Institute of Business Administration Karachi
Leadership and Ideas for Tomorrow

DEVELOPMENT OF UNCONVENTIONAL GAS POTENTIAL IN PAKISTAN

This Project Report is submitted to the School of Business Studies (SBS) as partial fulfillment of Executive MBA degree

by

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Fall Semester 2023
Institute of Business Administration (IBA), Karachi, Pakistan

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Executive Summary

The study explores the prospects of the unconventional gas plays with a focus on Southern Pakistan region to present a rational context for enhancing the local supply of gas in the country. This will contribute to the national objective of achieving economic security in the energy sector through development of local industry.

The country is gifted with over 100 TCF of unconventional reserves in the Lower Indus Basin. The development of these resources will provide gas to local supply and will reduce the dependency on imported LNG. However, the development of such resources has been facing strategic myopia, along with regulatory intricacies, marginal economy, and technological obstacles.

Furthermore, this study gives attention to the need to cultivate local expertise in unconventional resource development, import technologies aided by the government, and form an appropriate environment for commercial operation, investment, research and development. In addition to this, the report examines the factors that contributed to the US Shale journey's success and concludes that by following the similar footprints and best practices, the country can harness the potential of these resources. These lessons are explained in terms of ongoing technological improvement, economy of scale, and active government and regulatory support.

The study emphasizes that, given the complex requirements of developing unconventional resources and their need of significant investment with lengthy return on investment (ROI), these types of projects can be made economically viable by strategic cooperation among the key stakeholders including the industry and regulator, a strong service industry and efficiency in operating cost.

To pave the way for energy security and independence, the report offers insights and practical suggestions that E&P operators, investors, policymakers, and industry stakeholders should implement in order to focus on the development of unconventional resources.

Keywords: Unconventional Gas, Unconventional Oil, Shale Gas, Hydraulic Fracturing
Energy Mix

Chapter 1

Introduction

1.1 Overview

The increasing energy need has resulted in the scarcity of fossil fuels. From the start of Exploration & Production, and particularly in the last decade, the development of the indigenous reserves has not met the increasing need of energy. One of the main issues with Pakistan's already worsening economic circumstances is the energy shortage. Currently, the energy demand of a country is primarily covered with imported LNG and Oil which contributes to a quarter of the total import bill. The imports of these commodities have increased significantly over the past 20 years.

In the last few decades, oil & gas industry focus is on exploring and developing unconventional resources. North America is now producing enough energy with these resources to fulfil two third of their energy demand. This evolution has been called the US shale boom. The development of these unconventional resources needs extensive stimulation technique as unconventional reservoir is relatively tight compared to conventional reservoirs. In this stimulation technique, pressure is applied till the rock breaks which create additional channels/ pathways to produce hydrocarbons in large quantity. This technique is generally termed as Hydraulic fracturing. China and Oman have also followed the footsteps of the United States and adding significant production in their infrastructure from unconventional resources.

The report examines the presence of these resources in the southern part of Pakistan and the potential for large-scale economic growth. US unconventional journey will be beneficial for learning purposes. This study will examine the recommendations of experts and feasibility of the unconventional resources through horizontal well and large-scale hydraulic fracturing. The study's conclusions would be very valuable to the regional business community and provide investors, legislators, and other industry stakeholders with practical advice. Significant economic gains could result from this, such as improved energy security, the growth of the E&P industry, and a reduced need for imported energy.

1.2 Problem Statement

In Pakistan, gas is the largest domestic energy source. The discoveries in the early years created wide base of gas market with well-established surface network, but during the past decade, domestic production has lagged consumption, expanding the gap between supply and demand for gas. Now, demand control and costly LNG imports are used to balance the market. The exploitation of unconventional has progressively taken center stage in the attention of the global

oil industry over the last few decades. The Oil industry in North America is pioneered in successful development of these resources, that helped them to cover 2/3rd of their energy demand. The valuable insights gained from the North American industry will aid in development of these resources and Pakistan might save billions of dollars on LNG imports and create a large amount of economic activity.

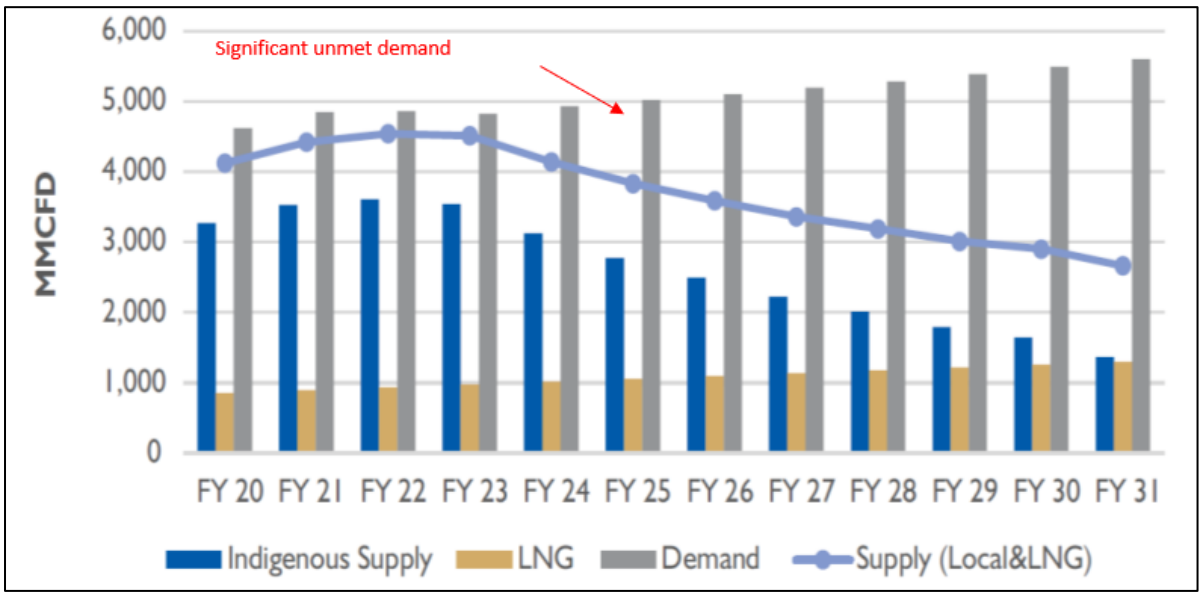

Figure 1: Forecast of Gas including LNG– (Source: Oil and Gas Regulatory Authority - Report 2020)

1.3 Research Questions

This study will focus on below mentioned questions:

1. What are major challenges & opportunities for developing untapped unconventional reserves in country?
2. How can the local industry in Pakistan adapt the best practices and lessons from the unconventional resource development journey of North American Oil and gas sector?
3. What is the commercial viability for local industry in developing the unconventional gas resources by hydraulic fracturing?

1.4 Research Objectives

Following are the research objectives that are associated with the above research questions:

1. Determine the prospects and obstacles associated with the development of unconventional resources in Southern Pakistan, taking into account the region's sub-surface potential, regulatory framework/ policies, and infrastructure.

2. Devise a practical plan for local E&P industry by adapting and implementing the lessons of US unconventional resource development journey, considering its success variables, infrastructure development, policy framework and technology.
3. Analyze the feasibility from a business standpoint for E&P operators in Pakistan of developing unconventional gas resources by hydraulic frac.

Chapter 2

Literature Review

2.1 Conventional Reservoirs

Conventional reservoirs are naturally occurring, porous rock formations with trapped hydrocarbons (oil and natural gas). These oil and gas reservoirs possess three key properties: pore space (porosity), ability to flow (permeability), and confinement (trap). Conventional reservoirs, predominantly comprises of sandstones or carbonates with varying porosity, permeability, and trap i.e., anticline or syncline or cap rock which provides seal and prevent hydrocarbon migration. Conventional reservoirs are easier to find and develop due to their well-understood geological characteristics and accessible locations, more productive and higher flow rates due to their higher permeability, less expensive to extract because they often require less complex drilling, completion, and stimulation techniques.

2.2 Unconventional Reservoirs

Unconventional reservoirs, in contrast, are also naturally occurring, porous rock formations with trapped hydrocarbons but differ in characteristics i.e., porosity, permeability and trap. Unconventional reservoirs have very low permeability and porosity which makes it difficult to produce through conventional methods. As per the established standards of the industry, unconventional (tight/shale) rock is described as formations containing oil/gas with lower than 0.1mD of the permeability (rock ability to transmit fluid). To extract hydrocarbon from unconventional reservoirs, specialized equipment and inventive methods are required. The economic feasibility of unconventional resources becomes achievable through the application lateral drilling and multistage fracs providing wellbore connectivity and circumventing natural flow restrictions. However, success in unconventional reservoir extraction is not solely reliant on availability. The sustained economic viability of unconventional resources can be ensured through collaborative efforts between industry and government, encouraging advancements in expertise, knowledge, and technological progress and policies in the field of unconventional tight gas.

2.3 Hydraulic Fracturing

Hydraulic fracturing is utilized in reservoirs with medium to low permeability to enhance the productivity of rock. Generally, production/injection wellbores are drilled to depths of 8000 to 10,000 feet, often incorporating horizontal or multilateral segments (Gidley, 1989). During hydraulic fracturing, pressurized fracturing fluids, typically consisting of water (over 90%), sand,

and various chemical additives are injected into the geological formation (Sawyer, 2009). This pressurized fluid creates fractures or fissures in the rock formations, and proppants, such as sand, are introduced to maintain these fractures open, thereby maintaining the high permeability of the fractured zone. The effectiveness of these fractures or fissures greatly depends on rock mechanical parameters (poisons ratio and elastic moduli). Subsequently, the internal pressure in the rock triggers the fracturing fluids to resurface, a phenomenon known as flowback. Flowback mixture (fluid and sand) can be retained in tanks or pits for subsequent recycling or disposal.

Hydraulic fracturing technology is in relatively nascent stage in Pakistan. Tight gas resources potential is quite high and requires feasible exploration and development policy and availability of technology to develop steep learning curve in terms of candidate selection, design, and execution.

