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MASTER THESIS

**THE ROLE OF THE ENERGY SECTOR ON THE
ECONOMIC DEVELOPMENT IN YEMEN**

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İSTANBUL-2023

ABSTRACT

THE ROLE OF THE ENERGY SECTOR IN ECONOMIC DEVELOPMENT IN YEMEN

Zaid HANNAF

This dissertation examines the role of the energy sector in Yemen's economic development by using a descriptive analysis method to examine and describe the characteristics of the data being analyzed. The study reveals the critical role of the oil sub-sector in supporting government revenues, which are closely tied to oil prices. However, declining oil production and underutilization of natural gas pose challenges to sustainable economic growth. The Granger causality tests revealed that the exchange rate (LEXR) exhibited unidirectional Granger causality with the logarithm of oil price (LOP), suggesting that changes in exchange rate can predict changes in oil prices, changes in the inflation rate can predict changes in exchange rate, changes in foreign direct investment can predict changes in the exchange rate and foreign direct investment can predict changes in the inflation rate. These findings contribute to a better understanding of the interrelationships between macroeconomic variables in Yemen and have implications for policymakers seeking to manage and stabilize the economy. The gas sector shows potential as an alternative revenue source, but contract negotiations and corruption hinder its full utilization. Yemen's renewable energy potential, particularly solar and wind energy, could reduce reliance on fossil fuels, but political conflicts impede progress. The energy sector's performance directly affects the overall economy, impacting unemployment, exchange rates, inflation, and foreign direct investment. These findings contribute to policymakers' understanding and have implications for managing and stabilizing Yemen's economy.

Keywords: Energy sector, Economic development, Oil sub-sector, Gas sector
Renewable energy.

ÖZ

YEMEN'DE ENERJİ SEKTÖRÜNÜN EKONOMİK KALKINMADAKİ ROLÜ

Zaid HANNAF

Bu tez, analiz edilen verilerin özelliklerini incelemek ve tanımlamak için betimsel bir analiz yöntemi kullanarak enerji sektörünün Yemen'in ekonomik kalkınmasındaki rolünü incelemektedir. Çalışma, petrol fiyatlarına yakından bağlı olan hükümet gelirlerinin desteklenmesinde petrol alt sektörünün kritik rolünü ortaya koymaktadır. Ancak, petrol üretimindeki düşüş ve doğal gazın yeterince kullanılmaması sürdürülebilir ekonomik büyümenin önünde engel teşkil etmektedir. Granger nedensellik testleri, döviz kurunun (LEXR) petrol fiyatının logaritması (LOP) ile tek yönlü Granger nedenselliği sergilediğini ortaya koymuştur; bu da döviz kurundaki değişikliklerin petrol fiyatlarındaki değişiklikleri, enflasyon oranındaki değişikliklerin döviz kurundaki değişiklikleri, doğrudan yabancı yatırımdaki değişikliklerin döviz kurundaki değişiklikleri ve doğrudan yabancı yatırımın enflasyon oranındaki değişiklikleri tahmin edebileceğini göstermektedir. Bu bulgular, Yemen'deki makroekonomik değişkenler arasındaki karşılıklı ilişkilerin daha iyi anlaşılmasına katkıda bulunmakta ve ekonomiyi yönetmek ve istikrara kavuşturmak isteyen politika yapıcılar için sonuçlar doğurmaktadır. Gaz sektörü alternatif bir gelir kaynağı olma potansiyeli taşımaktadır, ancak sözleşme müzakereleri ve yolsuzluk bu potansiyelin tam olarak kullanılmasını engellemektedir. Yemen'in yenilenebilir enerji potansiyeli, özellikle de güneş ve rüzgar enerjisi, fosil yakıtlara olan bağımlılığı azaltabilir, ancak siyasi çatışmalar ilerlemeyi engellemektedir. Enerji sektörünün performansı ekonominin genelini doğrudan etkileyerek işsizlik, döviz kurları, enflasyon ve doğrudan yabancı yatırımları etkilemektedir. Bu bulgular politika yapıcıların anlayışına katkıda bulunmakta ve Yemen ekonomisini yönetmek ve istikrara kavuşturmak için çıkarımlarda bulunmaktadır.

