LIRA Journal, 2024, Vol. 1, 53-64.
https://journal.lira.pk/LIRA/

Assessing Reservoir Potential: A Study of Petroleum Deposits in Pakistan

Syed Haider Ali*
M. Phil. Scholar, Politics and International Relations, Lahore Leads University, Lahore, Pakistan

Abstract

The world powers are tempted towards the rich reservoirs of natural resources in Pakistan. These natural resources take millions of years to form. The oil and gas exploration started in the world in 1840. The history of exploration on the Pakistani territory is older than Pakistan itself, it's more than a century. Exploration in Pakistan had been started in late 1952 in Baluchistan near a giant Sui gas field. Geographically the land area of Pakistan is divided into six sedimentary basins having oil reservoirs underneath called onshore Basins. The sea area falling in the territorial jurisdiction of Pakistan is divided into two offshore sedimentary basins. The basins' location, its potential for oil and gas reservoirs along with significant drilling activity is discussed one by one. The requirements of oil and gas in Pakistan along with the production and consumption of oil & gas are also discussed briefly. Future projects and prospects for easy Exploration & Production (E&P) in Pakistan. The strategic impact of Economic and Foreign policies in the region and influence of CPEC on natural resources are also mentioned. The prevailing security condition of the Country viz-a-viz lack of machinery and skills are also the major reason of unexplored natural resources. The latest policy in reduction of unnecessary steps required for getting approval to start drilling activities in potential areas is a sign of improvement in exploration and production. Strict adherence to policies and merit-based deployments are required for professionalism and eradication of corruption.

Keywords: Natural resources, Pakistan, Baluchistan, Exploration and production, CPEC, territorial jurisdiction, oil, gas, professionalism, eradication, corruption, economic and foreign policy

INTRODUCTION

Petroleum is a composite of naturally occurring hydrocarbons that can exist as solids, liquids, or gases, depending on the prevailing pressure and temperature circumstances. Almost all petroleum is extracted from the soil in the form of either liquid or gas. These substances are typically known as crude oil or natural gas, depending on the composition of hydrocarbons.[1]

Formation of Petroleum

Many years ago, creatures such as algae and microscopic animals and plants perished and deposited on the ocean floor. Below layers of other ocean sediments and in an oxygen-deprived environment, these fossils transformed into a material known as kerogen. Kerogen undergoes a slow transformation into oil or gas when exposed to high temperatures and pressure. They have the potential to reach sizes comparable to that of a metropolis.

Geologists employ several survey techniques, such as seismic surveys, gravity surveys, and geological mapping, to locate oil and gas resources. Seismic surveys employ the reflection of sound waves to provide a three-dimensional representation of the Earth's internal structure. Emerging technologies, like as advanced four-dimensional projections and intricate graphic depictions of rock

[1] Bradley, Howard B. "Petroleum engineering handbook." (1987).

strata, are enhancing our ability to locate traditional oil and gas reservoirs. Unconventional oil and gas refer to energy resources that are presently challenging to extract. In a world where energy resources are finite, Pakistan is actively seeking more effective methods to extract unconventional oil and gas reserves.

The organic content contained within rocks undergoes chemical transformations when it is deeply buried within the Earth and subjected to high temperatures. Heating causes the decomposition of complex organic compounds into simpler molecules. At elevated temperatures during deeper burial, these diminutive molecules may undergo additional fragmentation, resulting in the formation of even more minuscule molecules. At elevated temperatures, the oil molecules undergo more decomposition, resulting in increased production of natural gas. The depths and temperatures at which these chemical reactions occur vary depending on the type of organic matter and the rate at which temperature increases with depth.[2]

Petroleum Exploration & Production

Petroleum Exploration and Production (E&P) refers to the initial stages of the oil and gas sector, namely involving the search, exploration, drilling, and extraction of resources. The Exploration and Production (E&P) section represents the initial phase of the oil and gas production process. The main emphasis is on the identification and retrieval of natural resources from the Earth.[3] The oil and gas exploration and production process typically consists of seven stages, which are outlined as

a. Leasing of Block
b. Search-Geographical Surveys
c. Well Construction
d. Drilling
e. Extraction
f. Abandonment of Well

Origin of Petroleum Exploration in Pakistan

Present-day Pakistan is recognized on the globe for its great strategic importance, fast-growing economy, significant military might, and potential global actor was part of British India before independence. The Indo-Pak region had been tempting world powers due to its rich reservoirs of natural resources. Among the under crust natural resources, Coal, oil and Gas, generally known as fossil fuels, were not an exception. These unique high energy fuels are non-renewable resources. They took millions of years to form.

The Ancient Era

Use of oil by humans in its crude form as fuel for fire, as sealant, as body paint, and for medicinal purposes can be traced back to the ancient ages of 3600 BC. However, the breakthrough in its use as source of modern kinetic energy occurred in the 1840's, when a Canadian geologist named Abraham Gesner discovered kerosene distilled from coal or crude oil. In the ancient era, crude oil was acquired from the subsurface seeps of oil on natural soil.[4]

Pre-Partition Era

The oil and gas exploration started in the world in 1840. The world mostly focused on drilling of shallow boreholes in seepage reservoirs user's text is empty. The history of exploration in the region of present-day Pakistan predates the establishment of Pakistan itself by over a century. The inaugural drilling operation took place in 1866 at the Kundal oil seepage site located in the Mianwali District of Punjab Province. Throughout the final part of the 19th century, there were ongoing efforts to periodically drill shallow boreholes. The primary achievement occurred in the Sulaiman Fold Belt, with the finding of oil at Khattan in Balochistan. During the period from 1885

[2] Rodgers, Ryan P., and Amy M. McKenna. "Petroleum analysis." Analytical chemistry 83, no. 12 (2011): 4665-4687.