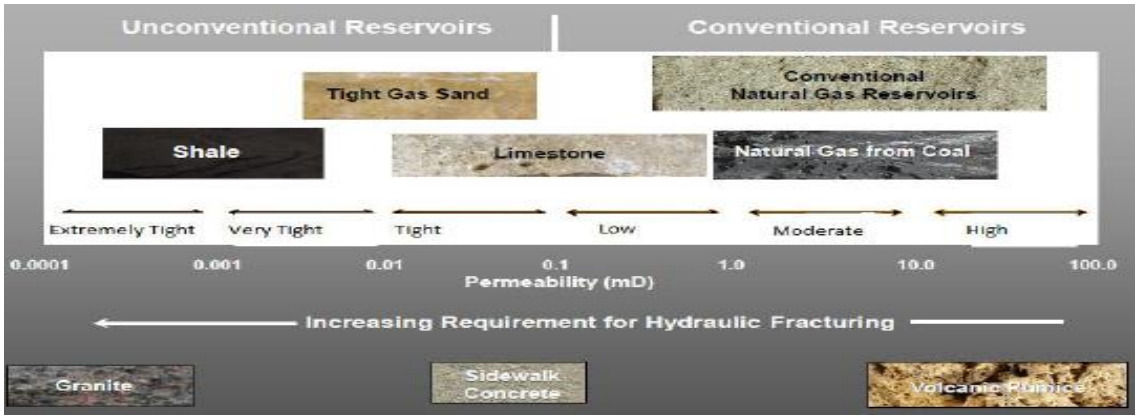

Figure 2: Tight Rocks compared with Conventional rock– (Source: Department of Energy, Mines, Industry Regulation and Safety – Government of Western Australia)

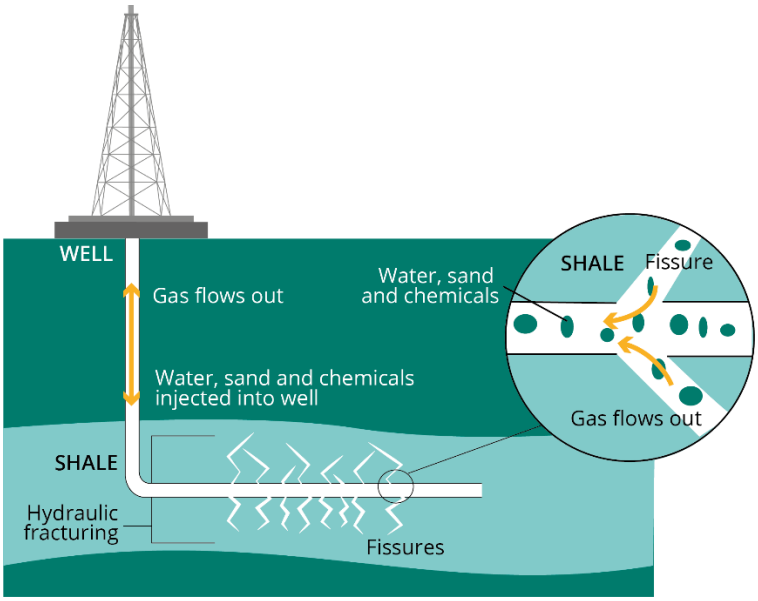

Figure 3: Schematic of Hydraulic Frac - (Source: European Environment Agency - Shale gas extraction through hydraulic fracturing)

2.4 Energy Mix of Pakistan

In the context of Pakistan's energy mix, gas (including LNG) constitutes approximately 50% of the energy requirements, followed by oil at around 32%. Hydropower contributes approximately 10%, coal 5% and nuclear power 2%. The largest consumer of energy sector is the industrial sector, comprising 36% of the total consumption, afterwards the transportation at 32%. In terms of electricity consumption, the domestic segment holds the highest share at around 47%, subsequently the industry with 29% (Wakeel et al., 2016).

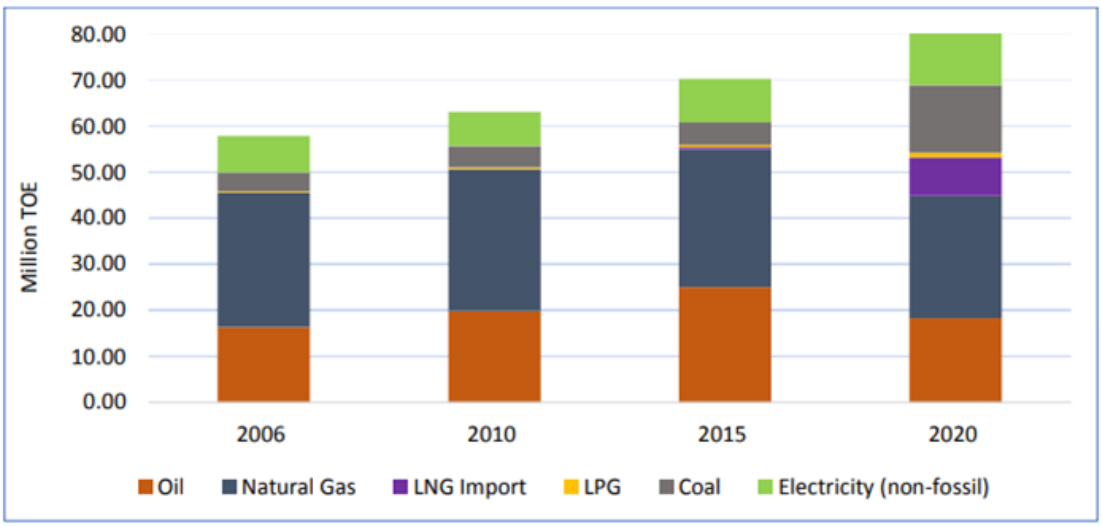

Figure 4: Energy Contribution of Various Sources in Pakistan - (Source: Pakistan Energy Projection Report 2021-2030)

The country's current energy scenario, worsened due toy governmental bureaucratic challenges with the surge in commodity prices around the globe, has become a significant impediment to annual GDP growth, potentially constraining it by up to 2%. The reasons for this crisis are connected with the decisions made during 90s, characterized by a heavy reliance imported energy leading to trade deficits, mounting circular debts, and stagnation in the local energy sector. This situation has led to economic growth challenges, including power outages, production hindrances, and rising costs. Addressing these issues calls for comprehensive reforms and immediate relief measures, focusing on reducing reliance on imported energy and increasing the domestic supply through the exploitation of local resources (Aftab, 2014).

The overview of the energy sector uncovers challenges in oil and gas sectors. The gas sector experiencing a negative annual decline rate of 5% over the past five years in local production. Projections suggests that this negative trend is expected to continue, reducing to ~2 BCFD by 2030 from ~3 BCFD in 2025. The decrease in production is alarming and proposes a significant threat to the energy balance, given the projected surge in demand to 4.3 BCFD by 2030, leading to a significant deficit in net supply. To mitigate these challenges, a multi-pronged strategy is essential, including instant development of untapped oil and gas resources and enhancements in infrastructure. A strategic, directed approach is crucial for ensuring a dependable and balanced future of energy in the country (Pakistan Energy Projection Report 2021-2030).

This detailed study covers the period from mid 90s to date and investigates the intricate patterns of gas usage in the country. During this period, our GDP grew by 57%, supplemented by an increase in per capita income, inducing energy consumption trends. Structural changes in sectors like power, transport, cement, fertilizer, and general industry have positively impacted towards economic development. The study emphasizes the need to reduce reliance on the import of energy, especially because the oil and gas contribute over two thirds of the total mix of Pakistan's primary energy source. Also, it highlights importance of capitalizing on local resources, such as Pakistan's vast sedimentary basins and rich fossil resources potential, to promote growing economy (Raza & Lin, 2023).

2.5 Unconventional Gas: Pakistan's Potential

Various studies highlight the potential of developing Pakistan's indigenous tight gas reserves as a solution to the natural gas shortage. Utilizing this unconventional resource could not only alleviate immediate energy concerns but also drive economic development within the country. With over 100 TCF of shale gas (as per 2011 EIA) and potentially 35 TCF+ of tight gas (2013 study), the country has a clear opportunity to leverage its significant unconventional gas resources. In the

face of a prevailing deficit of around 2.5 BCF, the state has adopted to import costly liquefied natural gas (LNG) and load management. Though LNG fills the immediate void, its high cost and foreign dependence cast a long shadow. The key to a brighter future lies in harnessing the vast, underutilized reserves of unconventional gas within Pakistan's borders, paving the way for energy security and economic prosperity (Mahesar et al., 2021).

In another study, researchers evaluated the potential of shale plays in the Indus Basin, located in the southern region of Pakistan. The research presented a volume of around 360 TCF unrisked and 43 TCF as risked volume in the Sembar formation. (Sheikh & Giao, 2017).

The successful US shale boom led to development of similar assets in China, Argentina, Oman and Turkey whereas India and Pakistan's are still in the initial phase of exploration. The unconventional resource opportunity provides a show potential path toward achieving energy independence and fostering economic progress. According to the Energy Information Administration (EIA), the Sembar resources contain volumes of over 100 BCF per square mile of gas and recoverable reserves of ~20 TCF (Haider et al., 2012).

With a deep commitment to addressing Pakistan's energy needs, companies like Eni, Orient Petroleum, and domestic giants like Pakistan Oil Field Limited and United Energy Limited actively explore the country's significant tight gas potential, alongside established E&P leaders like OGDC and PPL. To unlock the reserves, including the promising prospects of tight gas, Pakistan leverages its Petroleum & Exploration Policy, facilitating competitive bidding and collaborations with foreign companies. The limited scope of Pakistan's tight gas policy, offering extended leases and production rewards, fails to address key concerns like financial and tax incentives, R&D support, resource management, integrated energy policy, and pipeline infrastructure, highlighting the need for future revisions (Mahesar et al., 2021).

Despite promising discoveries, South Asia, encompassing Pakistan, lags with less than 3% of the global tight gas resources. Unlike the U.S., which has sustained stable natural gas production from unconventional sources, Pakistan encounters challenges such as high costs and lower returns on investments in unlocking its tight gas potential. To effectively maximize Pakistan's tight gas potential, a multi-pronged strategic approach is essential, addressing economic barriers, incentivizing exploration activities, and promoting technological advancements in unconventional resource extraction, particularly in geographically diverse regions like the Lower & Middle Indus, Potwar, Foldbelt and the offshore Karachi (Alam, 2010).

The detailed analysis studying shale formation of Pakistan with notable U.S. plays shows exciting parallels in geological features, suggesting significant potential for unlocking a secure

energy future for Pakistan. Estimating well costs in Pakistan's shale formations remains a complex problem, but the resource's richness and unique geological characteristics favors for its strategic development. Our focus is on advocating a responsible, collaborative, and strategic exploration and production strategy, firmly rooted in national interests, and upholding global best practices (Abbasi, Mehmood, & Kamal, 2014).

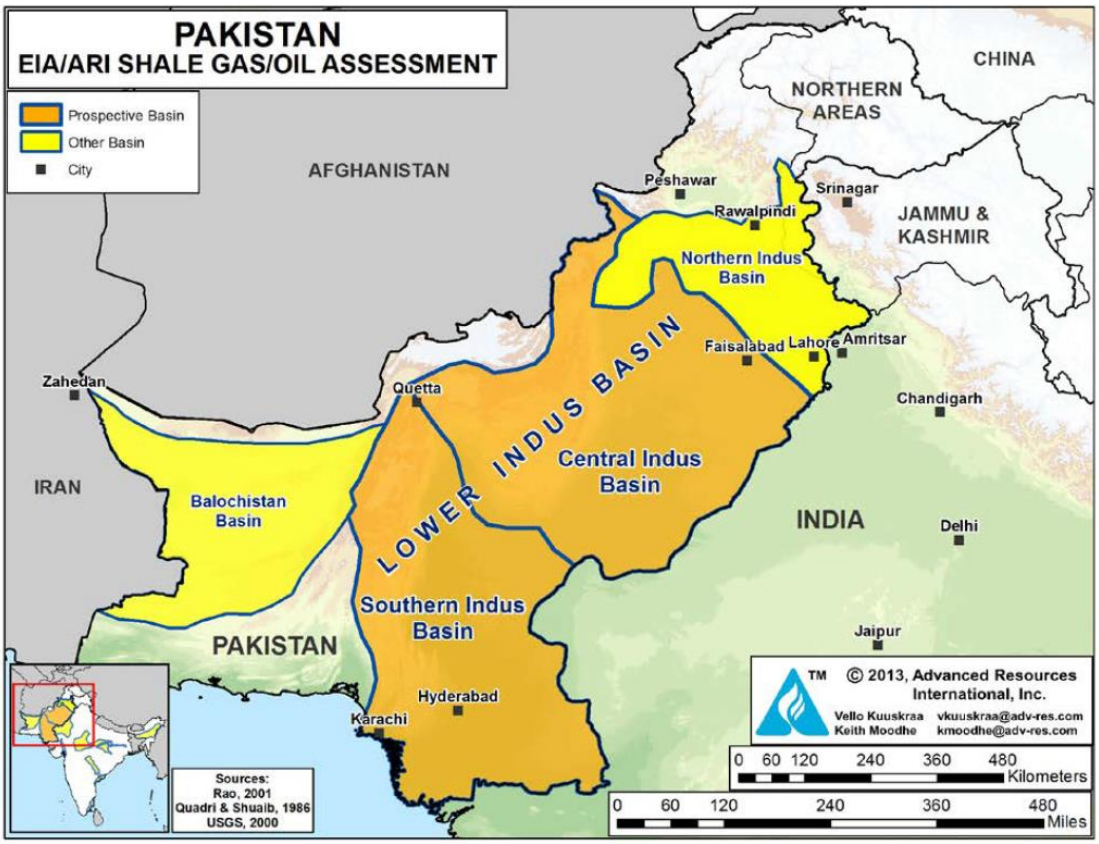

Figure 5: Map of Unconventional Resources in Pakistan - (Source EIA Pakistan Inda 2013)

2.6 Unconventional Learning Example: North America

The enormous natural gas reservoir accessibility in the United States corresponds to substantial resource, carrying reflective inferences to their economy and energy security. Their approach leverages the market dynamics while the state policies are strategically formulated to streamline the industry and consumer needs. This is enabled by funding for the Energy Information Administration (EIA) for innovation in technological implementation through collaboration of public & private sector. Recognizing the need of skilled workforce, the U.S. enhances intellectual capital development program through multi-level initiatives such as industry-university collaborations, government scholarships, and support for faculty and research to accommodate the shortfall. In addition, K-12 science literacy highlights the ongoing reviews and improvements in educational and training support contributions to mitigate the aging workforce's impact and

enforcing a continuous incursion of skilled professionals into the industry (Hackett, 2011).

