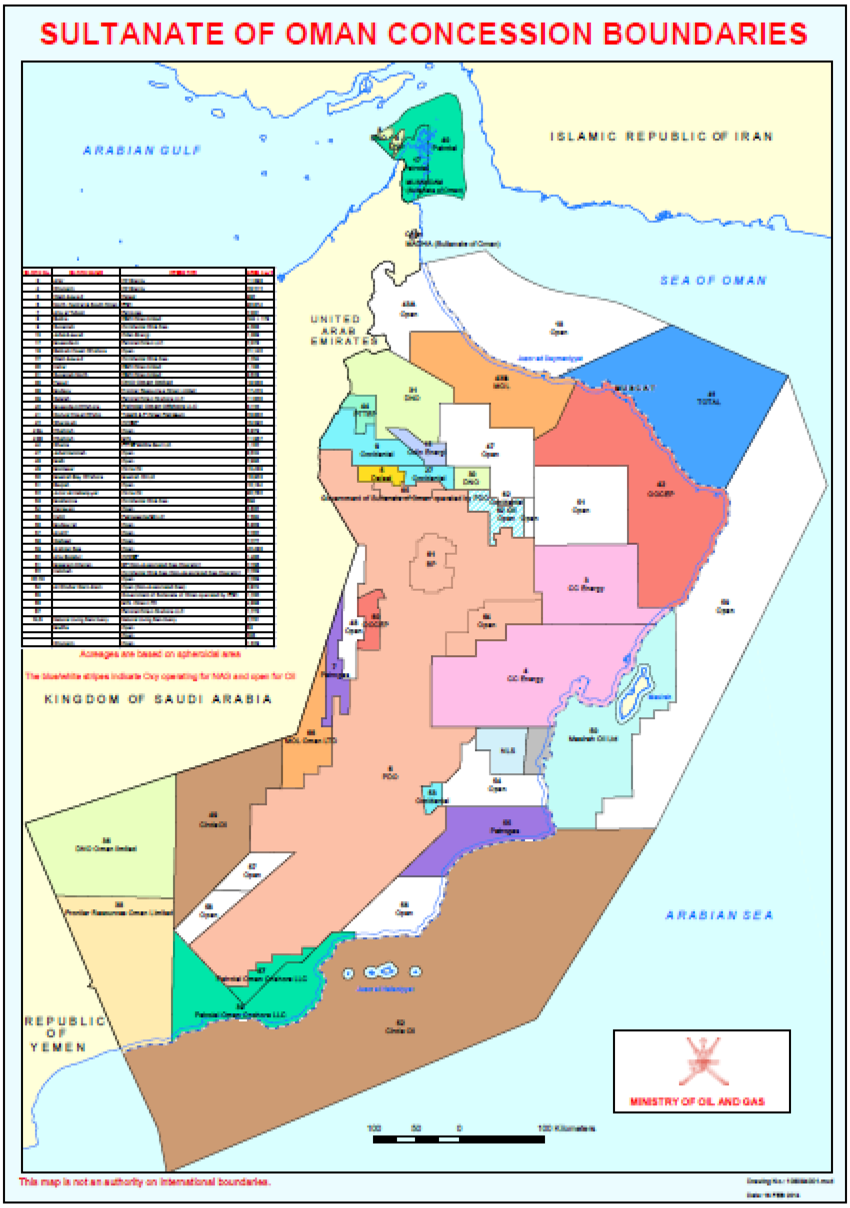

Figure 3: Oman Concession Boundaries (Sultanate of Oman Concession Boundaries)[3]

1.2 Single interest rate to evaluate projects

In Oman MOG is the regulator and of oil and gas work and the ministry has completed several projects in collaboration with various government sectors. Not only they make rules and regulations, they also manage, follow-up and oversee government investments to ensure maximum utilization of these investments. They also oversee all oil and gas Exploration and Production (E&P) activities, and these are conducted by companies operating within the concession areas in Oman.