[3] Atlas, Ronald M. "Petroleum microbiology." (1984).

[4] Nazir, Arif, and Tahira Fazeelat. "Petroleum geochemistry of Lower Indus Basin, Pakistan: I. Geochemical interpretation and origin of crude oils." Journal of Petroleum Science and Engineering 122 (2014): 173-179.

to 1892, a total of thirteen shallow wells yielded 25,000 barrels of oil. The issues encountered during production were primarily related to drilling in regions with oil seeps, resulting in a limited and short-lived oil production rate. Through the progress of knowledge and drilling technology, the scope of exploration expanded to encompass other sedimentary regions. In 1915, the Attock Oil Company achieved its initial commercial triumph by digging the Khaur-1 well on a surface anticline located in the Potwar Basin. The presence of oil was detected in the sand deposits located in the lower section of the Miocene formation. Subsequently, a total of 396 wells were drilled in the area between 1915 and 1954. Continual exploration drilling in the Potwar Basin resulted in the identification of three oil fields.[5]

Explorations on Soil of Pakistan

Pakistan's first oil field was explored in late 1952 in Baluchistan near a giant Sui gas field.

The Tut oil field, located approximately 135 km southwest of the capital city of Islamabad in the Potwar region of Punjab Province, was discovered in the 1960s and has a total area of 122.67 square kilometers. The first oil well was drilled in 1964 and commercial production from the well started in 1967.[6]

Oil production was entirely confined to the Potwar Plateau till 1981, however, after the discovery of the oil field at Meyal in 1968 and gas field at Dhodak in 1977, several foreign companies were given concessions for exploration.

In 1981 first oil field in Lower Sindh was discovered. By 1998-1999, the Lower Sindh gas fields were producing more oil than the Potwar Plateau.[7]

From Mid-nineties onwards, the exploration in the onshore regions of the country got momentum and a number of successful discoveries were made by companies. Resultantly gas was discovered at Sara, Sui, Chachar, Zamzma, Bhit and Zarghun oil fields, all located in the Middle Indus Basin except Zarghun which is located in Bolan Concession in Balochistan.

The Exploration in offshore regions had started in 1961 remained limited to the drilling of only eleven exploratory wells of which nine were located in the Indus offshore and two of the Makran Coast. Other wells in the offshore were all commercial failures.[8]

Current Status

Sedimentary Basins of Pakistan

Pakistan has total sedimentary area of 827,268 Sq kms. Geographically the land area is divided into six sedimentary basins having oil reservoirs underneath called onshore Basins. The sea area falling in the territorial jurisdiction of Pakistan is divided into two offshore sedimentary basins[9]

The basins location as shown in **Figure 1**, its potential for oil and gas reservoirs along with significant drilling activity is discussed one by one.

[5] Khan, M. A., and Hilal A. Raza. "The role of geothermal gradients in hydrocarbon exploration in Pakistan." Journal of Petroleum Geology 9, no. 3 (1986): 245-258.

[6] Cozzi, Andrea, Giuseppe Rea, and Jonathan Craig. "From global geology to hydrocarbon exploration: Ediacaran-Early Cambrian petroleum plays of India, Pakistan and Oman." Geological Society, London, Special Publications 366, no. 1 (2012): 131-162.

[7] Zaigham, Nayyer Alam, and Khalil Ahmad Mallick. "Prospect of hydrocarbon associated with fossil-rift structures of the southern Indus basin, Pakistan." AAPG bulletin 84, no. 11 (2000): 1833-1848.

[8] Fayyaz, Zohaib, Javed Iqbal, Ahsan Mehboob, Muhammad Affan Sabir, and Abdul Jabbar. "Structural Investigation for Locating Petroleum Reservoirs Using Geoinformatics in Meyal, Potwar Region, Pakistan." International Journal of Geosciences 7, no. 11 (2016): 1345.

[9] Ahmad, Adeel, and Mithilesh Kumar Jha. "Status of petroleum sector in Pakistan: A review." Oil and gas business 745 (2008): 1-15.

Figure 1

Kohat-Potwar (Upper Indus Basin)

The basin is situated to the north of Sargodha High. The basin has a maximum sedimentary thickness of 12,000 meters, which presents opportunities for the extraction of both oil and gas. The basin is subdivided into Potwar to the east and Kohat to the west of River Indus. Potwar is renowned for its long-standing history of oil and gas deposits. Kohat became recognized as an area with large oil and gas reserves after the discovery of Chanda in 1999, which was then followed by the finding of Manzalai in 2002. From 1900 to June 2015, a cumulative of 195 exploratory wells have been drilled in the Kohat-Potwar basin, leading to the identification of 43 finds. The estimated oil reserves in the basin are roughly 602 million barrels, while the gas reserves are estimated to be around 4.5 trillion cubic feet. At present, there are 30 exploration blocks that are being held under an exploration license.[10]

Punjab Platform.

The Punjab Platform is geographically delineated from the Upper Indus Basin by the Sargodha High in the north, the Mari-Kandhkot High in the south, and the Sulaiman Fore deep in the west. The basin has a variation in sedimentary thickness, ranging from a few hundred meters in the eastern region to around 8,000 meters in the western region. The Punjab Platform is recognized as having significant potential for the extraction of both oil and gas. Among the total of 30 exploratory wells, a mere 3 wells have yielded positive results by discovering gas reserves. At present, the basin is occupied by E&P companies which possess a total of 7 exploration blocks.[11]

Middle & Lower Indus.