Anahtar Kelimeler: Enerji sektörü, Ekonomik kalkınma, Petrol alt sektörü, Gaz sektörü Yenilenebilir enerji.

ACKNOWLEDGMENTS

This dissertation presents a comprehensive overview of the energy sector in Yemen, covering all elements of the sector including oil, gas, electricity, and renewable energy resources. In contrast to other studies that may focus on only one sub-sector of energy, such as oil, electricity, or renewable energy, this study examines the role of the entire energy sector in economic development by considering all energy variables in the economic growth process.

The structure of the dissertation divided to three parts. The first part, presents an overview of the current state of Yemen's energy sector and identifies in details the main energy resources in Yemen with its statistics and trends. Additionally, the end of this part outlines the contribution of fossil fuel and renewable resources in electricity and that will be addressed throughout the thesis. The second part, introduce the concept of economic development and the role of energy sector in sustainable development. This part also suggests to use alternative free-carbon fossil fuel resources instead of carbon fossil fuel resources for the purpose of increasing the government revenues and reducing CO₂ emissions. The third part, the empirical part which studies the role of fluctuating oil prices in Exchange rate (EXR), Inflation rate (INFR), Gross Domestic Product GDP and Foreign Direct Investment (FDI) and explain the methodology of collecting data and the hypothesis.

I would like to dedicate this work to my father, who has passed away, and to my mother, who has always been a source of the strength for me. I would also like to thank my wife, who supported me through difficult times, and my children Retag and Muhammed, who bring me pleasure also, I very much appreciate the efforts of my Supervisor Assist. Prof. Dr. Billur Engin Balin.

Zaid HANNAF

ISTANBUL, 2023

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ACRONYMS

BBL(S)	: A barrel of crude oil
CBY	Central bank of Yemen
EIA	: Energy Information Administration (US)
EXR	: Exchange Rate
FDI	: Foreign Direct Investment
IMF	: International Monetary Fund
INFR	: Inflation Rate
GDP	: Gross Domestic Product
GOVT	: Government
GFS	: Government Finance Statistic
GSS	: Gas Sub-Sector
LCOE	: Levelized Cost of Energy
MOF	: Ministry of Finance
MCF	: Million Cubic Feet
M.T	: Million Tons
MV	: Megavolts
MMTPA	: Million Metric Tons per Annum
OP	: Oil Price
O&G	: Oil and Gas
OR	: Oil Revenues
OSS	: Oil Sub-Sector
PEC	: Public Electricity Corporation
SR	: State Revenue
TCF	: Trillion Cubic Feet
T.M	: Ton Meter
Y	: Yemen
YR	: Yemen Rial Currency
YCSO	: Yemen Central Statistic Organization
YP	: Yemen Parliament

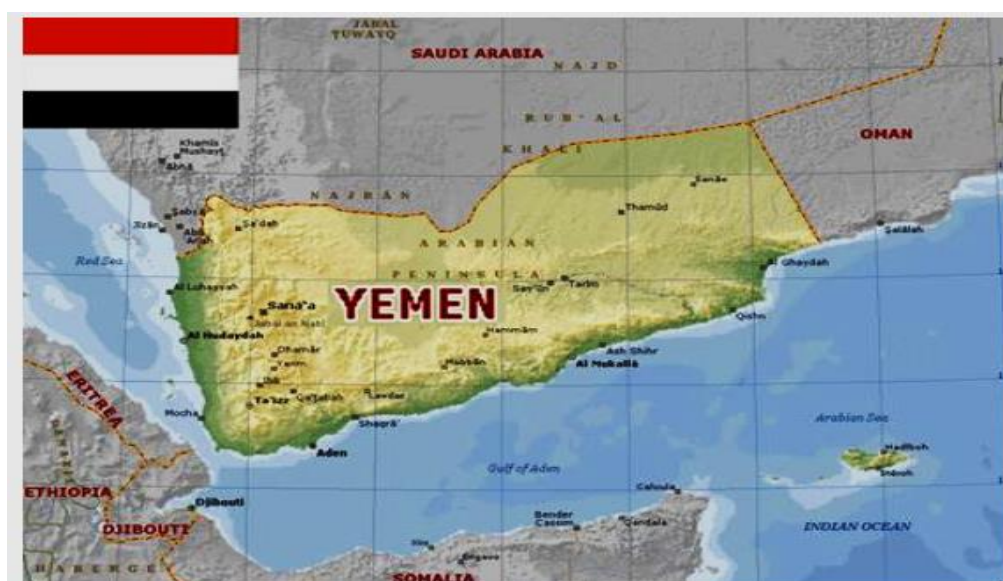
YCSO : Yemen Central Statistic Organization
YOGC : Yemen Oil and Gas Corporation
MOM : Ministry of Oil and Minerals
YGC : Yemeni Gas Company