In an independent investigation, there is a thorough examination of the factors that played a role in the exemplary expansion of the contribution of shale gas between 2000 and 2010. The notable rise in production from less than 2% to over 23%, transformed their energy horizon and drew the attention of other nations in the exploration of shale gas. The primary catalysts for this pick-up include technological innovation, governmental policies, entrepreneurial initiatives in the private sector, ownership right of private property, elevated gas tariffs, structure of consumer market, encouraging geological conditions with water accessibility and the presence of established natural gas pipeline infrastructure. Fundamental roles were played by technological advancements, emerging from both government research and entrepreneurial initiatives in the private industry. Governmental efforts in the 70s, including tax holidays and R&D, were undertaken for encouraging the development of the tight gas. Regulatory reforms like the Tax Act of 1980 with its subsidy for tight and shale fuel production, fostered the early growth of plays like Devonian shale. The study emphasizes the significance of establishing a conducive framework for the countries seeking to exploit their unconventional plays. In addition to this, elements like transport network, water disposal bores, favorable geography with minimal population densities in target regions, and a track record of conventional oil and gas development all played a collective role in this journey of theU.S. (Wang & Krupnick, 2013).

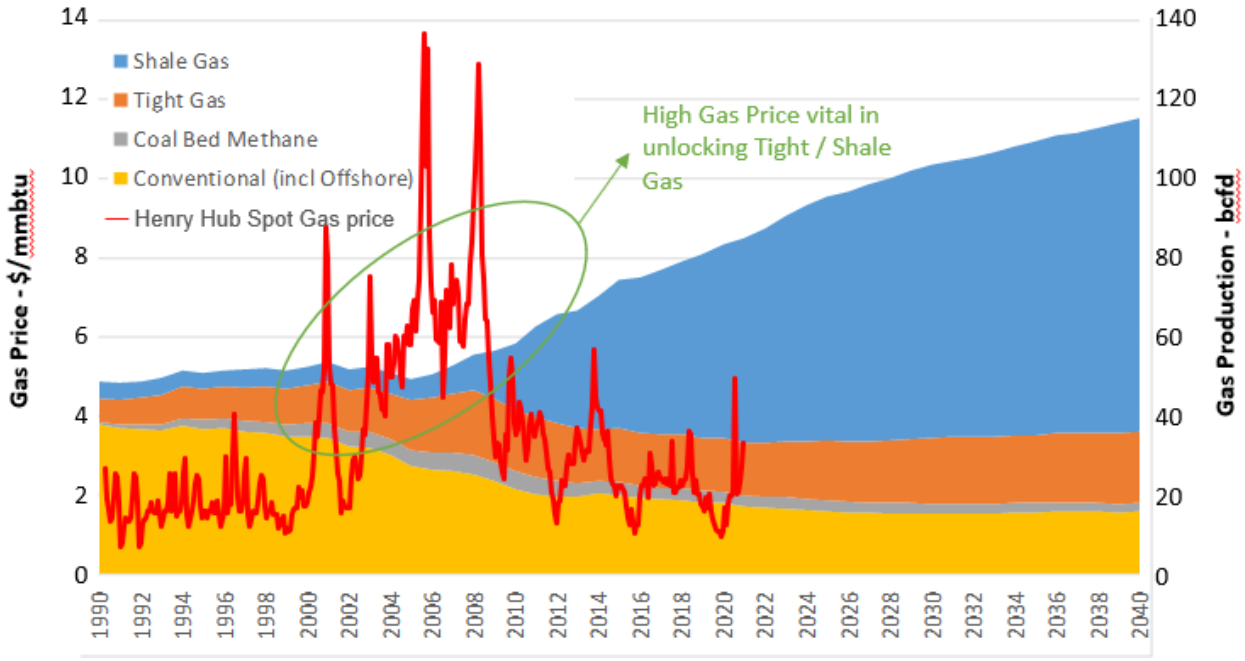

Figure 6: EIA – Timeline of US Gas Production vs Prices - (Source: EIA)

2.7 Unconventional Resource Development: Technological advancement

A thorough appreciation of the subsurface and technical factors, coupled with the application of cutting-edge techniques, is needed to exploit tight and shale resources. Challenges at the smaller scale are addressed by traditional methods. However, the low permeabilities that these types of rocks have, pose their inability to flow naturally and hence the integration of advanced technologies including lateral wells and multistage fracturing.

The revolutionary work of Union Pacific Resources Company while developing the Austin Shale Chalk Play in the early 90s laid foundation for modern shale development. Beyond its historical significance, the project served as a blueprint for modern practices showcasing the effectiveness of core techniques like horizontal drilling and multi-stage fracturing, techniques that unlock shale production from the Barnett to the Bakken.

Unconventional resource development is undergoing a transformative period driven by technological advancements. The exploration and extraction of these resources, such as tight gas, shale gas and oil sands, have been substantially developed by breakthroughs in drilling techniques, reservoir characterization, and hydraulic fracturing technologies (Holditch & Madani, 2010). These improvements enable more efficient extraction from previously challenging geological formations. Real-time data monitoring, precision engineering, and the application of artificial intelligence have become integral components in optimizing exploration and production processes. The conjunction of technological innovation and unconventional resource development holds the solution to unlocking new energy sources and addressing global energy demands in a sustainable manner. Unleashing the true potential of tight gas sands while protecting the environment requires a continuous partnership between industry leaders and technology developers, encouraging mature improvements for sustainable energy production (Naik, 2003).

2.8 Unconventional Resource Development: Feasibility & Economics

Pakistan boasts significant unconventional gas reserves, offer a potential solution to its persistent energy challenges. However, extracting this resource faces considerable challenges, primarily due to limited technological expertise and a complex economic landscape. This study investigates the technical and commercial viability of developing the unconventional in the country, drawing on comparisons with established US formations and proposing practical implementation strategies. While technical and economic challenges exist, development of Pakistan's shale gas potential is a practical option to unlock unconventional resources with the appropriate policies and implementation framework. Pakistan can develop its unconventional resources using a strategic approach by carrying out initial pilot wells and frac, strategic partnership and collaboration for

transferring technology and strong support from regulators. The study suggests a minimum pricing of $11, with certain assumptions of government incentives. However, when we compare it with the current tax framework, break-even gas prices will be in between $19 to $53 per Mscf respectively. (Ali, F., Khan., et al, 2021).

Chapter 3

Research Methodology

3.1 Research Method

The research conducted is qualitative in nature which address the development prospects of unconventional plays in the country. This approach enables a comprehensive evaluation of the interconnected areas of this study. This method is selected based on the need of a detailed evaluation of the possible opportunities and limitation posed by the current scenario in local industry and to implement the lessons learned from the US experience of such development in the local context. The intent is also to assess the overall viability of the unconventional gas reservoirs in with a focus on the Southern Pakistan region. We have interviewed a wide range of the key stakeholders that the present in the E&P sector. The objective of using this information is to put forward a strategy framework for addressing our regulatory landscape, technological needs and the recommended practices for business operations in this sector.

3.2 Data Collection Tool

Interviews with academics, regulators, and industry professionals serve as the main source of data. Some of the data is also derived from EIA reports and research publications accessible to the public. The intent of the questions is to collect insightful information on a range of important aspects of the development of unconventional resources. Assessing geological potential, comprehending the legal environment, and determining the necessary infrastructure are important areas of concentration. These organized interviews with a wide range of stakeholders ranging from regulatory policymakers, industry executives to academic specialists are made possible by facilitated these structured interactions and questionnaires. By interacting with parties who possess knowledge of both conventional and unconventional reservoir dynamics.

Quantitative information was also acquired through interviews; examples include average well expenses, EUR per well, frac complete operational details, and other services expense including stimulation of unconventional wells.

3.3 Sampling Design

Qualitative Data Collection: Interviews (10 in Numbers)

Sampling Technique: Purposive Sampling

Purposive sampling is used in our study to choose interviewees. This strategy is used because it will enable the deliberate selection of individual possessing the necessary industrial experience and specialized knowledge pertinent with study objectives. The target is to gather comprehensive,

high-quality insights that is relevant to the particular subjects and intricacies of the development of unconventional gas resources in specially in South of the country. There will be between 10 and 15 participants in the sample size chosen for the interviews. This spectrum was deliberately chosen to provide a variety of viewpoints from the regulatory body, academics, and industry. A comprehensive picture of the industry will be provided by the diversified representation, which will concentrate on a more focused and smaller set of respondents for detailed and comprehensive interviews. Considering the limited time and resources, the sample size is a weigh between completeness and practicality.

3.4 Method for Data Analysis

Both qualitative and quantitative data sets will be included in the data analysis. A thematic analysis will be performed on the qualitative interview material that was gathered. To do this, the replies must be coded in order to spot recurrent themes and patterns. The goals of the research will determine how these themes are mapped. The main goal will be to extract knowledge about the potential, difficulties, and tactical factors governing the exploitation of shale and tight gas plays. Additionally, the lessons learned from the US unconventional resource development path will be cross-referenced with the insights gleaned from the interviews. Finding and extrapolating the relevant best practices and strategies for the regional industry is the goal of this comparative research. The quantitative information gathered through the interviews includes subsurface, commercial and operating indicators. This data, in addition to the inferences drawn through literature review will be utilized to assess the commercial viability and its enablers. The following strategy will be used for mapping of the key themes in subsequent sections:

Table 1: Mapping of the key themes

Research Objectives	Interview Questions	Themes
RO1: Determine the prospects and obstacles associated with the development of unconventional resources in Southern Pakistan, taking into account the region's sub-surface potential, regulatory framework/ policies, and infrastructure.	1. What are the major opportunities in development of unconventional resources in the country?	Energy independence and unconventional opportunities
	5. What challenges are there in large-scale development?	Limitations and Challenges
	6.What is the present regulatory framework for the development of unconventional gas? What are the rewards available to E&P operators?	Regulatory Framework
	12. Since the development of unconventional resources calls for specialized knowledge and methods, such as hydraulic fracturing, What level of expertise, experience, and equipment does the local industry now possess?	Competency building and technological requirements
	2. Does Pakistan have a particular case of unconventional resource development?	
	7. Are existing E&P players in Pakistan interested in developing unconventional resources? Do you agree, disagree, or explain?	
RO2: Devise a practical plan for local E&P industry by adapting and implementing the lessons of US unconventional resource development journey, considering its success variables, infrastructure development, policy framework and technology.	8. The success of the US shale gas industry has opened up new avenues for the exploitation of oil and gas resources. What factors made this journey successful?	North American Unconventional Best Practices
	9. What insights from the US successful shale journey could be applied to local industry?	Lessons learnt for local Industry
RO3: Analyze the feasibility from a business standpoint for E&P operators in Pakistan of developing unconventional gas resources by hydraulic frac	3. There is significant capital expenditure and extended payback time in unconventional development, discuss the considerations for the industry in this case?	Economic Considerations
	10. What are the main cost associated with this development, and why does the US and Pakistani industries have such a large cost difference?	
	4. Is it preferable to develop unconventional gas than to import LNG from international markets?	
	11. How much does it cost to carry out a pilot project and how long does it take to pay for itself? How may the risks associated with this project be reduced? Which regulatory changes would be necessary to make this development possible?	