The basin has around 476 million barrels of found oil reserves and about 19 trillion cubic feet of discovered gas reserves. Currently, there are 33 exploration licenses held in the Basin. Currently, almost 73% of the basin is controlled under an exploration license. The success rate is higher; yet, the discoveries are of minor magnitudes.

Kirthar Fold belt

The basin has a maximum sedimentary thickness of 12,000 meters. Out of the 84 exploratory wells, 14 have been successful in finding new resources. The basin has approximately 16 million barrels (MM Bbl) of discovered oil reserves and 5 trillion cubic feet (Tcf) of discovered gas reserves. At now, there are 31 exploration licenses, and the Government of Pakistan is currently reviewing one application for granting or bidding.[12]

Sulaiman Fold belt

---

[10] Khan, M. A., Riaz Ahmed, Hilal A. Raza, and Arif Kemal. "Geology of petroleum in Kohat-Potwar depression, Pakistan." AAPG bulletin70, no. 4 (1986): 396-414.

[11] Memon, A. R. "Status of petroleum sector in Pakistan-a review." Journal of Information Communication Technologies and Robotic Applications (2018): 1-10.

[12] Dolan, P. "Pakistan: a history of petroleum exploration and future potential." Geological Society, London, Special Publications 50, no. 1 (1990): 503-524.

The Sulaiman Fold belt is a highly promising region in Pakistan. The basin has a maximum sedimentary thickness of 12,000 meters. In the Sulaiman Fold belt, a cumulative total of 66 exploration wells had been drilled from 1900 to June 2015, leading to the identification of 25 finds. The basin has a total of 24 million barrels of oil and approximately 29 trillion cubic feet of gas in found reserves. Pakistan's expansive fields, such as Sui, Uch, Qadirpur, and Dhodak, are situated in the Sulaiman Fold belt. At present, E&P companies possess a total of 34 exploration licenses.[13]

Baluchistan

Baluchistan is a sedimentary section as thick as 15,000 m. Up till now wells explored in Balochistan Basin include Chandragup 1 & Burmah Oil, (1916), Dhak 1 & Hunt Oil (1956), Dhak 2, Hunt Oil, (1956), Kech Band 1, Tidewater, (1962), Garr Koh 1.[14]

Offshore Basins

The sea waters of Pakistan are divided into two basins: the Indus Basin and the Makran Basin. These basins were formed due to the deposition of sediments caused by the ascent of the Himalayas. The ongoing process of sedimentation occurs as the Indus River system carries the eroded materials from the Himalayan Mountains. Currently, there are 17 offshore licenses being managed by corporations such as BP Exploration (Alpha) Limited (BPXA), Eni (Pakistan) Limited (Eni), and Nikore sources (Pakistan) Limited (NRPL).[15]

Up till now since inception of oil & gas exploration, total 2314 wells have been drilled out of which exploration wells are 992 (including 66 wells before 1947) and appraisal/ development wells are 1322 (including 33 wells before 1947). Total drilling density is 2.77 wells per 100 sq kms of the sedimentary basin. Out of the 992 exploration wells, the discovery was in only 349 wells bringing the success rate to 35% only. Out of the 349 total discoveries, 78 are oil exclusive and 271 are oil and gas condensates. Summary is illustrated in **Figure 2.**

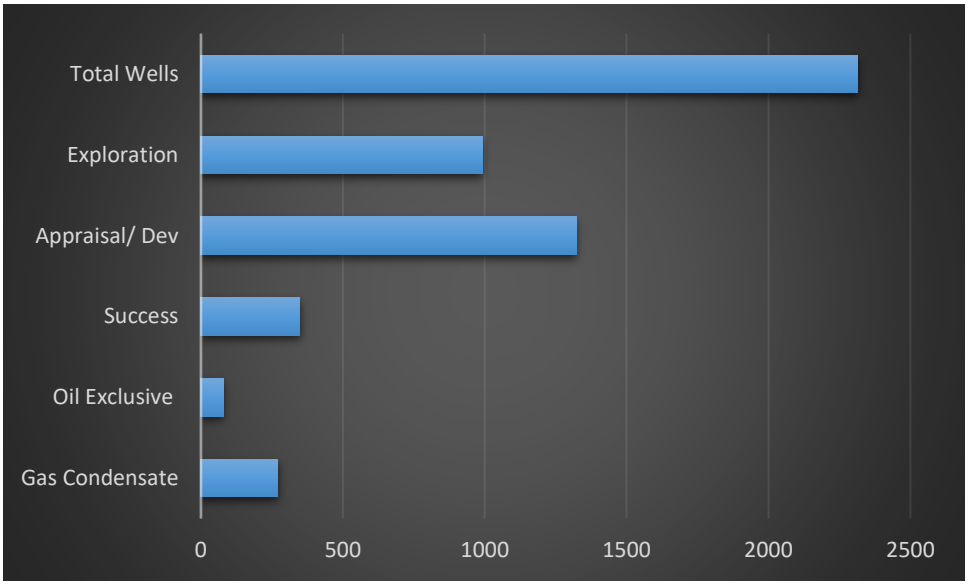

Figure 2

At present total 179 licenses are held for exploration out which 26 are with PPL, 64 are with OGDCL and 89 are with other private operators. Active leases are 164. There are total 30

[13] Mahesar, A. A., Shar, A. M., & Tunio, A. H. (2021). Tight gas potential status, obstacles and the way forward in meeting future energy needs of Pakistan. Mehran University Research Journal Of Engineering & Technology, 40(3), 570-581.

