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Shale Gas Potential in Pakistan: By comparison of Sembar formation and Barnett Shale Texas

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Abstract

In the current era where industrial growth has become rapid that it provokes the current supply of energy. The conventional sources are unable to meet the demand, while new sources of energy are being discovered. One of the major impacts leaving sources is the Unconventional reservoir that has proven to be a prominent source with the modern technology available.

USA has discovered the technology to extract from Shale oil and gas unconventional reservoirs that have proven to provide prominent productions and key to the future of petroleum industry. According to the U.S. Energy Information Administration (EIA) Shale oil and gas contributes 52% oil and 48% gas in the total production.

Pakistan has a rising economy growth and the demand for energy is rising. The most part of energy is fulfilled by the use of petroleum. As per survey (2014-2015) the supply of gas is 4BCFD and demand is 8BCFD with a gap of 4BCFD and it is expected to increase in the upcoming years. The known conventional sources of Pakistan are unable to fulfill the demand, so Pakistan should also consider the unconventional sources that it compounds. There are two major unconventional shale oil and gas bearing formations that are Sembar and Ranikot formation.

This paper discusses the major characteristics of shale gas sources in Pakistan with comparison to the already developed shale gas producing field of United State of America that is Barnett shale. The Barnett shale is one of major producers of shale gas contributing 10-12 BSCFD.

The major characteristics of shale gas that defines it to be an economic source are compared in form of polar charts with their minimum required characteristics that a shale gas producer has. The Sembar formation meets the minimum requirements as a shale gas producer and when compared to the Barnett shale it exhibits similarity. On the basis of these similarities we can assume similar productions from the Sembar as seen in Barnett Shale.

Keywords

Wind turbine generator; PSO algorithm; PI parameter; Stability; Grid voltage sag

1. Introduction

The known conventional sources of oil and gas are depleting faster and the demand of petroleum rises with every passing day. To fulfill this demand the petroleum industry has moved towards unconventional sources that were once considered as uneconomical. But with advanced technology these unconventional sources have become feasible for production.

According to a definition developed by US National Petroleum Council (NPC), Unconventional reservoirs are those that can be produced neither at economical flow rates nor in economical volumes unless the well is stimulated by following technologies:

- Hydraulic Fracturing.
- Horizontal wells.
- Multilateral wells.

Unconventional reservoirs are determined as very-very low permeability reservoirs that have a permeability value less than 0.1MD. Shale Oil and Gas reservoirs are classified as unconventional resources.

The shale gas is a natural gas predominantly found in shale rock. The name is derived from its source shale, Shale is basically a fine grain sedimentary rock composed of various clay minerals such as the fragments of quartz, calcite, carbonates and other minerals. The shale rock also acts as source rock and reservoir rock for hydrocarbons. Shale rocks are imposed to high compaction due to which it is characterized of lower permeability for fluid flows but have a higher porosity.

USA has applied the above mentioned technologies to produce large quantities of shale oil and gas from these reservoirs. The U.S. Energy Information Administration (EIA) estimates about 12.3 TCF of dry natural gas from shale reservoirs, that comprises of about 48% of total US gas production and is expected to reach 69% by 2040. While 4.9 million barrels per day shale oil comprising about 52% of total oil production[4].

Pakistan is one of the nations with a growing economy resulting in higher demand of oil and gas. As per survey (2014-2015) the supply of gas is 4BCFD and demand is 8BCFD with a gap of 4BCFD and it is expected to increase to 6.79 BCFD in the upcoming years. As per survey the gas statistics are show in FIGURE 1.