The results of the qualitative and quantitative analyses are integrated to provide thorough conclusions and suggestions based on the data analyses. This methodology ensures that every facet of the study is catered for, presenting a complete view of the topic.

3.5 Ethical Considerations

The project maintains the relevant ethical guidelines, procedures and standards, guaranteeing the integrity of all participants and the privacy of individual and organizational sources of information. The respondents will be made aware of the aim of research, the extent of their participation, and their will to discontinue participation.

The privacy and discretion of the information gathered will be ensured, data collected, evaluations and results & findings shall be reported impartially. The research constraints or biases, as well as constraints on data collecting, will be openly revealed in the report. Our study respects the rights and welfare of all participants and stakeholders engaged while also ensuring the integrity and validity of its findings by adhering to these ethical standards.

Chapter 4

Analysis & Findings

Following is thematic analysis based on the interviews conducted with industry experts, academia and regulators, this analysis, and themes attributes to main research objectives of the study and

4.1 Thematic Analysis - RO1

Table 2: Thematic Analysis - RO1

Theme	Codes	Interview Extracts
4.1 Energy independence and unconventional opportunities	Energy Self-sufficiency	"We need to leverage these reserves for energy self-sufficiency and more stable energy pricing, this can assist in gaining sustainability and economic growth. “
	Economic Growth Investment Attraction Innovation and Technology	"Industrial expansion, job creation, energy independence, and import reductions are critical economic advancement, the significant potential of unconventional gas development in Pakistan has the opportunity but it is stunted due to multiple factors including political insecurity, complex regulations, lack of technology etc. “
		"Exploiting the shale gas with advanced technologies including drilling and frac could set the path for sustainability in energy economic progress, this needs strategic partnership of the state and E&P operators."
4.2 Limitations and Challenges	Technical Challenges	“There are technical challenges such as subsurface uncertainties, underdeveloped services sector, lack of technological application and regulatory restrictions.”
	Regulatory Barriers Need for Capital Investment	“Main barriers are economic challenges such as circular debt, regulatory framework, poor strategic planning, expensive nature of allied operations and obsolete technologies”
4.3 Regulatory Framework	Regulatory Support & improvement Price Incentives	"A significant revision is required in the current policies. The certification and approval process involves unclear TORs and third-party certifications. There are lengthy approval processes requiring check-in with the regulator at every stage."
	Approval & Certification Process	"The country is buying expensive LNG in upwards of $12-15/mmbtu while the locally offered price for unconventional resources is only a 20-40% premium in 2011 and 2012 policy. This example shows the disconnect in the policymaking and the need for reforms. “

Theme	Codes	Interview Extracts
4.4 Competency building and technological requirements	Technology Transfer	"The potential of our industry in terms of such growth is underdeveloped. Local E&Ps need to set up strategic partnerships with global technology leaders to provide training and develop local expertise."
	Industry Growth and Skill Investment	"With the low levels of the activity, we do not have the required local expertise for horizontal well drilling and multistage fracturing. This is understandable as it will follow the investment and industrial growth trajectory. “
	Strategic Partnerships	
	Expansion challenges	"From what I know UEP has made multiple attempts for breakthroughs in Sember and HP Shale formations in the Mirpurkhas area, resources were tested and confirmed but were not commercial."
	Pilot project Limitation	"There have been active efforts by operators like PPL, POGC, and Mari in the Rehman and Rizq fields. These are a few litmus tests that suggest a growing focus on exploiting tight gas reserves. “
	Operator Efforts and Limitations	"But even with their efforts, the overall contribution to the energy portfolio from tight and shale gas is almost zero, owing to technical and commercial hindrances."
	Development Pace and Challenges	"In the recent past, we have seen baby steps and cautious progress by UEP in exploring the resources in the lower Indus basin... partly due to technological limitations in horizontal wells and multistage hydraulic fracs and partly because of insufficient incentives. “
	Progressive Efforts in Exploration	
		"Other than national oil companies (NOCs), UEP, POGC, ENI, and MOL are operating in this sector. However, their current focus is mainly on conventional projects with easier commercialities."

4.2 Thematic Analysis – RO2

Table 3: Thematic Analysis – RO2

Theme	Codes	Interview Extracts
4.5 North American Unconventional Best Practices	Technological Advancement	"The deregulated market in the US encouraged innovation and diverse investments. There was significant funding of more than $6 billion by the state in R&D in the 1980s and 1990s."
	Efficiency & Cost reduction	"The USA's success in shale gas is a result of impressive technological progress in the 70s and 80s, progressive improvement in subsurface knowledge, a supportive regulatory environment with clear and streamlined policies, and active public-private partnerships that enabled risk hedging in the investment in the early years."
	Government Supportive Policy State Investment in R&D	"Such successful journey is marked with favorable policies, conducive market conditions, and state-supported R&D investments in technological innovations."
	Investment Attraction & Industry Collaboration	"The incremental advancement in the oil field technology including horizontal multistage drilling through a single surface location, massive multistage hydraulic fracs significantly reduced the operational costs."
4.6 Lessons learnt for local Industry	Research and Development (R&D)	"Lessons from the US shale industry which are applicable to Pakistan include active R&D, favorable government policies like tax holidays and royalty incentives. "
	Government Incentives	"Key enablers for our country are government support with policy incentives, capacity building with local expertise to support the service industry and gradually minimizing dependency on international expertise. "
	International Collaboration	
	Strategic Planning	"We need to form strategic collaborations where operators, regulator and academia can support each other with geological data, best practices and technical support to build a well-rounded knowledge base."

4.3 Thematic Analysis – RO3

Table 4: Thematic Analysis – RO3

Theme	Codes	Interview Extracts
4.7 Economic Considerations	Business Certainty	"E&P operators, when dealing with large CAPEXes and long payback periods tend to have higher confidence in the geological certainty, right technological implementation and obviously the economic viability. “
	Collaboration for financial risk sharing	"Joint ventures have been a strategic choice across the globe for E&P operators, this creates an opportunity for sharing the financial load and risk in unconventional projects. “
	Phased Growth Strategy	"No operator would want to invest heavily and end up in a failure and loss of investment, therefore, the companies start with pilot projects in an area with relatively lower risks and then gradually expanding in the periphery of the established resources. “
	Economy of Scale	"The costs mainly include drilling, completion, and fracs. Due to the economy of scale, availability of services and technology, there are significant differences between the operating costs in the USA and our country. “
	Service Sector Development	"Local industry is reliant on international service providers and Schlumberger etc. Their costs vary based on the level and scale of activities they are being offered. “
	Operational cost	"US has technology and economy of scale after years of activity in unconventional resource development. The difference between the operational costs can be well understood with the example of difference between prices offered by a wholesaler and a retailer. “
	Energy independence	"There is a huge outflow of foreign reserves in the need of energy, around 30% goes into energy import... The development of local resources can bridge this gap and bring out economic benefits while supporting the local industry and employment. “
	Cost of LNG Imports	"Importing LNG is inevitable in the current scenario where we can only meet 50-60% of gas demand... However, this reliance can be gradually reduced by investing strategic focus into local resource development to create self-sufficiency."
	Financial Benefits	"Local resources mean minimal capital flight and up to 50% net back to the government in terms of taxes, royalty, and subsequent economic activity of the service sector. “
	Initial Investments and Scale of Operations	"This depends on various factors but as a litmus test, we need to notice that a single stage frac treatment costs up to $0.8 mm in the country (comparatively $0.1-0.15mm in the USA)."
	State Support and Regulatory Environment	"Pilot projects in the Lower Indus Basin would typically need a budget of $20-40 million... the operator should start with less risky prospects and gradually expand further, all while having the required support by state-backed incentives and a friendly regulatory environment."

4.4 Thematic Findings

4.4.1 Energy Independence and Unconventional Opportunities

Unconventional hydrocarbon resources which are yet to be tapped in Pakistan presents a

substantial prospect for the country's future. Based on the USAID study assessment, there is unconventional gas of over 200 TCF that lies underneath. Similarly, another study from EIA in 2013 suggest considerable volumes with estimates of over 105 TCF. Furthermore, coalbed methane (CBM) also poses great opportunity for its development. The formations with fundamental potential are Ranikot, Pab, Chiltan, Ghazij and Sembar within Middle and Lower Indus Basins together with Sulaiman and Kirthar Foldbelt region.

These sources have the tendency to supplement the provision of local natural gas, thereby lessening the import requirement. It is pertinent to understand that even if a small segment of these resources is converted to being economically producible, it would result in significant amount, appreciably decreasing reliance on LNG import. This expansion would establish the assurance for future energy needs, enhance economic growth, provide job ventures, and assist local industries, primarily in the oil and gas sector.

4.4.2 Limitations and Challenges

At present, there are numerous challenges for development of unconventional resources, mainly comprising of technical, infrastructural and unavailability of required advanced technologies in the region. Essential problems include scarcity of sophisticated seismic techniques & allied services required to determine of networks of natural fractures other prolific zones, directional drilling for lateral sections and petrophysical acquisition & interpretation.

The respondents also pointed technical and operational difficulties due to scarcity of frac services in the country. At this point, there is no preference or inclination shown from service companies for getting the essential additional equipment and manpower due to limited business outlook in Pakistan considering the low activity portfolio. Though, if the plan is substantiated with considerable quantity of activity set, global service providers might exhibit tendency & inclination to bring the required services for operations in Pakistan, subject to business growth, investment, and revenue opportunities.

In addition, rigs with high horsepower capabilities are required for managing the drilling of horizontal wells at around 4,000 meters depth. Provision of such rigs comes with enormous cost in the country while there is also scarcity of necessary downhole and completion equipment. The shortage of these tools and the higher associated costs suggests that technology and infrastructure require hefty investment to attain the economy of scale. Focusing on the demand for advanced technology, proficient workforce, and organizational progress will become central to effectively rationalizing the development of unconventional hydrocarbon in the country.

4.4.3 Regulatory Framework

The policy framework for local hydrocarbon industry is surrounded by limitations of the 2011 and 2012 Tight Gas Pricings. The regulations outline strictly defined conditions for formations to be qualified for tight gas pricing entitlement. This includes the failure to flow naturally at measurable rates with standard approaches, the necessity and utilization of complex techniques, and reservoir permeability of less than 1.0 milli Darcy. The respondents highlighted the requirement for reforms in the conditions to offer fair incentive to the operators. PPEPCA is a recognized organization and provides the view that existing policies do not encourage the Operators to an extent that they venture into risky opportunities. This is primarily because incentives are quite low and regulatory complexities do not support the cause either.

Other important issue cited is that certifications by third-party consultants are quite extensive and lengthy, and at times may take up to two years, thus prolonging the whole process. There has been strong suggestion from people who were interviewed that E&P industry should have the authority to manage bidding themselves with a condition to choose a third-party consultant from government approved list. In order to streamline the third-party certification process, it is recommended that the standard document with comprehensive Terms of Reference (TOR) should be pre-approved by the Regulator.