[14] Rauf, Omer, Shujie Wang, Peng Yuan, and Junzhe Tan. "An overview of energy status and development in Pakistan." Renewable and Sustainable Energy Reviews 48 (2015): 892-931.

[15] Daud, Farrukh, Gulzeb Nabi Khan, and Muhammad Ibrahim. "Remaining hydrocarbon potential in Pakistan a statistical review." In Society of Petroleum Engineers (SPE) Annual Technical Conference, Islamabad, Pakistan. 2011.

operators presently busy in exploration in the country, out of which 18 are foreign based while 12 are locals. Apart from this, there are 22 non operators foreign firms and 3 local non operator firms working in oil & gas industry in Pakistan. At present 12 semantic crews and 28 Rigs are active.[16]

The geological surveys have established that Pakistan a huge reserve of oil and gas. The original recoverable reserves of oil are 1185.47 million US barrels, out of which cumulative production is 834.87 million US barrels and the balance recoverable is 350.6 million US barrels. Similarly, Pakistan has original recoverable reserves of 53907.23 billion cubic feet of Gas, out of which cumulative production so far has been 34749.26 billion cubic feet and recoverable balance is 19,157 billion cubic feet.[17]

The name of the well is Kekra-1. Pakistan was optimistic about discovering substantial oil and gas deposits in its territorial seas in the Arabian Sea, amidst significant anticipation. According to Pervaiz Akmal, the former CEO of Oil and Gas Development Authority (OGDCL), this would be the 14th or 15th off-shore oil and gas exploration well that has been found to be unproductive, despite optimistic expectations from those in charge. The intended drilling depth of 5,470 meters was successfully accomplished, incurring an expenditure of Rs14 billion. The exploratory endeavor incurred an extra expenditure of $100 million to acquire an excess supply of steel, cement, and other materials for the purpose of drilling the Kekra-1 well in an alternative path. The Kekra-1 exploration, a collaborative effort between four oil exploration companies, concluded the process of offshore drilling on May 15, 2019, after a duration of four months.[18]

Oil & Gas Requirement in Pakistan

According to the statistics shown in August, 2019, Pakistan is producing 92,000 Barrels Oil per day against its total requirement of around 1,000,000 barrels' oil per day making a huge shortage gap of 908,000 barrels of oil per day as shown in **figure 3.**

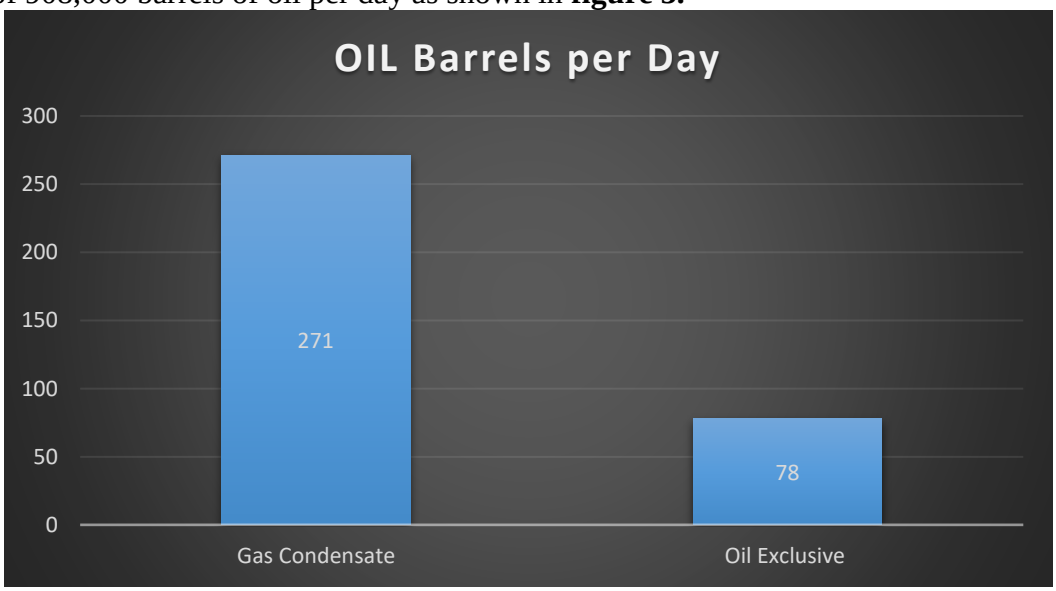

Figure 3

Similarly, Pakistan is producing 4 billion cubic feet gas per day whereas the total requirements are 6 billion cubic feet per day, marking a shortage of 2 billion cubic feet per day. The shortage of energy is met by investing huge amount of money of National exchequer on the import of oil and LPG as shown in **figure 4.**

[16] Javaid, Prof Dr Umbreen, and Azhar Rashid. "Oil and Gas potentials of Central Asian Republics and relations with Pakistan." South Asian Studies 30, no. 1 (2020).

[17] Fayyaz, Zohaib, Javed Iqbal, Ahsan Mehboob, Muhammad Affan Sabir, and Abdul Jabbar. "Structural Investigation for Locating Petroleum Reservoirs Using Geoinformatics in Meyal, Potwar Region, Pakistan." International Journal of Geosciences 7, no. 11 (2016): 1345.

[18] Ahmed, Riaz, S. Manshoor All, and Jalil Ahmad. "Review of petroleum occurrence and prospects of Pakistan with special reference to adjoining basins of India, Afghanistan and Iran." Pakistan Journal of Hydrocarbon Research 6, no. 1 & 2 (1994): 7-18.