[3] Sultanate of Oman Concession Boundaries Map, Retrieved on July 23, 2014, from http://www.mog.gov.om/Portals/1/pdf/Concession-Map-Feb-2014.pdf

One of many economic indicators that local companies use is Net Present Value (NPV), and quite often a single hurdle rate in a range between 8 to 10%. This could lead to imprecise cost evaluation which will eventually result in an unwise financial/investment decision.

To illustrate the importance of accurate and realistic interest rate, and due to lack of information of cash flows, the Future Value (FV) of a capital investment of a production project (gas plant) will be calculated using 10% and 12.5%. Musandam Gas Plant (MGP) is a three-year project and at estimated capital of $480 million dollars. The FV of 10 and 12.5% hurdle rate would be 639 and 683 million dollars, respectively, and that is a difference of more than 44 million dollars. Therefore, it is really important to accurately measure your hurdle rate as a mere 2.5% and just over three years resulted in whopping underestimation of 44 million dollars.

1.3 Problem statement

Cost evaluation of many Exploration and Production (E&P) projects in Oman founded on single, and usually assumed at 10%, interest/hurdle rate. The objective of this paper is to explore if single hurdle rate is appropriate to use in E&P projects in Oman and to identify a more pragmatic range that can be employed in different types of E&P investments.

2. Calculating interest rate

The MARR can be calculated with the following formula:

$$\text{MARR} = \text{WACC} + \text{Risk Scoring} + \text{Country Risk}$$ [4] (Equation 1)

Capital Asset Pricing Model (CAPM) is calculated by following formula[5]:

$$Rs = RF + \beta s\,(Rm\text{-}Rf)$$ (Equation 2)

Where:

RS = Stock S rate of return
RF = risk-free rate of return
βS = contribution of stock S to market risk
RM = market portfolio rate of return
(RM– RF) = market risk premium.

Weighted Average Cost of Capital (WACC) equals[6]:

$$\text{WACC} = \text{WACC} = \lambda\,(1 - t)\,i_b + (1 - \lambda)\,e_a$$ (Equation 3)

[4] Gideon, (2014, March 29). W5.0_GW_Drilling a Well Hurdle Rate_Kristal AACE2014, Retrieved on June 24, 2014, from http://kristalaace2014.wordpress.com/2014/03/29/w5_gw_drilling-a-well-hurdle-rate/comment-page-1/
[5] Risk-Free Rate of Return, Retrieved on June 26, 2014, from http://www.investopedia.com/terms/r/risk-freerate.asp
[6] Gideon, (2014, March 29). W5.0_GW_Drilling a Well Hurdle Rate_Kristal AACE2014, Retrieved on June 24, 2014, from http://kristalaace2014.wordpress.com/2014/03/29/w5_gw_drilling-a-well-hurdle-rate/comment-page-1/

Where:

λ = the fraction of the total capital obtained from debt
$(1 - \lambda)$ = the fraction of the total capital obtained from equity
t = effective income tax rate as a decimal
ib = the cost of debt financing, as measured from appropriate bond rates.
ea = the cost of equity financing, as measured from historical performance of the CAPM

The interest rate of a ten-year US Treasury bond is assumed as the risk-free rate.[7]

Rf = 2.52%

βs = 1.24[8]

(RM– RF)[9] = 6.05%

Calculating for Rs;

Rs = 2.52% + 1.24 × 6.06% = 9.82%

Since the project is not debt financed, it is 100% equity. Therefore,

WACC = Rs = 9.82%

Country Risk[9] = 1.05%

Risk scoring and MARR is calculated in section 5.