Some critical pieces would incentivize the whole business, particularly offering an attractive gas price for tight gas development and simplifying the regulatory processes. At present, operators do not show intent to take initiatives for Tight gas development, particularly due to complex regulatory approvals. They do not have clarity and assurance for their investment commitments.

The existing Tight Gas Policy of 2011 contains three prong criteria in order to qualify for the Tight Gas Reservoir and Reserve definition, which would eventually lead the field to be allocated with the incentive gas price.

The interviewees proposed that the condition should get relaxed and if 2 out of the 3 criteria outlined in the definition are met, the reservoir/field should qualify for incentives of Tight Gas policy. It was also discovered that the E&P sector in Pakistan in-principal agrees with this modification. The more critical condition in currently prevailing 2011 tight gas policy is the involvement and requirement to seek the Regulator consent at every step during third-party certification process. As discussed earlier, since no pre-approved document exist with terms of reference (TOR) for the certification; therefore, the whole process is prolonged, extensive and cumbersome. The extent of complexity can be understood by the fact that the in certain cases the production from drilled wells was significantly delayed with the overall process taking more than

2 years.

It is advocated that companies in E&P sector should be given the freedom to have their own technical & commercial assessment and assign external consultant out of a preapproved pool. A predefined and structured TOR document for external certification should be provided to the Operators to streamline the certification process. There should be provision that E&P companies are able to directly connect with consultant within the boundaries of approved TOR. There is requirement of individual certification for each well within the same field in existing framework to qualify for the tight gas incentive price, this makes it extremely tedious, complex and time consuming. The recommendation is to break down the process of certification in two-steps, initially after the drilling and encouraging results of exploration well and then during the development stage after the appraisal. This methodology will facilitate the Operators, seeking to get the entire discovery area certified as tight gas field and get around the recurring process after each well. The E&P sector requests to streamline the procedure and make it conducive for Operators with the intention to expedite the tight gas resources development in Pakistan.

To sum up, the current tight gas policy further burdens the operator with GoP having carried interest in tight gas prospects similar to the conventional exploitation. The portfolio economics for tight gas is already marginal, and this condition on operator further consumes its commercial feasibility.

4.4.4 Competency Building and Technological Requirements

Unconventional resource development in Pakistan is primarily deterred due to shortage of home-grown expertise and required technology. Interviewees underlined the necessity for competency growth, principally in hi-tech operations such as sophisticated seismic techniques & allied services required to determine networks of natural fractures & other prolific zones, directional drilling for lateral sections and petrophysical acquisition & interpretation.

To bridge these shortcomings, we need to formalize strategic collaborations with international E&P companies and Service Providers. This would not only facilitate the provision of technology but also the critical exposure and trainings required for effective development of these resources. More importantly, there is absolute need to grow a local service industry with the capability for these sophisticated operations as over reliance on international service companies exponentially increases the expenses. This requires the support from the state in terms of R&D for technological & industrial expansion, competency development of local manpower and policy incentives with beneficial pricing and tax subsidies, particularly during the incipient phases. The respondents also mentioned that such ventures become viable in a longer outlook with large scale

operation and a robust service division which brings in the economic efficiency. They also highlighted that the state needs to provide facilities to the allied industry with subsidized equipment and chemical imports to encourage drilling and fracs operations and healthy activity set for reasonable time.

4.4.5 North American Unconventional Best Practices

In US, the drive for the development of unconventional energy resources was commenced in 70s after the Oil embargo and Arab war. Post these happenings, US recognized the value and necessity to become self-sufficient in energy. Strategies were made and this self-sufficiency was made achievable with the state support encompassing tax holidays, policy incentives along with mammoth funding of $6 billion to different entities in industry and academia for research and development during this period. The research and technological progressed resulted in extensive and profitable utilization of hi-tech operations such as sophisticated seismic techniques & allied services required to determine networks of natural fractures & other prolific zones, directional drilling for lateral sections and petrophysical acquisition & interpretation. Currently, the operators in US employ the most advanced in successful development techniques and achieve commercial production from unconventional reservoirs. They are employing techniques to drill multiple lateral bores from one surface location through controlling trajectories during drilling to reach the optimal target in resource rock. During mid-2000s, which was the early stage of Shale boom; the government even offered prices of around $12-14/mmbtu to facilitate the progress of industry and fasten its development. This created the favorable environment for industry to get the maximum benefit and allowed them to work for exploitation of unconventional resources with “cookie cutter” techniques. Fundamentally, the U.S. voyage and learning of unconventional potential accentuates the value of an encouraging policy structure, research & development, and the economic viability as the core enablers for exploitation of unconventional resource.

4.5 Lessons Learnt for Local Industry

USA, Canada, Argentina, Oman, China and others concentrated on fostering a favorable and investment friendly culture by means of policy incentives, tax holidays, beneficial tariffs in addition to continual technological progress its adoptions on commercial level. Canada capitalized its geographical neighboring with the USA with identical subsurface conditions and progressed while following the similar route. On the other hand, Argentina with massive reserves, also enticed the technology and allied services in late 2000s when the activity in the USA was going thorough financial challenges. Turning towards Middle East, Oman also exploited its enormous potential by creating a conducive ecosystem of the activity, providing attractive tariff while assembling its

state-owned E&P company with BP through tactical collaboration. Turkey initiated the development of its unconventional accumulation considering the accessibility to attractive gas tariffs in EU market. These examples provide evidence that these countries deduced the same ingredients for the benefit of local industry.

Pakistan can also recognize and implement these global models as a steppingstone to meet the demands and requirements for the development of unconventional reservoirs. These examples provide testament that the strategies taken on by the US have effectively been inferred and implemented in other areas of the globe with amendments and improvements as per their regional, governmental, and technological constraints and requirements.

4.6 Economic Considerations

It is revealed in the interviews that the unconventional resource developments generally need significant capital investments and are marked with extended periods of ROI. As a result, the Operators, and more specifically the IOCs looks towards the state and the regulator for setting up an investment friendly environment with favorable policies which address the key issues prevailing in the industry. The notable areas as highlighted in the interviews including streamlining of the approval/certification procedures, tax holidays for initial phases, incentivized tariffs, solutions for circular debt, early revenue from gas sales, and favorable gas pricing structures.

The cost of drilling and completion of a standard unconventional well in the US is markedly less in comparison to the country. The higher capital cost incurred by the local industry is primarily driven from a weak service sector in the local market and resultingly the dependency on external service providers for providing drilling and fracturing services. This is couple with the absence of economies of scale and large costs associated with the equipment mobilization and demobilization,

Considering the local industry, the drilling and completion of a typical conventional well of 3000 meters costs between $10-15 million for commercial production. Such wells on average have the production rates of 15-30 mm ft^3/d. In contrast, drilling a horizontal well to the same depth incurs higher costs with exceed $20 million. Additional outlays for necessary downhole equipment and multistage fracs require another $5-8 million. Despite these substantial costs of $22-25 million for one horizontal well, the estimated production is around 4-6 mmscfd with a projected estimated ultimate recovery (EUR) of roughly 5 billion cubic feet (BCF). Such investments face prolonged payout periods, and yet the Operators around the globe and more specifically in the US take up such ventures knowing that the project would still be viable in the longer run. In the country, the E&P companies would also be willing to proceed with these capital expenditures, but the current

unsupportive regulatory conditions and macroeconomic uncertainties are significant deterrents to these prospects.

Due to the reasons discussed above, there is also a notable disparity between the local Tight/Shale resource horizon and elsewhere around the globe. For instance, the floor price in Oman is reported to be at $2.5/mmbtu, whereas in the local industry, it is approximately $6/mcf. This notable contrast portrays the financial and economic hurdles the local sector faces in comparison to its international counterparts with similar resources. The interviewees also highlight that a higher proposed gas price range of $8-10 per million British thermal units (mmbtu) still lower than LNG imports with spot cargoes priced at $16-18/mmbtu. They also highlight that roughly 40% of the gas price paid would still benefit the state in the form of net backs with taxes and royalties, with the additional benefit of stimulating tax revenue through local oil and gas industry activities associated with the sector.

A suggested increase of 40% over the rates specified in the 2012 policy is based on the economic analysis of comprehensive field development, taking into account the various scenarios and while considering the local industry wide benchmarks of typical operational and capital costs incurred with potential pricing policies of 2009, 2011, and 2012, factoring in the additional incentive percentages. The economic evaluation results provided by an executive of one of the leading IOCs are appended in with his interview responses.

The interview feedback highlight that addressing the obstacles related to policy framework, local skills and expertise, long term vision & strategy is inevitable if the country is to draw local and foreign investments to capitalize on the indigenous unconventional reserves.

Chapter 5

Conclusions & Recommendations

5.1 Conclusions

The goal of the project is to find the crucial opportunities & challenges in the path of exploring and developing unconventional resources in Pakistan, examine important lessons from US shale boom and to evaluate the business feasibility of developing shale/tight resources with the valuable insights from seasoned professional, regulator, and academia. The study conclusions are as followed:

1 There are several studies that shows the greater than 100 TCF potential resource of shale in Pakistan. The E&P companies including National and International calculates ~70 TCF of Tight Unconventional Gas potential in Southern region. Only a few steps have been taken so far, Polish Oil (POGC) is one of the first company that developed a tight gas field and producing ~55 mmscfd. There are certain challenges due to difficult and cumbersome regulatory approvals that is limiting the increase in production which can go up to ~100 mmscfd. The regulators can come forward to amend the policy then this potential can be quickly realized. One of the horizontal wells was tested by PPL in Middle Indus Basin in Nosheroferoz block and the second well in Lower Indus Basin in Gambat South. But the flow from these could only commercialized if the regulator issues incentive prices for tight gas development. United Energy Pakistan (former British Petroleum Pakistan) and its joint ventures also conducted some of the studies and tested some of the wells in Miano and Sawan Area to proof the concept of tight potential. But the full field development of tight gas is waiting from policy incentives because significant upfront capital is required to drill multiple wells and other technologies to bring the commercial production from theses well, according to experts this potential in UEP area can add ~200 MMscfd into the system.

2 The valuable insights and learnings from US shale boom includes stronger support from government, tax benefits and price incentives in initial capital investment of unconventional resources, R&D support, and strong service sector that made breakthroughs in unconventional logging, seismic, technology of hydraulic fracturing, and scale drilling of horizontal wells. Pakistan can adopt the same principles of extended government support, technology imports and establishing strategic alliances to explore the world of unconventional. Another key to the success will be in building competencies of local talent for achieving sustainable accomplishment. The development of strong service sector will bring important technologies

and a healthy consortium can start the activities at the scale level which can lead to a successful shale development in the country by tapping more reserves and adding more production into gas network system.

3 One of important aspect that study reveals that one of the largest E&P operators is considering developing Tight Gas resources with an expected recovery of ~5 BCF per well. High stressed environments and expensive technology and services could cost a tight gas well with frac in the range of $22-25 MM USD, and it will be uneconomical under existing pricing regime of the gas. A horizontal well with multistage frac well would have a breakeven gas price of ~$6/mcf at 15% discount rate. In case, if $7/mcf is paid as incentive price for Tight Gas, approx. ~$5-6 will remain in the country and prevent the capital flight, ~$3 will go back to government in terms taxes and statutory royalties and ~$3 will again be utilized in the subsequent development and stimulate industry to create tax revenue , approx. ~$1-2 will be profit for the company, and if development is done by the National oil company it would remain in the country. It also came to know that ~70% of tight gas is with the National oil companies i.e.PPL and OGDC. This is economically very effective than when compared with LNG where $12 to $14/mmbtu are paid as settled cost of imported LNG.

5.2 Recommendations

The following recommendations would help in unlocking tight and shale unconventional gas potential of Pakistan:

1 One of the first steps is to develop relatively easy tight gas wells and then look for the development of extremely tight shale reservoirs through the combination of same and more advance technologies as the cost of these service are extremely high. Drill more pilot horizontal wells and carryout multistage fracs in tight gas and then use the technology on scale level to bring down the cost of operations. In order to make a breakthrough in this development, advance technologies must be available to the operators at reasonable prices.