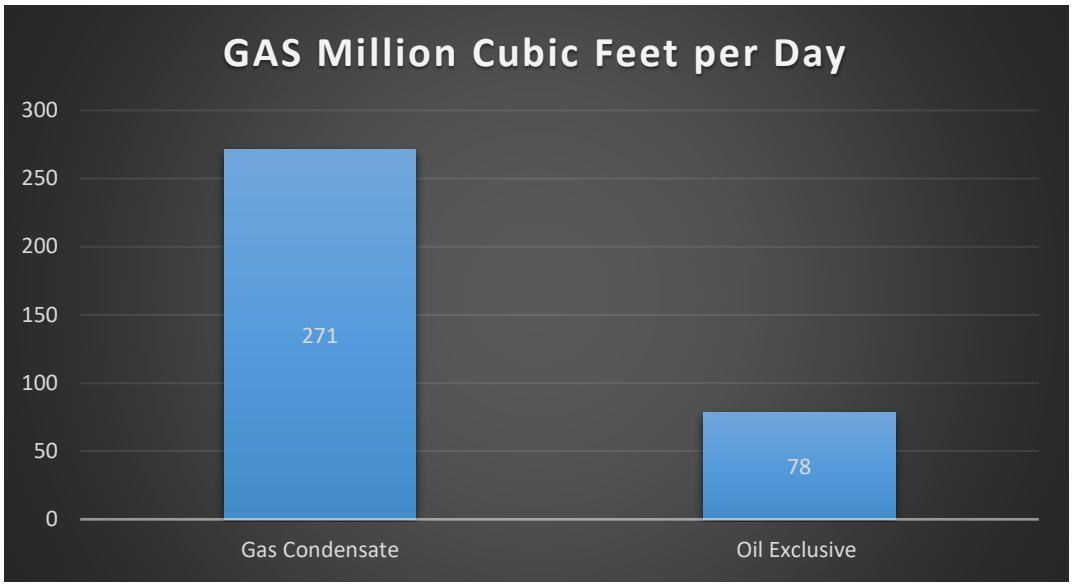

Figure 4

On the global perspective, Pakistan is 44th among oil producing countries with daily average production of 92,000barrel per day of crude oil. Kingdom of Saudi Arabia is at the top with daily production of 12,000,000 barrel per day. Oil & Gas are imported from the OPEC countries. The import of oil and Gas is one of the major contributors to the negative balance of payment of 6.3 billion USD per year. The trend of production vs consumption from 1965 to 2015 shows a steep widening of gap between the production and consumption.[19]

Future Projects & Prospects

Between 2007 and 2018, approximately 95 licenses were issued, and the businesses conducted 381 exploration wells and 514 appraisal/development wells. The administration was implementing a cautious approach to intensify oil and gas exploration endeavors in promising regions of the nation. The Petroleum Division of the Energy Ministry intends to commence the open bidding process for 35-40 recently selected exploration blocks in December 2019.As per the petroleum policy of 2012, the initial duration of the production and exploration lease in offshore areas would be a maximum of 25 years, with the option to renew for an additional period of up to five years. The policy mandates that 10 percent of the royalties be allocated towards the benefit of the local community.[20]

During its initial year in office, the Pakistan Tehreek-e-Insaf (PTI) administration granted five new exploration blocks through a fair and open bidding process. In contrast, the previous government did not provide any blocks throughout its five-year tenure. The government has implemented legislative adjustments to streamline the process for new firms in the E&P industry. Specifically, they have eliminated 10 out of the 24-30 procedures previously required to obtain approval for drilling activities in promising locations. Presently, the nation's whole sedimentary region measures approximately 827,268 square kilometers, with 320,741 square kilometers being subjected to investigation. Citing a recent research on the rapid depletion of current hydrocarbon resources in the country, he expressed concern that the deposits would decrease by a further 60 percent by 2027. He emphasized the urgency of expediting exploration efforts in promising locations (Raza, A., Gholami, R., Meiyu, G., Rasouli, V., Bhatti, A. A., & Rezaee, R., 2019)[21].

[19] Abbasi, Arshad H., Fareeha Mehmood, and Maha Kamal. Shale oil and gas: lifeline for Pakistan. Islamabad: Sustainable Development Policy Institute, 2014.

[20] Khan, M. A., Riaz Ahmed, Hilal A. Raza, and Arif Kemal. "Geology of petroleum in Kohat-Potwar depression, Pakistan." AAPG bulletin70, no. 4 (1986): 396-414.

[21] Raza, Arshad, Raoof Gholami, Guo Meiyu, Vamegh Rasouli, Amanat Ali Bhatti, and Reza Rezaee. "A review on the natural gas potential of Pakistan for the transition to a low-carbon future." Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 41, no. 9 (2019): 1149-1159.