3. Project Risk Category for E&P Project in Oman

3.1 Risk by activity type

The activities that involve Exploration and Production in oil and gas industry are usually referred to as the upstream section. Upstream corporations take the foremost steps in locating, testing and drilling for oil and gas and once reserves are proven, extraction of that reserves commence.[10]

[7] Risk-Free Rate of Return, Retrieved on June 26, 2014, from http://www.investopedia.com/terms/r/risk-freerate.asp
[8] Damodaran, Total Betas by Sector (for computing private company costs of equity), Retrieved on June 26, 2014, from http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/totalbeta.html
[9] Damodaran, Country Default Spreads and Risk Premiums, Retrieved on June 26, 2014, from http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ctryprem.html
[10] Investopedia, Upstream, Retrieved on July 24, 2014, from http://www.investopedia.com/terms/u/upstream.aspfm

a. Exploration and drilling

A well is only drilled after the 3-D seismic investigation is completed. Normally, dedicated drilling rigs, either on mobile onshore units or offshore floating rigs, are used.

Exploration is an expensive and high-risk operation as it costs tens of millions of dollars and, as rule of thumb, two out of three wells contain no hydrocarbons. Therefore, it is quite often required to drill multiple wells in one area before finding any oil or gas, and that takes several years to be accomplished. Exploration is also risky because it is usually in a remote area with no infrastructure and the uncertainties associated with the activity like, how deep the reservoir is, quantity of hydrocarbons present and whether there are any in the first place. These uncertainties make exploration higher risk activity than Production.[11]

b. Production activities

The prime objective of the production phase, simply put, is pumping hydrocarbons to the surface. During this phase, which can last for a number of decades, additional wells could be drilled within the concession/development area in order to enhance hydrocarbon recovery. After being extracted, fluids initially separated into its main prime components, i.e. oil, gas and water.

Other activities associated with production is production enhancement, well servicing, which is a routine maintenance job like replacing worn and faulty equipment, and well work over, which is a more extensive equipment repair.

There are many risks associated with oil and gas production. These risks include, but not limited to the following:[12]

- Cost estimate/containment: The end of "easy oil" is looming due to rising costs of production and equipment and labor being more and more expensive.
- Health, Safety and Environment Risks: Health and safety have risen in the oil and gas industry and now it is a paramount issue, which was not the case 20 years back. A driver for this was increased public pressure and more complex operational challenges.
- Price volatility: Unrest in some parts of the world like Middle East and north Africa in 2011 resulted in an oil price surge.
- New operational challenges including unfamiliar environment
- Human capital deficient: A research done by EY shows that 22% of oil and gas respondents indicated a lack of qualified personnel was impacting their operations.

3.2 Project risk by location

Most of Oman oil reserves, 5.2 billion barrels, are situated in the country's northern and central region. Yibal, Naith, Fahud, Al-Huwaisah, Lekhwair and Bukha are located in the north and they comprise almost half of the total Omani oil production. The former, Yibal, produces 180,000 bbl/d and it is the largest field in the country. Crude found in northern central Oman is mainly medium or light, API 32 to 39, and normally found with associated gas. The only two

[11] The Exploration and Production Lifycycle, Retrieved on July 23, 2014, from http://www.bp.com/content/dam/bp-country/en_au/environment-society/education/oil-gas-exploration-production/m3-learning-experience-2.1.doc

[12] Oil and Gas – Top 10 Risks, Retrieved on July 25, 2014 from http://www.ey.com/GL/en/Industries/Oil---Gas/Turn-risk-and-opportunities-into-results--oil-and-gas---The-top-10-risks

unconventional resources in Oman, tight gas reservoirs, are Khazzan and Abu Butubul and they are located in north and middle of the country, respectively.[13]

Crude found in southern Oman is relatively heavy, especially in Nimr, Mukhaizna and Amal fields, with average API of 20 and usually not associated crude.