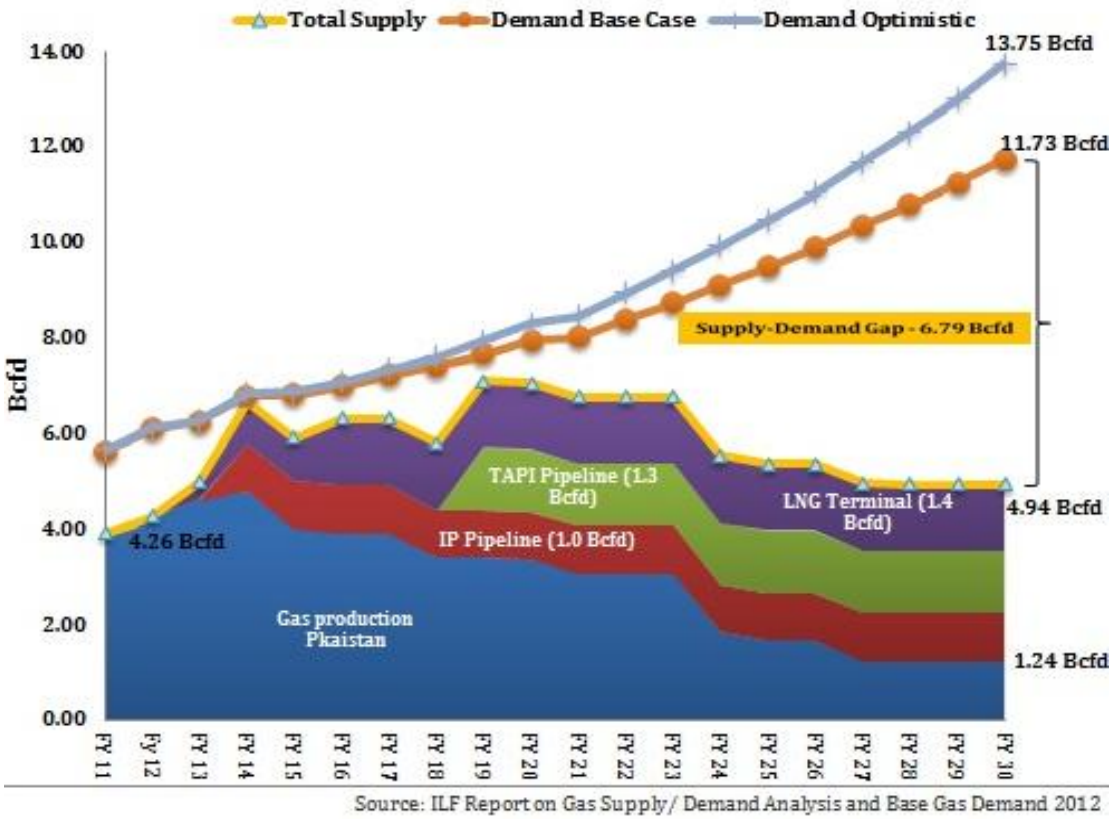

Figure 1. Gas supply and demand statistics of Pakistan

2. Characteristics of Shale Gas:

There are various characteristics of shale gas, but the major characteristics for a shale gas to prove if it is a potential producer and worth of risking are:

I. Total Organic carbon (TOC):

The total organic carbon determines the quantity of organic matter in rock that is expressed in weight %. The value of TOC is proportional to the quantity of oil and gas generated. The scale for TOC is:

Table 1 TOC ranges

RANGE (weight %)	DESCRIPTION
0.0-2.0	Poor risk for oil and Gas
2.0 <	Good risk for oil and Gas

II. Thermal Maturity (Ro):

Thermal maturity can be defined as the temperature required converting the kerogen into liquid or gas hydrocarbons overtime. Thermal maturity can be expressed in % and inform of temperature. The typical ranges for thermal maturity are as following:

Table 2 Thermal maturity ranges

Range (%)	Hydrocarbon	Description
0.6	Onset Oil	Poor risk for gas
0.9	Peak Oil	Poor risk for gas
1.0	Wet Gas	Good risk for gas
1.4-2.1	Dry Gas	Good risk for gas

For Ro value greater than 2.1% it may danger the reservoir and CO2 productions are possible.