The policy aims to expedite exploration and production activities, encourage foreign direct investment, support domestic E&P businesses, enhance the training of Pakistani professionals, and stimulate expanded exploration and production activity in Pakistan. There are forecasts suggesting that a potential increase in solar energy usage and the adoption of electric vehicles might lead to a 50% decrease in gasoline and diesel consumption. Consequently, despite projected growth, there is a possibility that oil demand may decline even further over the next decade. The statement highlights the significance of understanding the challenges and dilemmas encountered by energy planners and policy makers, assuming they are aware of the future predictions and possibilities. The conventional energy paradigms are gradually diminishing. The situation is undergoing transformation and it will inevitably compel more transformation. It is advisable to embrace and adapt to change rather than allowing oneself to be controlled or overwhelmed by it.[22]
The license for oil exploration in the Makhad block has been issued by the Petroleum Division to Kirthar Pakistan BV, a subsidiary of Kuwait Foreign Petroleum Exploration Company (Kufpec). Kufpec has committed to a minimum investment of $9.8 million in the block. In addition to the mandatory minimum work commitment, the corporation is also required to allocate a minimum of $30,000 per year towards social welfare projects in the Makhad block.[23]

Future Production Vs Requirement. Pakistan has set a target of domestic production of 43.8 million barrels of crude oil and 1.51 trillion cubic feet gas for the next fiscal year.[24]
Integrated energy studies suggest requirement of 40 mm toe oil and 67 mm toe gas in 2025. The imports of bill of oil in 2025 is expected to be 90 billion US Dollars.

New Demand due to CPEC

Pakistan has tremendous growth potential in terms of its economy as well as energy consumption. In the post CPEC scenario, Pakistan has become the most attractive country for investment by all major economic powers. Other countries including Russia, France, Iran and Turkey are showing interest to be part of CPEC. This development is indicating prospects of a new economic order of the globe.[25]
In the very near future, Pakistan will be receiving the largest cargo transactions from the China and the Central Asian States via its land routes. In the start of the CPEC, a number of energy production units are being installed in the country, where major focus is on the Electricity production from fossil fuel i.e. oil, gas and coal. Additionally, new projects are also in hand. This activity will increase the demand for fuel and Energy tremendously.

Quest for New Reservoirs

Sensing the emerging scenario, Pakistan is all set to find new treasures of oil & gas in its shale structures. In a recently conducted shale gas survey, it has been found that Pakistan has recoverable reserves of around 200 trillion cubic feet (TCF) of natural gas and around 58 billion barrels of oil in its shale structure. Most of the shale reserves are in Mianwali area.[26]

Limitations in Oil & Gas Exploration

However, oil & gas exploration has some significant limitations with respect to Pakistan. The oil and Gas exploration is too much expensive and investment oriented. It needs thorough professionalism and state oft heart technology, usually not available with small companies of developing countries. Resultantly, services of big multinational companies are hired, who are very

[22] Ahmad, Adeel, and Mithilesh Kumar Jha. "Status of petroleum sector in Pakistan: A review." Oil and gas business 745 (2008): 1-15.
[23] Farooqui, Muhammad Ahmed, and Syed Mobasher Aftab. "China-Pakistan Economic Corridor; Prospects and Challenges for Balochistan, Pakistan." In IOP Conference Series: Materials Science and Engineering, vol. 414, p. 012046. IOP Publishing, 2018.
[24] Gondal, Irfan Ahmad, Syed Athar Masood, and Muhammad Amjad. "Review of geothermal energy development efforts in Pakistan and way forward." Renewable and Sustainable Energy Reviews 71 (2017): 687-696.
[25] Javed, Hafez Muhammad, and Muhammad Ismail. "CPEC and Pakistan: Its economic benefits, energy security and regional trade and economic integration." Chinese Political Science Review 6, no. 2 (2021): 207-227.
[26] Gondal, Irfan Ahmad, Syed Athar Masood, and Muhammad Amjad. "Review of geothermal energy development efforts in Pakistan and way forward." Renewable and Sustainable Energy Reviews 71 (2017): 687-696.

choosy in picking an investment opportunity and also sensitive to local conditions like law and order etc.[27]

The success rate is very low as viz-a-viz the cost of exploration. Up till now overall success rate in Pakistan is 40 % while the 60 % proved to be dry wells.[28]

The reservoirs in Balochistan and KPK have been under-explored due to the issue of accessibility. The areas not only lack access routes to the field and need a huge investment to construct access routes, but there is serious issue of law and order in both the provinces.[29]

Geographical surveys suggest a huge reservoir of oil & gas under sea shore, but the off shore exploration is even more expensive and technically tricky. Therefore, there has been very little progress in the offshore exploration.[30]

Although the earth crust and the sea underneath are full of natural resources and we have plenty of reserves but due to the limitations, very lesser have been discovered/ explored up till now. The dilemma is that the already discovered reservoirs of oil & gas are very quickly depleting throughout the world and may not sustain for longer.

In spite of new reserves, the total demand is not likely to be met by the own resources. Pakistan is negotiating with countries to be part of multinational Oil & Gas pipelines projects. The most prominent projects are

- Iran-Pakistan-India Gas pipeline
- Turkmenistan-Afghanistan-Pakistan Gas pipeline
- LNG from Qatar to Pakistan

These projects will not only enable Pakistan to meet its own requirements but will also earn handsome amount of foreign exchange as royalty for the route. However, Oil & Gas is not the only source of energy. Other sources include exploration of coal reservoirs, use of atomic energy, solar energy and wind energy are other options open for Pakistan. Presently various projects of alternate energy are in under progress in the country.

Impact of Economic & Foreign Policies

Shortage of oil & Gas has vast impact on economic and foreign policy as under: -

A vibrant foreign policy and favorable economic conditions are required to attract handsome investment.

Effective representation/ lobbying at international forums help in getting economic and political concessions for projects.[31]

Mega multinational projects of oil & gas pipelines are totally dependent on good foreign policy dividends.[32]

ANALYSIS AND RECOMMENDATIONS

Pakistan has substantial reserves of oil & gas. The detailed analysis of these reserves along with extensive efforts for exploration of new avenues, futuristic requirements and upcoming projects bring me to the key outcomes that include: -

The present efforts for production and exploration in oil & gas fields don't commensurate with the requisite needs.