3.3 Project risk by reservoir type

a. Conventional Reservoirs

Characteristics of the reservoir and its fluid permit oil or natural gas to flow readily into well bores and that is attributed to the buoyant forces that keep hydrocarbons in place below sealing caprock. This term is developed in order to distinguish conventional resources from unconventional ones like shale oil/gas or tight gas reservoirs. Conventional resources are easier to develop than unconventional ones.[14]

Contemporary search for new oil and gas reserves, however, has proven that it is getting more and more difficult to find “easy oil”, as it might be called, because conventional reservoirs are now found in deep water, unconsolidated formation, increasingly sour fluids and high temperature and pressure, making development and production of these resources ineffective or uneconomical. Maturing reserves require new technology to enhance hydrocarbons recovery, or so called, Enhanced Oil Recovery (EOR), which always poses risks. First of which is that, EOR has proven less response to uncertainties in reservoir characteristics, compared to conventional operations. Another risk is that, EOR has a response period of two to four years after the investment and returns being rather sensitive to optimizations at eventual stages of the project.

Horizontal drilling has been implemented, since its advent in 1980s, as an EOR scheme and it allows for better access to the formation than vertical drilling. It, however, still poses some risks like complexity of its operation, flow pattern readings are often complex and misunderstanding or lack of information could lead to operational complexities.[15]

b. Unconventional Reservoir

Unconventional reservoirs features in low permeability and porosity and, therefore, are difficult to produce.

Examples of these include tight gas, shale oil/gas, coal bed methane and gas hydrates. These types of reserves are normally undeveloped for one main reason; they are more costly to produce, transport and refine than conventional sources.[16]

Shale gas has, increasingly, become an important source of gas especially in North America. Europe, India, China, South Africa, Australia and Argentina see an increasing interest in this type of unconventional resource and that is driven by advances in contemporary techniques like

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[13] Oman Oil and Gas Country Analysis, Retrieved on July 23, 2014, from http://www.omaninfo.com/oil-and-gas/oman-oil-and-gas-country-analysis.asp

[14] Schlumberger, Oilfield Glossary, Retrieved on July 25, 2014, from http://www.glossary.oilfield.slb.com/en/Terms.aspx?LookIn=term%20name&filter=conventional%20reservoir

[15] Alberta Research Council (2012), Technology Development for Conventional Petroleum Reservoirs, Journal of Canadian Petroleum Technology, Retrived on August 2, 2014, from http://people.ucalgary.ca/~schramm/TechDev.pdf

[16] Unconventional Resources, Retrieved on July 25, 2014, from http://www.cgg.com/default.aspx?cid=3501

horizontal drilling, hydraulic fracturing, and increasing utilization of seismic to understand and predict the geological drivers behind productive wells to optimize drilling plans and better design simulation programs.

In various parts of the world, tight gas has proven viable for many E&P companies because of advances in hydraulic fracturing, fracture simulation techniques as well as growth of demand for natural gas. Main risk associated with tight gas though is that its bed is very low in porosity and permeability and thus making it difficult to develop. E&P companies, therefore, target reservoir zones with highest fracture intensity by using seismic data which helps in identifying areas with highest potential of naturally occurring fractures and subsequently making it easier for operators to spot best locations for productive wells.

4. Analytical Hierarchy Process

The Analytical Hierarchy AHP is a process for making a decision in an organized way to generate priorities. To make a comparison, a scale of numbers, that indicates how many times more important, or dominant, one element is over another element with respect to the criterion to which they are compared is required.

Table 1: The fundamental scale of absolute numbers (source: T.L. Satty, 2008)[17]

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate Importance	Experience and judgment slightly favor one activity over the other
4	Moderate Plus	
5	Strong Importance	Experience and judgment slightly favor one activity over the other
6	Strong Plus	
7	Very Strong or Demonstrated Importance	An Activity is very strongly favorite over another, its dominance demonstrated in practice
8	Very, Very Strong	
9	Extreme Importance	The evidence favoring one activity over another is the highest possible order of affirmation

5. Application of MARR Calculation

5.1 Hierarchical Tree

In this section, range of project risk, based on activity, location, reservoir type and drilling type, is illustrated as follows;

[17] Saaty, T.L. (2008). Decision Making with analytical hierarchy process. Int. J. Services Sciences, Vol.1, No.1.