UNITES OF MEASUREMENTS

Barrel	158.9872 Liters
Barrel	5.6146 Cu.ft
Cubic foot	28.32 Liters
Cubic Meter	35.314 Cu.ft
Cubic Meter	6.2898 Barrel
Meter	3.281Ft.

Petroleum Products	M.Ton	Barrel	Liter
Gasoline	1	8.77	1395
Jet-1 (Kerosene)	1	8	1272
Kerosene	1	8	1272
Diesel	1	7.55	1200
Mazot. (Fuel oil)	1	6.66	1059
LPG	1	11.8161	1887.7

1Ton of LPG is Equivalent to 86 Cylinders of 11.5 Kg. Capacity.



INTRODUCTION

The energy sector is a crucial component of modern society, as it is responsible for the production and distribution of energy sources that power our homes, businesses, and transportation systems. There are several different types of energy sources, including fossil fuels (such as coal, oil, and natural gas), nuclear energy, and renewable energy sources (such as solar, wind, geothermal, biomass and hydroelectric power). The energy sector has undergone significant changes in recent years, as governments and organizations around the world have increasingly recognized the need to shift away from fossil fuels and towards renewable energy sources. This shift has been driven by concerns about climate change and the negative environmental impacts of fossil fuels, as well as the need to reduce dependency on non-renewable resources. There are many challenges facing the energy sector today, including the need to balance the demand for energy with the need to protect the environment and reduce greenhouse gas emissions. The development of new technologies, such as renewable energy sources and energy storage systems, is also an important area of focus for the energy sector. Overall, the energy sector plays a vital role in modern society and economic development becomes a subject of ongoing research and discussion.

Doing my study is to show the impact of available energy sources in Yemen on the pathway of economic development and clarify the relationship between the different energy segments and the energy sector to link them by the Yemeni Government for a sustainable development period post-conflict.

The structure of the dissertation divided to three parts as follow:

- **Part 1** presents an overview of the current state of Yemen's energy sector and identifies in details the main energy resources in Yemen with its statistics and trends. Additionally, the end of this part outlines the contribution of fossil fuel and renewable resources in electricity and that will be addressed throughout the thesis.
- **Part 2** introduce the concept of economic development and the role of energy sector in sustainable development. This part also suggests to use alternative free-carbon fossil fuel resources instead of carbon fossil fuel resources for the purpose of increasing the government revenues and reducing CO2 emissions.
- **Part 3** the empirical part which studies the role of fluctuating oil prices in Exchange rate (EXR), Inflation rate (INFR), Gross Domestic Product GDP and Foreign Direct Investment (FDI) and explain the methodology of collecting data and the hypothesis.

Research Questions

- What are the potential and contributions of the oil sub-sector for supporting the revenues of the Yemeni government?
- Is the gas commodity a potential alternative energy source to oil for meeting the energy demand of the Yemeni domestic market and contributing to the budget of the Yemeni government?
- What are the alternative renewable energy sources that can be utilized in Yemen instead of relying on fossil fuels?
- What is the role of the energy sector in shaping the macroeconomic landscape and driving economic growth in Yemen?
- Do the fluctuations of the oil prices in the international market affect the Exchange rate (EXR), Inflation rate (INFR), Real Gross Domestic Product RGDP and Foreign Direct Investment (FDI) in the economic development of Yemen?