---

[27] Rehman, Syed Aziz Ur, Yanpeng Cai, Nayyar Hussain Mirjat, Gordhan Das Walasai, Izaz Ali Shah, and Sharafat Ali. "The future of sustainable energy production in Pakistan: A system dynamics-based approach for estimating hubbert peaks." Energies 10, no. 11 (2017): 1858.

[28] Javaid, Prof Dr Umbreen, and Azhar Rashid. "Oil and Gas potentials of Central Asian Republics and relations with Pakistan." South Asian Studies 30, no. 1 (2020).

[29] Khan, M. A., Riaz Ahmed, Hilal A. Raza, and Arif Kemal. "Geology of petroleum in Kohat-Potwar depression, Pakistan." AAPG bulletin70, no. 4 (1986): 396-414.

[30] Sohail, Ghulam Mohyuddin, Christopher David Hawkes, and Qamar Yasin. "An integrated petrophysical and geomechanical characterization of Sembar Shale in the Lower Indus Basin, Pakistan, using well logs and seismic data." Journal of Natural Gas Science and Engineering 78 (2020): 103327.

[31] Ghouri, Salman Saif. "Economic analysis of trends in oil and gas exploration in Pakistan, 1947-1988, An." 1990-1999-Mines Theses & Dissertations (1990).

[32] Javaid, Prof Dr Umbreen, and Azhar Rashid. "Oil and Gas potentials of Central Asian Republics and relations with Pakistan." South Asian Studies 30, no. 1 (2020).

1. The improvement in prevailing security conditions are not being duly highlighted to attract the Multi-National Companies for direct investments in E&P sector.
2. The shale oil & gas reserves provide new avenues towards better future in fields of E&P sectors in Pakistan.
3. Off shore exploration is the most neglected area.
4. The importance to the energy mix concept is not being given due consideration resulting in consumption of Oil and Gas for every energy requirement.
5. Multinational projects of oil & gas pipelines would not only help in meeting own energy requirements but also would give away dividends in form of route royalty.
6. The prevailing Pakistan Petroleum Policy-2012 is not being implemented in letter and spirit. In addition, it doesn't encompass the global developments in E&P sectors.
7. Vested interests of authorities results in unprofessional deployments and menace of corruption are severely affecting E&P sector in Pakistan.

Recommendations

In view of the research and analysis, following is recommended: -

Reserves

(1) More international companies be hired for exploration of reserves by giving incentives like reduction in taxes

(2) Own local companies be encouraged to acquire new technology and modern machineries through govt subsidiaries/ Incentives.

(3) Companies be encouraged to focus on offshore exploration as they are most neglected areas.

Improvement in Security

(1) Military and LEAs are doing their best to maintain peace. However, spec security be given to MNCs to provide security to their investment and infrastructure.

(2) Media should also play a role in spreading peace worldwide. No negative security lapse be shown on National Television.

(3) Threatened/ conflict areas be publicized to show peace in the areas after Military operations to attract MNCs for direct investment.

Alternative Energy

(1) Usage of solar Technology and its accessories may be increased manifold. Prices be made low and encourage people to use cheap solar energy.

(2) As petrol and LNG mileage of a vehicle are the same LNG kits may be used in vehicles which is cheaper than petrol.

(3) Electric vehicles be introduced with recharging stations and advertise the project for cheaper energy.

(4) Hybrid vehicles be used at large scale which also has less consumption.

State Policies

(1) As three supply lines of natural gas are in progress, the foreign office needs to expedite the projects of gas pipelines to meet energy needs.

(2) One window policy be implemented to facilitate foreign companies to invest in oil and gas exploration.

(3) Strict adherence to policies and merit-based deployments are to be ensured by the regulatory authorities.

(4) Professionalism must be ensured to eradicate corruption.

CONCLUSION

The world is rapidly nearing a critical juncture where the exhaustion of aging oilfields cannot be compensated for by the diminishing influx of new oil supplies, resulting in a shortfall of oil output relative to global demand. Hence, to safeguard economic prosperity in the 21st century, it is imperative to enhance reliance on alternative energy sources to address the challenges posed by the depletion of world oil supplies. Pakistan has tremendous growth potential in oil & gas production. Pakistan enjoys an unmatchable edge due to huge unexploited reservoirs added with a strategic location in manipulating foreign relations to the advantage of pipeline projects, as an alternative to the exploration. Reliable energy is the primary catalyst for economic growth. To

secure a sustainable energy future, Pakistan must enhance the diversity of its energy supply mix. Pakistan possesses substantial capacity for renewable and alternative energy sources. Harnessing indigenous energy resources is the definitive approach to bolster the country's energy security. Direct investments by MNCs in the E&P sector are a pre-requisite for a country like Pakistan. In the past, the deteriorated security situations in the country have seriously hampered this aspect. Now there has been a marked improvement in prevailing security conditions that need to be advertised to attract the MNCs for direct investment. It's the responsibility of every citizen especially the stakeholders, to safeguard the country's foreign exchange with intelligent and diplomatic ways and concentrate, explore, and utilize these resources to our national benefit and take our country to the heights of prosperity and development.

References

Atlas, Ronald M. "Petroleum microbiology." (1984).

Abbasi, Arshad H., Fareeha Mehmood, and Maha Kamal. Shale oil and gas: lifeline for Pakistan. Islamabad: Sustainable Development Policy Institute, 2014.