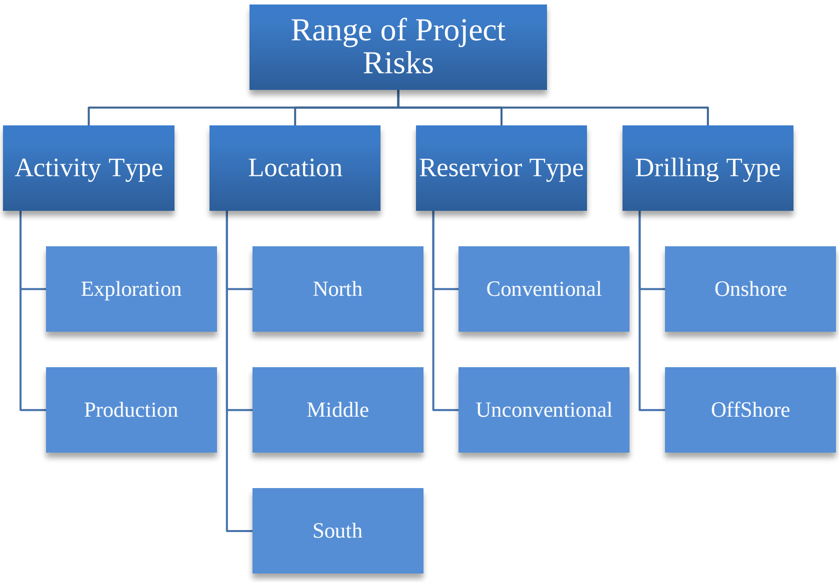

Figure 4: Range of Project Risks and its Criterion (source: Author)[18]

5.2 Judgment of relative ranking

In order to determine range of project risk and its criterion, see Figure5. After that, those criterions are summarized to determine the relative ranking for each sub-criterion, Figure6.

Table 2: Pair wise comparison matrix of Activity Criteria (source: Author)[19]

Activity	Exploration	Production
Exploration	1	9
Production	1/9	1

Table 3: Pair wise comparison matrix of Reservoir Type Criteria (source: Author)[20]

Reservoir Type	Conventional	Unconventional
Conventional	1	1/9
Unconventional	9	1

Table 4: Pair wise comparison matrix of Drilling Type Criteria (source: Author)[21]

Drilling Type	Onshore	Offshore
Onshore	1	1/9
Offshore	9	1

[18] By Author
[19] By Author
[20] By Author
[21] By Author

Table 5: Pair wise comparison matrix of Location Criteria (source: Author)[22]

Location	North	Middle	South
North	1	3/7	1/3
Middle	7/3	1	5/9
South	3	9/5	1

5.3 Hierarchical tree with Matrix Rank Result

A pair wise comparison matrix for each criterion, shown in Figure5, is carried out and matrix is solved until priorities obtained for the each sub criterion.

To calculate for each of the criterion of the above section, Matrix algebra is used and results are summarized in below table and graph.

Table 6: Matrix Results and Matrix Rank for each Criterion (source: Author)[23]

Matrix Result				Matrix Rank			
Activity	Location	Reservoir Type	Drilling Type	Activity	Location	Reservoir Type	Drilling Type
20	5.36	20	20	0.9	0.155	0.9	0.9
2.22	11.22	2.22	2.22	0.1	0.324	0.1	0.1
	18.09				0.522		