III. Transformation Ratio (TR)

The transformation ratio determines the conversion of kerogen under the thermal maturity into oil or gas or mixed oil and gas deposits. Transformation Ratio is expressed in % and the typical ranges are:

Table 3 Transformation ratio ranges

Ranges (%)	Hydrocarbon	Description
0-50	Primary oil	Poor risk for gas
50-80	Mixed oil and gas	Poor risk for gas
80-90	Primarily gas	Good risk for gas
90-100	Primarily Dry gas	Good risk for gas

IV. Gas Dryness:

This factor determines the presence of dry gas in the formation. It is determined in % and the typical ranges are as following:

Table 4 Gas Dryness ranges

Ranges (%)	**Hydrocarbon**	**Description**
0-50	Primary oil	Poor risk for gas
50-80	Mixed oil and gas	Poor risk for gas
80-90	Primarily wet gas	Good risk for gas
90-100	Primarily Dry gas	Good risk for gas

From the above data for shale gas, the minimum values for a shale gas to be proven as a potential producer on average scale are as following in form of polar chart.

Table 5 Shale formation ranges

TOC (wt %)	**Ro (%)**	**GAS (%)**	**Tmax (^{o}C)**	**TR (%)**
0.5	1	80	455	80

The minimum requirements for a formation to be a shale oil and gas producer are shown in CHART 1**.**

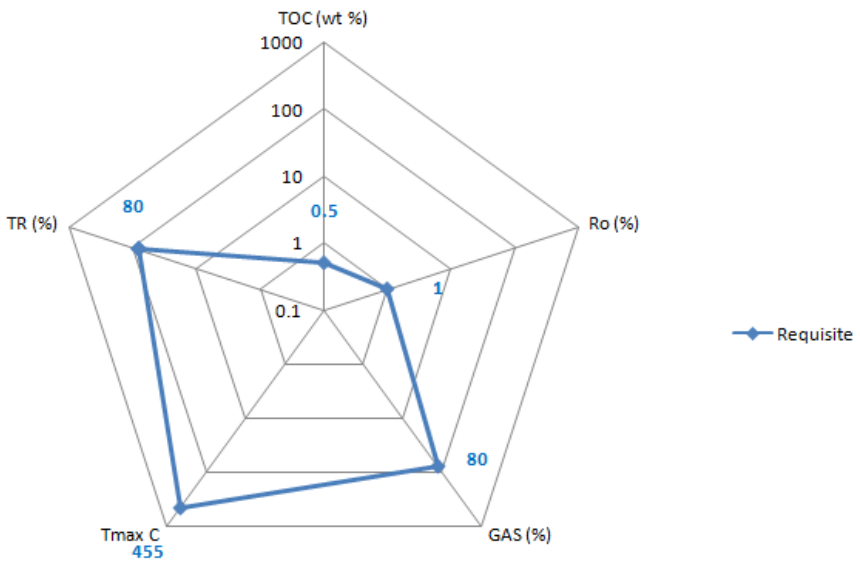

Chart 1. Requisite range for a potential shale producer

3. Shale Gas Reservoir In Pakistan

The shale gas reservoir in Pakistan is distributed in the Baluchistan, lower Indus and upper Indus in form of thick sequences. The two major formations that have been identified as potential producers for shale gas are:

- Sembar formation
- Ranikot formation

According to report from the EIA assessment Pakistan comprises of 586 TCF gas, from which 105TCF is technically recoverable. This data confirms Pakistan has the 9th largest shale gas source in the world.

Compare the characteristics of Sembar formation to the minimum requisite properties that prove if formation is economic. That is determined by using polar chart that compares the requisite data to the Sembar formation data (the data provided is on average values).

Table 6 Characteristic for comparison of requisite and Sembar formation

Characteristics	**TOC (wt %)**	**Ro (%)**	**GAS (%)**	**Tmax ^{0}C**	**TR (%)**
Requisite	0.5	1	80	455	80
Sembar	1	1.3	90	470	90

From the polar chart 2 we can assume that the Sembar formation can be a potential shale gas producer as it meets the minimum requirements.