Hypotheses:

H0: Fluctuations in oil prices have a significant impact on the exchange rate in Yemen.

H1: Fluctuations in oil prices do not have a significant impact on the exchange rate in Yemen.

H0: Fluctuations in oil prices have a significant impact on the inflation rate in Yemen.

H1: Fluctuations in oil prices do not have a significant impact on the inflation rate in Yemen.

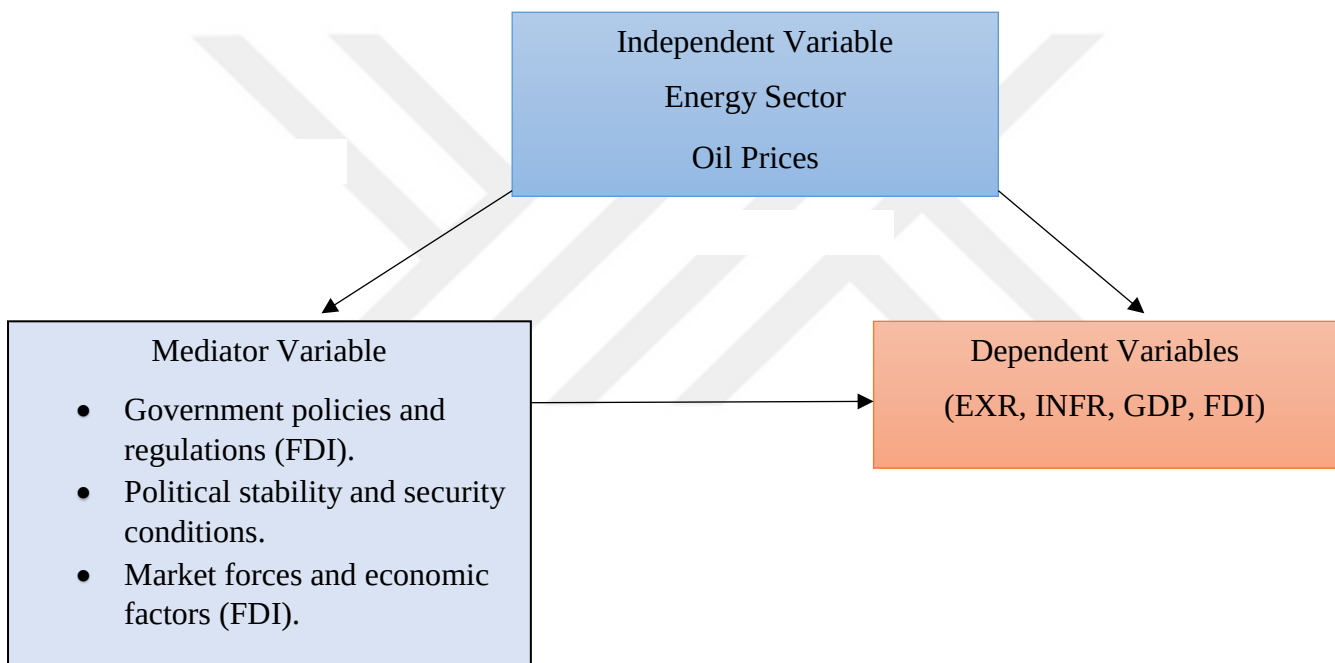
H0: Fluctuations in oil prices have a significant impact on the real gross domestic product (RGDP) in Yemen.

H1: Fluctuations in oil prices do not have a significant impact on the real gross domestic product (RGDP) in Yemen.

H0: Fluctuations in oil prices have a significant impact on foreign direct investment (FDI) in Yemen.

H1: Fluctuations in oil prices do not have a significant impact on foreign direct investment (FDI) in Yemen.

Conceptual Framework



Research Methodology:

- Descriptive and quantitative analysis using statistical techniques, such as Var model, to examine the relationship between oil price fluctuations and the dependent variables
- Collection of relevant data on oil prices, exchange rates, inflation rates, RGDP, and FDI from reliable sources, such as central banks, international organizations, and economic databases.