Ahmed, Riaz, S. Manshoor All, and Jalil Ahmad. "Review of petroleum occurrence and prospects of Pakistan with special reference to adjoining basins of India, Afghanistan and Iran." Pakistan Journal of Hydrocarbon Research 6, no. 1 & 2 (1994): 7-18.

Ahmad, Adeel, and Mithilesh Kumar Jha. "Status of petroleum sector in Pakistan: A review." Oil and gas business 745 (2008): 1-15.

Bradley, Howard B. "Petroleum engineering handbook." (1987).

Cozzi, Andrea, Giuseppe Rea, and Jonathan Craig. "From global geology to hydrocarbon exploration: Ediacaran-Early Cambrian petroleum plays of India, Pakistan and Oman." Geological Society, London, Special Publications 366, no. 1 (2012): 131-162.

Dolan, P. "Pakistan: a history of petroleum exploration and future potential." Geological Society, London, Special Publications 50, no. 1 (1990): 503-524.

Daud, Farrukh, Gulzeb Nabi Khan, and Muhammad Ibrahim. "Remaining hydrocarbon potential in Pakistan a statistical review." In Society of Petroleum Engineers (SPE) Annual Technical Conference, Islamabad, Pakistan. 2011.

Farooqui, Muhammad Ahmed, and Syed Mobasher Aftab. "China-Pakistan Economic Corridor; Prospects and Challenges for Balochistan, Pakistan." In IOP Conference Series: Materials Science and Engineering, vol. 414, p. 012046. IOP Publishing, 2018.

Fayyaz, Zohaib, Javed Iqbal, Ahsan Mehboob, Muhammad Affan Sabir, and Abdul Jabbar. "Structural Investigation for Locating Petroleum Reservoirs Using Geoinformatics in Meyal, Potwar Region, Pakistan." International Journal of Geosciences 7, no. 11 (2016): 1345.

Ghouri, Salman Saif. "Economic analysis of trends in oil and gas exploration in Pakistan, 1947-1988, An." 1990-1999-Mines Theses & Dissertations (1990).

Gondal, Irfan Ahmad, Syed Athar Masood, and Muhammad Amjad. "Review of geothermal energy development efforts in Pakistan and way forward." Renewable and Sustainable Energy Reviews 71 (2017): 687-696.

Hussain, Sajid, Faisal Khan, and Muhammad Ayaz. "Politico-Economic Implications of CPEC on Pakistan." FWU Journal of Social Sciences 15, no. 4 (2021): 147-162.

Javaid, Prof Dr Umbreen, and Azhar Rashid. "Oil and Gas potentials of Central Asian Republics and relations with Pakistan." South Asian Studies 30, no. 1 (2020).

Javed, Hafez Muhammad, and Muhammad Ismail. "CPEC and Pakistan: Its economic benefits, energy security and regional trade and economic integration." Chinese Political Science Review 6, no. 2 (2021): 207-227.

Khan, M. A., and Hilal A. Raza. "The role of geothermal gradients in hydrocarbon exploration in Pakistan." Journal of Petroleum Geology 9, no. 3 (1986): 245-258.

Khan, M. A., Riaz Ahmed, Hilal A. Raza, and Arif Kemal. "Geology of petroleum in Kohat-Potwar depression, Pakistan." AAPG bulletin70, no. 4 (1986): 396-414.

Khan, M. A., Riaz Ahmed, Hilal A. Raza, and Arif Kemal. "Geology of petroleum in Kohat-Potwar depression, Pakistan." AAPG bulletin70, no. 4 (1986): 396-414.

Memon, A. R. "Status of petroleum sector in Pakistan-a review." Journal of Information Communication Technologies and Robotic Applications (2018): 1-10.

Mahesar, A. A., Shar, A. M., & Tunio, A. H. (2021). Tight gas potential status, obstacles and the way forward in meeting future energy needs of Pakistan. Mehran University Research Journal Of Engineering & Technology, 40(3), 570-581.

Nazir, Arif, and Tahira Fazeelat. "Petroleum geochemistry of Lower Indus Basin, Pakistan: I. Geochemical interpretation and origin of crude oils." Journal of Petroleum Science and Engineering 122 (2014): 173-179.

Rodgers, Ryan P., and Amy M. McKenna. "Petroleum analysis." Analytical chemistry 83, no. 12 (2011): 4665-4687.

Rauf, Omer, Shujie Wang, Peng Yuan, and Junzhe Tan. "An overview of energy status and development in Pakistan." Renewable and Sustainable Energy Reviews 48 (2015): 892-931.

Raza, Arshad, Raoof Gholami, Guo Meiyu, Vamegh Rasouli, Amanat Ali Bhatti, and Reza Rezaee. "A review on the natural gas potential of Pakistan for the transition to a low-carbon future." Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 41, no. 9 (2019): 1149-1159.

Rehman, Syed Aziz Ur, Yanpeng Cai, Nayyar Hussain Mirjat, Gordhan Das Walasai, Izaz Ali Shah, and Sharafat Ali. "The future of sustainable energy production in Pakistan: A system dynamics-based approach for estimating hubbert peaks." Energies 10, no. 11 (2017): 1858.

Sohail, Ghulam Mohyuddin, Christopher David Hawkes, and Qamar Yasin. "An integrated petrophysical and geomechanical characterization of Sembar Shale in the Lower Indus Basin, Pakistan, using well logs and seismic data." Journal of Natural Gas Science and Engineering 78 (2020): 103327.

Zaigham, Nayyer Alam, and Khalil Ahmad Mallick. "Prospect of hydrocarbon associated with fossil-rift structures of the southern Indus basin, Pakistan." AAPG bulletin 84, no. 11 (2000): 1833-1848.