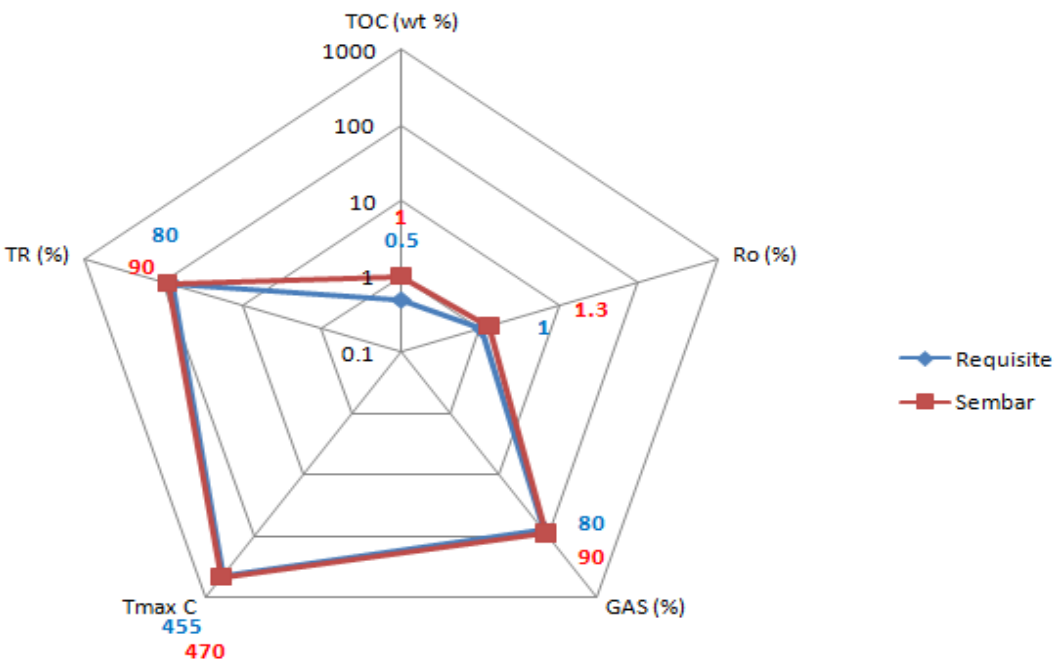

Chart 2 Comparison of Sembar characteristics with Requisite ranges

4. Comparison of Sembar and Barnet Shale:

The Barnett shale is located in Bend Arch-Fort Worth Basin, Texas, USA. The Barnett shale was discovered in the 1980's and started producing from 1999. The reserves in the formation are about 44 TCF with depth of 6500-9500 ft. The Barnett shale is one of the pioneers in the production of shale gas in the history of USA with an average production of 12 BCFD[7].

The major purpose of this paper is to compare the Sembar formation to the Barnett formation and determine if it is a potential producer that could contribute in the gas production of Pakistan. The characteristic data obtained from the Sembar formation as compared to the Barnett shale are as following:

Table 7 Characteristics ranges of Sembar and Barnett shale for comparison

CHARACTERISTICS	SEMBAR	BARNETT
Total Organic Carbon (wt %)	Ranges from 0.56-4.33	Ranges from 2-6
Thermal Maturity (Ro %)	1.3%	Ranges from 1.2-1.9%
Thermal Maturity (Tmax ^{0}C)	470 ^{o}C	465 ^{o}C
Total Porosity (%)	Ranges from 5-8%	Ranges from 3-6%
Transformation Ratio (TR %)	90%	93%

The data to be used in polar charts for comparison are based on average values as following [5]:

Table 8 Comparison of all formations characteristic values

Characteristic	TOC (wt %)	Ro (%)	GAS (%)	Tmax C	TR (%)
Requisite	0.5	1	80	455	80
Sembar	1	1.3	90	470	90
Barnett	2	1.6	90	465	93

From Polar Chart 3 we can assume Smebar formation to be similar to Barnett shale.