2 There is a strong role that government should need to play to assist in importing technologies and should offer a number of incentives to the service sector to support unconventional tight gas activity that includes the duty-free imports of frac, drilling and other allied equipment and frac chemical, also tax breaks for this equipment.

3 The minimum recommended proposed price is the 40% premium in 2012 tight gas policy price. This price should be given to the new fields as well as to the old fields where this price has not been materialized and actual field development has not been done yet, this can bring the required investment in the Tight Gas development.

4 One way to develop quickly these resources is to build local competency, one way is to grow chartered engineers with proper personal development plan and by investment in advanced level trainings for advanced drilling and multistage fracturing design and operations.

5 It is recommended to make strategic alliances with international oil companies for the investment, knowledge sharing and technology transfer. The making of a robust service sector where service companies can benefit by brining efficient and cost-effective technologies and strategic alliance to support that the activity level should be reasonable with at least 20-25 horizontal wells with multi-stage fracs so that cost may bring down.

5.3 Limitation of the Study

Although the research presents valuable conclusions to develop unconventional fields by the application of hydraulic fracturing in horizontal wells but there are some of the limitations that needs to be understood. The research nature is qualitative, and the selected people provided their feedback on their experiences that may limit the applicability of final conclusions and recommendations of this research. Furthermore, due to resources and time limitations, this research will require further in-depth study from regulators, operators and service companies. Significant changes in the regulatory process and other factors could change the findings of this study.

5.4 Research Audience / Stakeholders

This research provides valuable insights for several stakeholders including Oil and Gas upstream Operators and Allied industry, State institutions and regulatory bodies such as Ministry of Energy (MOE), Oil and Gas Regulatory Authority (OGRA), Directorate General of Petroleum Concession (DGPC) and the Academia.

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Appendices

Appendix A: Interview Questionnaire

1. What are the major opportunities in development of unconventional resources in the country?
2. Does Pakistan have a particular case of unconventional resource development?
3. There is significant capital expenditure and extended payback time in unconventional development, discuss the considerations for the industry in this case?
4. Is it preferable to develop unconventional gas than to import LNG from international markets?
5. What challenges are there in large-scale development?
6. What is the present regulatory framework for the development of unconventional gas? What are the rewards available to E&P operators?
7. Are existing E&P players in Pakistan interested in developing unconventional resources? Do you agree, disagree, or explain?
8. The success of the US shale gas industry has opened up new avenues for the exploitation of oil and gas resources. What factors made this journey successful?
9. What insights from the US successful shale journey could be applied to local industry?
10. What are the main costs associated with this development, and why does the US and Pakistani industries have such a large cost difference?
11. How much does it cost to carry out a pilot project and how long does it take to pay for itself? How may the risks associated with this project be reduced? Which regulatory changes would be necessary to make this development possible?
12. Since the development of unconventional resources calls for specialized knowledge and methods, such as hydraulic fracturing, What level of expertise, experience, and equipment does the local industry now possess?

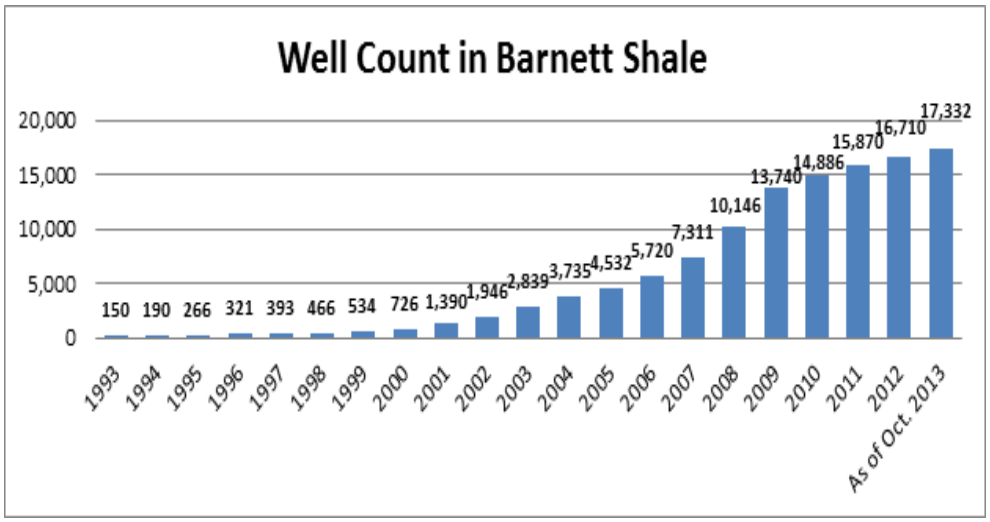
Appendix B: Transcript of Interviews

Interview 1

1. We have significant reserves of unconventional gas, EIA 2015 report estimates them between 586 to 1878 TCF. We need to leverage these reserves for energy self-sufficiency and more stable energy pricing, this can assist in gaining sustainability and economic growth.
2. While there is the intent to pursue the exploration and development of unconventional gas for energy self-reliance and economic progress, the process faces multiple challenges including scarce data, high costs, and regulatory issues. This needs robust government support and technological progress.
3. E&P operators, when dealing with large CAPEX and long payback periods tend to have higher confidence in the geological certainty, right technological implementation and obviously the economic viability. This is generally possible in areas where they already have subsurface knowledge and surface footprint.
4. Unconventional gas development is critical for our energy security and growth of the oil and gas industry. This can potentially lower the energy imports and improve payment balances by reducing the import of fuels. In the longer run this will result in a more reliable and secure energy supply and can also help in the service industry's growth.
5. There are technical challenges such as subsurface uncertainties, underdeveloped services sector, lack of technological application and regulatory restrictions, fiscal disincentives, political and security risks notably in Baluchistan region etc.
6. Pakistan does not have a clear framework for tight/ shale gas, although the 2011 and 2012 Petroleum Policy covers the unconventional resources development aspect.
7. Yes, there are operators like PPL, OGDCL, MPCL, UEPL, and POGC who are operating to exploit the unconventional. But even with their efforts, the overall contribution to the energy portfolio from tight and shale gas is almost zero, owing to technical and commercial hinderances.
8. The US shale gas boom has been possible thanks to technological advancement with capacity building initiatives like in-house training, economy of scale to achieve commercial viability, active governmental support in R&D and policies.
9. Lessons from the US shale industry which are applicable to Pakistan include active R&D, favorable government policies like tax holidays and royalty incentives, development of the

local service industry, technological advancement and building up the local skills and capacity.

10. The costs mainly include drilling, completion and fracs. Due to the economy of scale, availability of services and technology, there are significant differences between the operating costs in the USA and country.
11. The cost and payback period for unconventional gas pilot projects can vary based on multiple factors so there is no universal rule on this. Even for the US, their initial costs while developing the Barnet and Eagle ford shale were very high and lowered down over the years as they scaled up the operations. Learning from there experience we can shrink this timeline for us by utilizing the right technology and leveraging on the regulatory framework.



12. With the low levels of the activity, we do not have the required local expertise for horizontal well drilling and multistage fracturing. This is understandable as it will follow the investment and industrial growth trajectory.

Interview 2

1. We have sizable potential of over 100 tcf, this can give us energy security and help with development of local industry.
2. There have been some efforts by operators like PPL, POGC and Mari in the Rehman and Rizq fields but I think so far no notable example, there are sporadic examples of pilot project only which don't count in my opinion.
3. Need to form static collaborations and target the bigger picture in longer term, as these projects have longer payback times.

4. LNG import only give an immediate relief on energy supply, it is very costly and disturbs our trade balance as it is anchored to the global oil prices. In comparison, the local gas development creates energy autonomy and economic growth. But these needs initial investment and supportive, investment-conducive regulatory environment.
5. Notable challenges are the absence of advanced drilling and fracturing technology, subsurface uncertainties, and an immature regulatory system. Addressing these challenges needs integrated efforts by the government and the industry in technology acquisition, bringing foreign investment, and regulatory reforms.
6. The current regulatory landscape for unconventional gas surrounded with inconsistency and lack of clarity. The existing policies are unclear, unsupportive, and sometimes contradictory. This cannot attract an investor investor's confidence and the growth. The incentives are not well articulated and are very difficult and length y to obtain. It takes years to get approvals and even then, offered pricing are not attractive, given the associated cost of business in tight and shale resources.
7. There are limited activities at this stage while some companies are seeking to develop unconventional resources. Such operators have the Exploration licenses and they have carried out pilot projects in the past also, but progress is slow because of technological and commercial constraints.
8. The USAs success in shale gas is a result of impressive technological progress in 70s and 80s, progressive improvement in subsurface knowledge, a supportive regulatory environment with clear and streamlined policies, and active public-private partnerships that enabled risk hedging in the investment in the early years.
9. Pakistan can follow the US's path by providing a competitive market, promoting the state and private investments through a supportive regulatory environment. As in the case of USA, focusing on R&D and innovation and application of technology fit for local geology can be the key ingredient for our country.
10. The development costs are exploration, drilling, completion, and surface setups. The differences in costing are due to technological gaps and geological uncertainties. The regulatory frameworks are different and unlike US we must rely on imported technology. US unconventional gas industry is operating at economy of scale.
11. Anywhere between $100-$200 million can be cost of such development, with the payback period of several years depending on the productivity and market conditions. The risks can

be mitigated by stakeholder engagement, comprehensive planning, and government incentives.

12. While we have notable potential, the domestic industry is falling short of the required expertise and technology. There is a need to invest in R&D, trainings, and technology to build a capable domestic workforce.

Interview 3

1. Our untapped unconventional gas in the Sember and Ranikot formations can be the key to energy independence and economic progress. The country needs to devise investment friendly policies to bring in overseas investment and technology to capitalize this potential.
2. There have been efforts in the past, as we speak the 2017 Sember Formation pilot project by UEP comes to my mind as I was involved in that.
3. E&P operators in Pakistan are risk-averse due to multiple uncertainties, so they often select projects which have lower risk and larger return potential. There is the preference of investing in ventures with established reserves and capitalizing on the existing infrastructure with only the most needed expansion in the footprint. Local industry needs to engage in technology sharing and risk-sharing agreements on strategic grounds.
4. Aiming for the development of local unconventional gas resources will give out long term benefits of self-sufficiency and economic stability. Although the current energy demand cannot be immediately met thought this, we need to kick start this on the national scale and maintain a balanced strategy while integrating the domestic resource development with LNG imports until we are completely self-sufficient.
5. The stunted and rather nonexistent growth of unconventional resources is due to the expensive nature of allied operations including horizontal wells and hydraulic fracturing. Service companies are reluctant to bring in the right set of expertise and equipment due to lack of activity and overall insecurity in business operations.
6. The policy and regulations are still evolving for the unconventional gas, currently they lack the required clarity and support to the operators. Currently offered incentives are insufficient and cannot attack the operators to invest heavily in this venture.
7. As we speak, there are very few IOCs remaining in the country, besides the NOCs. Even few are the one who have the required financial capability into such ventures. However, PPL, OGDC, Mari and UEP etc. have the plans for development of unconventional gas in their agenda.