Figure 5: Hierarchical Tree with Matrix Rank Result

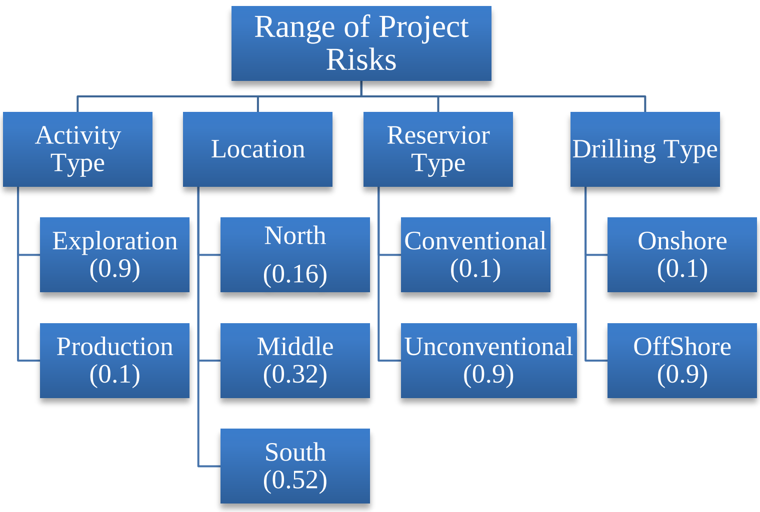

Figure 6 shows range of risks of Oman based on different criteria's. The risks at the southern part of the country are greater than risks at north and middle. This is attributed to the fact that

[22] By Author
[23] By Author

more than half of the oil production is in the central and northern area and crude oil from southern Oman tend to be heavy crude.

Activity Type	Location	Drilling Type	Reservoir Type	Result
Exploration	North	Onshore	Conventional	0.14%
Exploration	Middle			0.29%
Exploration	South			0.47%
Exploration	North	Onshore	Unconventional	1.30%
Exploration	Middle			2.59%
Exploration	South			4.21%
Exploration	North	Offshore	Conventional	1.30%
Exploration	Middle			2.59%
Exploration	South			4.21%
Exploration	North	Offshore	Unconventional	11.66%
Exploration	Middle			23.33%
Exploration	South			37.91%
Production	North	Onshore	Conventional	0.02%
Production	Middle			0.03%
Production	South			0.05%
Production	North	Onshore	Unconventional	0.14%
Production	Middle			0.29%
Production	South			0.47%
Production	North	Offshore	Conventional	0.14%
Production	Middle			0.29%
Production	South			0.47%
Production	North	Offshore	Unconventional	1.30%
Production	Middle			2.59%
Production	South			4.21%

Table 7: Risk Scoring Based on Risk Matrix Rank (source: Author)[24]

6. Conclusion

Calculating for MARR by including both maximum and minimum risk scoring, it was found that looking at Table7, and since no reservoir in Oman that can be described as an offshore and unconventional at the same time, 37.91% is considered as an outlier and 4.21% can be considered as highest most reasonable percentage. Lowest risk is 0.02%

- The most risky project is Southern Exploration Project reservoir with 4.21%

MARR= 9.82% + 1.05% + 4.21% = 15.08%

[24] By Author

- The least risky project is the Northern Production Onshore project with 0.02%.

  MARR = 9.82% + 1.05% + 0.02% = 10.89%

From the above, it is evident that single hurdle rate is not appropriate and a range of 11 to 15% to be used, depending on location and reservoir type.

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About the Author

Saaed Ali Mohammed Al-Shehhi

Musandam, Sultanate of Oman

Saaed Al-Shehhi is currently working as a Process Engineer in Oman Oil Company Exploration & Production (OOCEP). He previously worked with Oman Gas Company (OGC) as a Process/Concept Engineer. He has a total of four 4 years experience in oil and gas projects from concept stage and feasibility analysis to commissioning. Main Projects were Muscat Gas Network Concept and Feasibility, Gas Supply Stations Feasibility and Engineering. and Musandam Gas Plant Project. Saaed holds a B.Sc. in Chemical and Process Engineering from Sultan Qaboos University, Muscat. He can be contacted at saaed.alshehi@oocep.com.