5. Conclusion

Since America has applied the technology to produce from unconventional sources the entire world has been driven on the same track to remove the lack of energy required to run the industrial world, and Pakistan is one of the nations with a growing economy that is struggling for supply-demand of energy. The already developed Barnett shale is still contributing in the daily production by 12BCFD on average. Pakistan has also discovered two major shales that are Ranikot and Sembar formation.

The average daily gas production and consumption is 4BCFD and 8BCFD respectively, as predicted this gap will increase in the coming future and Pakistan is left with 23 TCF of natural gas reserves that are expected to be fully depleted by 2025. To overcome this difference Pakistan has to move towards the unconventional resource and produce from the above formations. If the shale gas reserves of Pakistan are subjected to production, they may be enough for the next 44 years.

The Sembar formation has proved to be a potential producer as it meets the minimum requirements for potential producer in CHART 1.When compared to Barnett formation (chart 2 and chart 3), the Sembar formation shares most of similarities with the Barnett formation that is considered to be one of the pioneers in the USA gas production.

If Sembar formation is exploited for shale gas and oil then it may prove to be a potential producer and help to reduce supply-demand gap and help in the economic growth of Pakistan.

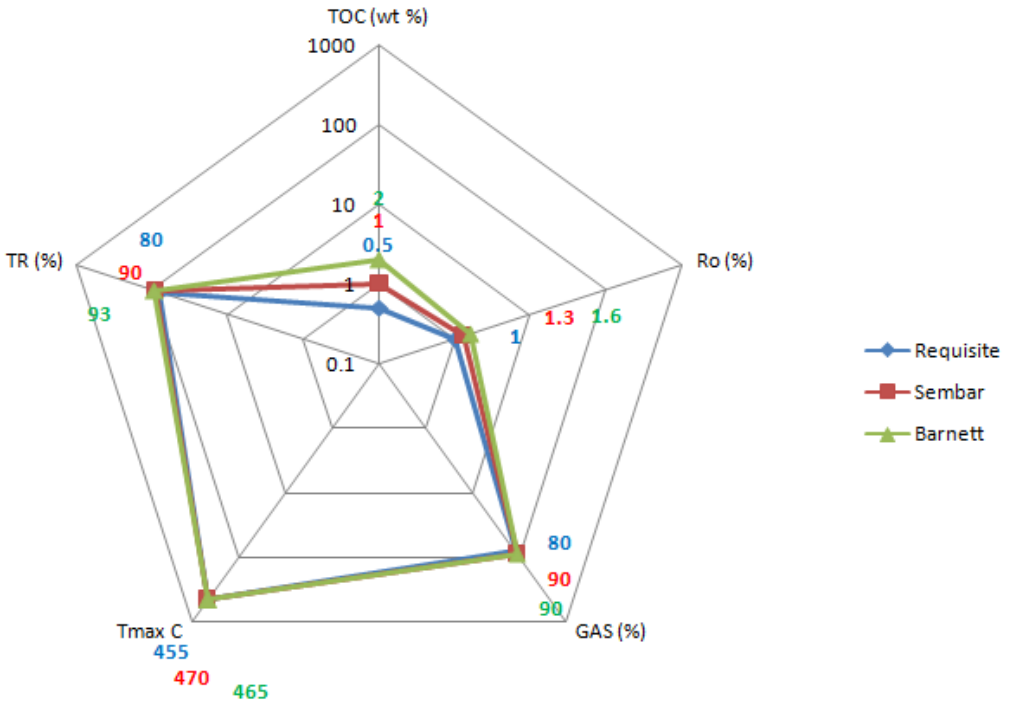

Chart 3. Comparison of Sembar, Barnett shale and requisite ranges

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