8. Such successful journey is marked with favorable policies, conducive market conditions and state supported R&D investments in technological innovations.
9. We need technological innovation and adaptability with state-of-the-art techniques. The approach by the state should be market-driven with flexibility and incentives for private companies. Like the USA, the industry can flourish in the presence of transparent and streamlined regulatory processes and conducive environment.
10. US industry is more established, and operations are scaled for efficiency, and this creates the difference in operating costs. The major capex requirements in Pakistan are higher due to the same reason.
11. Setting up an unconventional resource development project on pilot scale can be around $80-100 million. That entails exploration, lateral bores, fracturing operation and processing infrastructure, this can easily have a payback period of 8-10 years. The Operators can mitigate their risks by getting into joint ventures and choosing areas where can have better handle on the geology.
12. The local industry currently needs active collaboration with international experts, with focused training programs. The local expertise are not adequate and we require competency building in the areas of lateral drilling and staged fracs and unconventional reservoir management.

Interview 4

1. The opportunity lies in exploring the unconventional gas as this also aligns with our aim for energy independence. This can be made possible through the right policies and vision; it could support the economy and reduce import dependency.
2. There have been active efforts by operators like PPL, POGC and Mari in the Rehman and Rizq fields. These are few litmus tests that suggest a growing focus on exploiting tight gas reserves.
3. Joint ventures have been a strategic choice across the global strategic for E&P operators, this creates opportunity of sharing the financial load and risk in unconventional projects, it becomes even more important when targeting unknown subsurface geology and give the luxury to lessen the capital expenditure risks with existing infrastructure of partners.
4. The country cannot afford expensive energy imports and will exhaust its foreign reserves this way, as seen in the recent past also. So, we need to invest in domestic unconventional

gas an only this can eventually give out energy independence and lower long-term energy costs.

5. Main barriers are economic challenges such as circular debt, regulatory framework, poor strategic planning, and obsolete technologies.
6. A significant revision is required in the current policies. The certification and approval process involves unclear TORs and third-party certifications. There are lengthy approval process requiring check-in with the regulator at every stage. This slows down the process and a foreign investor then prefers to move toward easier projects.
7. Other than national oil companies (NOCs), UEP, POGC, ENI, and MOL are operating in this sector. However, their current focus is mainly on conventional projects with easier commerciality.
8. The deregulated market in the US encouraged innovation and diverse investments. There was a significant funding of more than $6 billion by the state in R&D in the 1980s and 1990s. The offered price in the initial years were as high as $12-14/mmbu to attract the industry. These were the enablers for the mid-2000s shale gas boom.
9. The industry needs a long-term strategic planning which should include a clear and stable legal framework to encourages activity, the stakeholders should focus on strategy rather than short term business objectives.
10. Pakistan is yet to develop a competitive service market, adopt the existing global technologies and scale the operations at a level where operating costs come down. For the US, they have been through this phase already and we can learn from there example.
11. This can vary greatly because of terrain and geological conditions but typically such a project would need $100 million with a multi-year payback period. Risk for the E&P companies can be addressed through strategic alliances and joint ventures. The regulatory reforms for early stages would also be critical to facilitate project feasibility.
12. With very few companies having prolific outcomes from the journey so far, the local expertise remains limited in terms of unconventional resource development. We will need to rely on international expertise until we develop our own.

Interview 5

1. Exploring the shale gas with advanced technologies including drilling and frac could set the path for sustainability in energy economic progress, this needs strategic partnership of the state and E&P operators.

2. There has been some activity in tight formations like Pab and Ranikot by PPL and Sembar by UEP, but they were small scale and only pilot in nature. We are yet to see large-scale unconventional gas projects in the country.
3. IOCs and NOCs can invest in unconventional resources if given the right incentives through government policies including the subsidies or tax breaks. The feasibility depends on state-of-the-art technology, expertise of local workforce and stable political conditions. No company can make it possible without a diversified project portfolio for risk mitigation and return optimization.
4. LNG imports is only a quick band-aid energy solution and lacks sustainability. This creates exploitation of our country at the mercy of international market movement. There is an ever-growing need of gradually shifting the focus on targeting indigenous resources and Tight/Shale resources are still untapped.
5. Notable challenges are the need for large capital, lengthy ROI period, and an unfavorable regulatory environment which doesn't support the smooth scaling up of unconventional projects, so much so that the approvals sometime take 1-2 years and until the project cannot move ahead. Other challenges are a lack of skilled workforce and primitive technologies available in the country.
6. To get the tight gas policy awarded, every well of the prospective field needs to be certified individually, the time and effort it can take will never encourage any investor.
7. The current industry dynamics is signaling a shift towards diversifying the energy mix. While there are numerous challenges, both local and foreign operators are having a plan to tap the unconventional gas in Pakistan.
8. The oil industry was already very mature in late 19th century when the early activity in unconventional resource started. This has been an incremental journey, and nothing has been possible without due efforts. the industry fully supported the state initiative to create specially after the Oil Embargo in 1970s. With its established infrastructure and expertise, USA achieved the successful development of its shale gas sector.
9. Key enablers for our country are government support with policy incentives, capacity building with local expertise to support service industry and gradually minimizing dependency on international expertise.
10. Due to the limited equipment availability for deep/ horizontal drilling and multistage fracs (single fleet of Slb currently available) and absence of local expertise, there is a need for initial investment which in turn increases the operating costs of any such project. The

whole process is initiated with costly seismic activity for an extensive exploration, only after which the drilling, completion, and production operations can follow. We at UEP conducted detailed economics evaluation while covering the possible cases and using the local industry benchmarks costs, the outcomes show that any price below $6-8 per mmbtu does not meet commercial viability (provided results of economic assessment which are attached), this presently discourages the operators. Its critical to understand at the policy level that offering a supportive pricing to local operators is much better than LNG import at $16-17. Activity in local industry give out economic net back of ~40% in the form of taxes and royalties. With almost half of the per mmbtu price effectively returned to the state, a mutually beneficial situation for the nation, consumers, and the gas industry can be fostered.

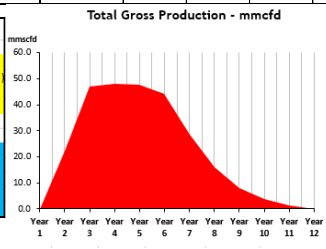
Economics Input Parameters	Unit	Base	High	Low	Sensitivity
Production (Sales gas) & Reserves					
Approx Reserves for the field	bcf	100	120	80	
Average Reserves per well (including dry hole)		5.8	7.0	4.6	
Number of Wells		17	17	17	
Starting flow rate / Reserves	mmcfd	8.0	9.6	6.4	
Monthly decline rate	%	4.0	4.0	4.0	
Ending flow rate per well	mmcfd	0.5	0.5	0.5	
ELT		When cash flow becomes negative			
Capex					+ / - 20%
Horizontal or High Angle Well with Multi-stage fracs	$MM	20.0	20.0	20.0	
50 mmcfd Plant (CO2 below 8% assumed)	$MM	50.0	50.0	50.0	
Opex					+ / - 20%
With 2% Inflation	$/boe	3.5	3.5	3.5	
Well intervention per well every 3 years	$MM	0.2	0.2	0.2	
Minimum Opex in a year	$MM	2.0	2.0	2.0	
Price Cases					
Brent	$/bbl	50.0	50.0	50.0	Brent $35 and $65 per bbl
2009 Policy +40%	$/mmbtu	4.92	4.92	4.92	
2012 Policy +20%	$/mmbtu	5.34	5.34	5.34	
2012 Policy +40%	$/mmbtu	6.23	6.23	6.23	
Others					
Cashflows calculated on a pre-tax basis					
Royalty assumed at 12.5% - no other PCA obligations assumed					
Past expenditure not factored in (Sunk cost: Seismic, studies, etc.)					
All Cashflows assumed mid year					
No liquids have been assumed					

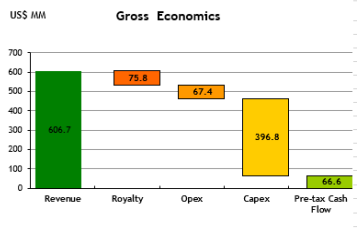
Sensitivities Summary	Case Name	Gas Price ($/mmbtu)	Capex ($MM)	Net Present Cost ($MM)	NPV10	IRR	NPV10/ NPC	Breakeven Price ($/mmbtu)	Breakeven Capex ($MM)	NPV15 ($MM)
Case 1	Base Case at $50 Brent for 2009 Policy +40%	4.97	396.8	317.0	(79.8)	-5%		6.4	313.1	(89.6)
Sensitivities	High Capex - Plus 20%		476.2	380.4	(143.2)	-13%				(147.2)
	Low Capex - Minus 20%		317.4	253.6	(16.4)	6%				(32.0)
	High Opex - Plus 20%				(88.2)	-7%				(96.6)
	Low Opex - Minus 20%				(71.5)	-4%				(82.7)
	$35 Brent	4.39			(112.6)	-12%				(116.9)
	$65 Brent	5.47			(51.7)	0%				(66.2)
Case 2	Base Case at $50 Brent for 2012 Policy +20%	5.33	396.8	317.0	(59.5)	-1%		6.4	334.4	(72.7)
Sensitivities	High Capex - Plus 20%		476.2	380.4	(123.0)	-10%				(130.2)
	Low Capex - Minus 20%		317.4	253.6	3.9	11%	2%			(15.1)
	High Opex - Plus 20%				(67.9)	-3%				(79.7)
	Low Opex - Minus 20%				(51.2)	0%				(65.7)
	$35 Brent	4.33			(116.0)	-13%				(119.8)
	$65 Brent	5.93			(25.6)	5%				(44.4)
Case 3	Base Case at $50 Brent for 2012 Policy +40%	6.22	396.8	317.0	(9.3)	8%		6.4	387.0	(30.8)
Sensitivities	High Capex - Plus 20%		476.2	380.4	(72.8)	-1%				(88.4)
	Low Capex - Minus 20%		317.4	253.6	54.1	22%	21%			26.7
	High Opex - Plus 20%				(17.7)	7%				(37.8)
	Low Opex - Minus 20%				(1.0)	10%				(23.9)
	$35 Brent	5.06			(75.2)	-4%				(85.8)
	$65 Brent	6.92	396.8	317.0	30.2	15%	10%			2.2

Development Plan	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Number of wells	3	4	3	3	3	1
Plant Cost	50%	50%				
Plant Commisioned		1-Jul				

Reserves Per Well 5.8 bcf
Reserves for Field 100 bcf
Starting production rate 8 mmcfd

Inputs & Results	
Inputs	
Capex ($ Million)	Base
Opex ($/boe)	Base Opex (3.55/boe)
Brent Price ($/bbl)	50
Policy Price	2012 Policy +40%
Results (Linked)	
NPV 10 - $ Million	(9.3)
NPV 15 - $ Million	(30.8)
IRR	8%
Discounted Payback (Number of Years)	N/A
NPV 10 / Net Present Cost (Capex)	N/A





11. A horizontal well can cost up to $20-22mm, downhole completion will be another $5mm, then typically a 10 stage frac would be $3-4mm, this means that a single well would be of $30 mm. with typically 5-7 mmscfd production (typical of horizontal multistage tight gas wells), the payback will be at least 8-10 years. But as the operations scale up, the costs will come down significantly, in the US, such a well would cost significantly lower.
12. We have limited technical resources, but same has been the case with other nations of the world who embarked on this journey, this includes South Americas, Middle East, and Even China. Gradually they built up they local competency.

Interview 6

1. Targeting and developing our unconventional gas reserves is critical to expand the energy portfolio and meet the ever-growing energy demand.
2. Mari (MPCL) targeted the Zarghun South field within the Chiltan Limestone and gained some encouraging results also, unfortunately the project could not be expanded to large scale.
3. The operators target the opportunities to adopt advanced research and development to lower down operational costs to achieve economic viability of unconventional resources, for a balanced project portfolio. The state needs to provide a conducive environment also.

4. There is a huge outflow of foreign reserves in the need of energy, around 30% goes into energy import. For a country with dwindling foreign reserves, LNG import is never a wise option. The development of local resources can bridge this gap and bring out economic benefits while supporting the local industry and employment.
5. Dominant issues are the absence of long-term strategic planning and overall political uncertainty, if this gets resolved, things will automatically start improving.
6. The current 2011 and 2012 policies provide insufficient support to the operator while demand for stringent regulatory compliance at the same time. There needs to be a balance between the two. For example, the certification process involves third-party certification without a predetermined TOR and with delays in approval process. A better approach can be the flexibility to select consultants from a pre-approved. Likewise, a pre-approved, standardized TOR by the regulatory body can fast track the process. Tight Gas Policy 2011 needs a three-step criterion for the classification of the resources to be tight and calls for individual certification of each development well in the same field.
7. The focus on unconventional resources is relatively lower compared to the conventional oil and gas projects. This is obviously due to prevailing challenges around commerciality and regulatory constraints as well as political scenario.
8. Technological advancement through active R&D, state support, conducive market conditions and well-developed local industry were the key enablers.
9. Just like the USA, the state and NOCs can set up the example by leading from the front for international oil companies to follow. If we implement tax incentives and provide infrastructure support to lessen costs and attract international investment, we can scale up the development of these resources.
10. The US is much ahead of us in the learning curve where initial R&D investment, setting up of service sector and economy of scale are well-established and these have enabled more cost-efficient operations. Compared to our case, the cost variances are attributed these factors
11. This will involve phased investment of up to $200mm, given the current scenario, no operator would like to invest individually in such a project so partnerships and joint ventures can be of help for risk management.
12. Technology transfer and knowledge sharing from developed markets will be our key in the initial phase, with time this can get improved as the current expertise are in nascent stage.

Interview 7

1. Industrial expansion, job creation, energy independence and import reductions are critical economic advancement, the significant potential of unconventional gas development in Pakistan has the opportunity but it is stunted due to multiple factors including political insecurity, complex regulations, lack of technology etc.
2. We currently don't have quotable examples of large-scale unconventional gas developments, there are only small-scale pilot projects by different IOCs and PPL also.
3. The companies around the globe prefer an integrated development, merging the development of the unconventional resources with conventional project to benefit from existing footprint and surface facilities, this maximizes the efficiency and economic gain.
4. Local resources can supply steady energy at predictable pricing and drive the economic progress, thus lowering the reliance on LNG imports, until then it is the only available solution.
5. A multipronged and diverse strategy including regulatory reforms to attract investment, workforce and expertise development is needed to address the challenges at hand which are obviously stemming out of the current situation.
6. The significant barrier to both conventional and unconventional project developments, which discouraging foreign investment is the challenging regulatory environment, with slow approval processes and complicated licensing procedure.
7. Yes, there are OICs like UEP and POGC etc. whose track record shows interest in unconventional resource development. But we need to understand that any significant activity will be depending on better regulatory regime and commercial certainty.
8. The success in the US catalyzed by conducive policy making regarding mineral rights, this encouraged landowners to permit drilling on their lands just like a farmer is free to choose cultivation on his land. With this, deregulated market boosted economic activity and attracted huger investment from the local and European E&P companies in 70-80s.
9. We need to form strategic collaborations where operators, regulator and academia can support each other with geological data, best practices, and technical support to build a well-rounded knowledge base. The operators also need to go into joint ventures for risk management in the portfolio just like they do in the case of conventional resources.
10. The costs are always higher for pilot projects and early stages of development with geological understanding limited operations. Same has been the case with the US in early years but now they operate at an economy of scale, which Pakistan lacks, particularly in deep rigs and fracturing equipment.

11. Costs for unconventional gas projects in Pakistan can be from $20-30 million to $100 million, typically with much longer payback compared to the conventional ventures. There is a need of regulatory reforms reducing bureaucratic procedures to attract investment.
12. The industry and academia need to focus on R&D and skill development and the state should support just in the case of USA. We need more of the international partnerships and joint ventures which can aid in learning from the existing experience of the industry.

Interview 8

1. Unconventional gas exploration can bridge the current gap between supply and demand by increasing the production. This can be achieved through innovation, foreign investment and establishing a thriving energy sector through technology and policy reforms.
2. OGDC targeted Kunar and Hala fields where they attempted frac in Talhar Shale but could not succeed due to equipment limitation.
3. The prudent development strategy is a phased approach, starting with the pilot projects to assess the workability and subsequently going ahead with scaling the business operation and activity in the unconventional resources.
4. Development of local resources, especially unconventional ones will need significant investment and strategic focus compared to simply importing energy, but in longer term it will give out its merits and advantages.
5. There has been political volatility and insecurity since we can remember, the largest province is virtually untapped (saving few earlier discoveries) due to security concerns. Foreign investors are divesting business operations. To make things worse, there is a non-supportive policy framework. All this adds up to investment uncertainties in the unconventional gas sector and these are the challenges at hand.
6. The country is buying expensive LNG in upwards of $12-15/mmbtu while the local offered price for unconventional resource is only 20-40% premium in 2011 and 2012 policy. This example shows the disconnect in the policy making and the need for reforms.
7. Currently, the industry faces technical and market challenges due to lack of technology, underdeveloped service sector and policy issues. The operators recognize the strategic importance of tapping the untapped resources to stay in the business but that the same time,

the policy makers also need to realize that long term energy security is only possible if the local resource is developed through enabling and facilitating the local industry.

8. The Oil embargo in 70s led to US's realization of the need to create energy self-reliance. This was the kickstart of the subsequent strategic efforts supported by state and industry collaboration, to target local resources rather than relying on the OPEC oil.
9. We know that the Thar coal project only progressed after state support and conducive policies. Such was the case with the US journey. Hence the industry needs a focused state-level support in all aspects on developing the untapped resources. This would call for investment in R&D and setting up supportive policies from the early stages.
10. The comparison is not pertinent as they currently have entirely different industry dynamics, they produce over 100 bcf of gas per day and more than 600 rigs operate at any given day. This huge difference in the scale of activity is the reason of difference in operating cost.
11. Such ventures need substantial financial capex with costs varying based on multiple factors, there is no fit for all response in this case.
12. This area follows the same path as of the business operations, as the business operations grow, the local expertise the developed. However, a focus on this can of additional help as it will lower down the operating cost and reduce reliance on service industry from international market.

Interview 9

1. As per EIA 2013, Pakistan has about 9 billion bbl and 105 trillion cf of shale gas, not to mention coalbed methane prospects. These resources stand as cornerstones for energy autonomy and sustainable growth.
2. From what I know, UEP has made multiple attempts for breakthroughs in Sembar and HP Shale formations in the Mirpur Khas area, resources were tested and confirmed but was not commercial.
3. No operator would want to invest heavily and end up in a failure and loss of investment, therefore, the companies start with pilot projects in area with relatively lower risks and then gradually expanding in the periphery of the established resources, so this is a gradual and phased growth strategy.
4. Importing LNG is inevitable in the current scenario where can only meet 50-60% of gas demand of 5-6 bcf through local resources, stopping its import means shutting down the

remaining industry. However, this reliance can be gradually reduced by investing strategic focus into local resource development to create self-sufficiency.

5. The main problem is ineptitude for improvement and lack of vision. All other problems are the offshoot of these.
6. The policy framework slowly improving we hope to get the new tight gas policy approved which offers better operability for both government and E&P companies. The policy draft has been presented to the ministry by the PPEPCA and is currently under review. It asks to simplify the certification process as well as offer better incentives.
7. In the recent past, we have seen baby steps and cautious progress by UEP in exploring the resources in the lower Indus basin. There have been mixed results and the projects have not been scaled up as yet, partly due to technological limitation in horizontal wells and multistage hydraulic fracs and partly because of insufficient incentives.
8. The incremental advancement in the oil field technology including horizontal multistage drilling through single surface location, massive multistage hydraulic fracs significantly reduced the operational costs. As result, this made the operations economically viable and made the production of gas from challenging sub-darcy reservoirs possible.
9. A well setup industry, large base of service sector, favorable policies and long-term vision enabled USA, same are the required ingredients for our industry.
10. Local industry is reliant on international service providers and Slb etc. There costs vary based on the level and scale of activities they are being offered, currently they only have one frac fleet in the country and that too is outdated with obsolete technology. We can stop relying on foreign service industry once we develop the local skills and expertise. With this, the operating costs can be brought down.
11. Pilot projects in the Lower Indus Basin would typically need a budget of $20-40 million. There would be a need of a phased approach where the operator should start with less risky prospects and gradually expand further, all while having the required supported by state-backed incentives and a friendly regulatory environment.
12. The skills and expertise are elementary in nature, especially in the Operating sector because none of the Operators have a proven track record of unconventional resource development. The Sector operates on such a model that they can bring in the required resources in terms of equipment as well as workforce as an when required by the local industry.

Interview 10

1. The development of unconventional gas resources could spur economic growth, attract investments, and generate employment across several sectors. Engaging with international expertise and fostering a conducive investment climate is key.
2. OMV, which has now divested from Pakistan previously targeted Hot Sands in the Miano region and established the presence, now the asset is with UEP and ENI and they have recently made attempts.
3. In such cases which need large initial capex and have delayed paybacks, the operators target the resources which lie in the vicinity of existing infrastructure to create synergy and optimization.
4. LNG prices are volatile, and market driven. Spot agreements result in up to $16-18/mmbtu and even long-term agreements don't guarantee energy security. Just recently, the country must go into international court against and LNG supplier which violated the contract and sold the commodity to a different buyer at higher profits (identity asked not to disclose). On the other hand, local resources mean minimal capital flight and up to 50% net back to the government in terms of taxes, royalty and subsequent economic activity of service sector.
5. The overall E&P industry is very small in size and magnitude of operations. No individual operator including NOCS, and IOCs can bring the required change alone. The challenges of dis economy of scale, lack of investment, outdated technology, unskilled local workforce etc. need a collaborative solutions involving multiple stakeholders including government and industry.
6. There is a significant room for improvement and streamlining the current policy framework and only this can draw foreign direct investment and encourage local players. The Tight Gas Policy 2011 and subsequently 2012 was developed fail to nurture the development of tight gas and lack support in specific policies, guidelines, taxation, and pricing structures.
7. We see a growing trend exploring the unconventional resources in Pakistan over the years, as the large conventional pools like Sui, Mari, Qadirpur etc. have matured. In IOCs, particularly UEP has been actively engaged activity and liaising with the ministry for policy adjustments.
8. US has he culture of innovation and willingness to take risks, as they say, "The Land of the free and the home of the brave", this was also the case in the US energy sector. They

also capitalized especially during the period of high oil prices in the early 2000 and made considerable investment in shale exploration.

9. We lack in strategic planning and vision, and one end the foreign investment is leaving the country due to difficulties in doing business, on the other end the state is spending heavily on energy import. If we could synergize the policies and the same or even lower spending could be done to nurture local unconventional industry through policy incentives, we can be successful.
10. US has technology and economy of scale after years of activity in unconventional resource development. The difference between the operational costs can be well understood with the example of difference between prices offered by a whole seller and a retailer.
11. This depends on various factors but as a litmus test, we need to notice that a single stage frac treatment costs up to $0.8 mm in the country (comparatively $0.1-0.15mm in the USA). Consider having to carry out a 10 stages frac in a single well and consider having at least 4-5 wells in an unconventional field development project.
12. The potential of our industry in terms of such growth is underdeveloped. Local E&Ps need to set up strategic partnerships with global technology leaders to provide trainings and develop local expertise for the years to come. The state also needs to devise a well deliberated framework that promotes skills and technology transfer to local industry.

Authors' Introduction

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Dissertation	☐
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Sign Page	☒	
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List of Figures	☒	
Executive Summary	☒	
Chapter Format	☒	
Running Title	☒	
References	☒	
Other	☐	

ADDITIONAL COMMENTS

All above contents of the research project were found in compliance to the approved format.

OFFICIAL NOTES

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