The research will analyze the data, apply appropriate statistical methods, and test the hypotheses to determine the extent to which fluctuations in oil prices affect the exchange rate, inflation rate, real gross domestic product, and foreign direct investment in Yemen's economic development.



CHAPTER ONE

OVERVIEW OF YEMEN'S ENERGY SECTOR

1.1.1 Energy Position in Yemen

The societies need energy likes the human's body needs energy, in 2011, Yemen experienced a political crisis that exposed longstanding vulnerabilities in its economy, which is heavily dependent on oil and natural gas exports to fund government expenditures. At the time, the country had 4.788 billion barrels of crude oil and 1.816 billion barrels of remaining oil reserves, as well as 18.283 trillion cubic feet (TCF) of proven natural gas reserves¹. However, due to the ongoing political conflict, only Yemen's consumption of natural gas is relatively low, with a peak consumption of 34 billion cubic feet (Bcf) in 2010. However, in 2013, the country exported a significant amount of liquefied natural gas (LNG) - around 330 Bcf, which accounted for over 90% of its total dry natural gas production that year. According to IHS Global Insight, this LNG made up approximately 3% of the total global LNG volumes in 2013². Interestingly, the conflict did not impact oil and natural gas production during this period, as the production blocks were not located in the conflict zone³. The access of Yemenis to basic necessities such as energy, electricity, food, and water has been weakened over time due to ongoing economic and political conflict. According to world bank data, in 2014, 76% of urban and only 18.6% of rural of the Yemeni population has access to electricity, only 32% has access to limited-standard drinking water, and 41.2% has no access to limited-standard sanitation services⁴. These issues can be traced back to the instability caused by political events starting in 2011, which resulted in the damage of government-generated power plants. As a result, many Yemeni households turned to solar energy as a source of lighting for their homes. Initially, the high demand for solar energy supplies led to higher prices, but as the

¹ "Productive Sectors," Ministry of Oil and Minerals, accessed March 10, 2023, <https://rb.gy/hkptsk>.

² International - U.S. Energy Information Administration (EIA), November 13, 2020, <https://rb.gy/skxenj>.

³ Ministry of finance, "annual finance report" 2014, p:30

⁴ Household Energy Supply and Use in Yemen Volume II (World bank, 12AD), <https://rb.gy/2p0ujp>, 51,90.

market became more competitive, the cost of purchasing solar energy decreased⁵. Also, the ongoing instability in Yemen has also had a negative impact on the country's water sector, leading to a halt in the expansion and improvement of water services. As a result, the number of water service subscribers has remained constant at 676,661 from 2013-2014. This lack of progress in the water sector has likely had detrimental effects on the accessibility and quality of water for the population⁶. In 2015, UN agencies began providing oil products to water stations in Yemen, enabling them to pump water to crowded neighborhoods on a weekly schedule with limited distribution hours and a limited water grid. According to the World Bank, 18.8% of Yemenis lived on US\$1.90 per day in 2014, which affected their access to electricity and water. The average electricity consumption in Yemen was 129 kwh per person, which is only 4% of the global average of 3,132 kwh per person. This indicates that many Yemenis were experiencing energy poverty. According to a Brief on Poverty & Equity report from the World Bank in 2020, the population of Yemen in 2014 was approximately 25.82 million, with about 12.8 million people living below the poverty line⁷. The destructive conflict in Yemen has had a negative impact on the country's economic growth, as reflected in the GDP per capita of the Yemeni people. From 2009-2014, the growth rate of GDP per capita in Yemen was -2.57% on average. This decrease in economic growth can be attributed to the destabilizing effects of the conflict, which has disrupted industries and trade, and hindered the ability of individuals and businesses to thrive and generate income. The ongoing conflict has also likely contributed to a decrease in the overall standard of living for the population⁸. Yemen growth rate of Real GDP reaches its peak level in 2000 with 7.1% because of the increase in oil exports (159.371, Million/barrel) as the conflict is expanding to most areas, the annual

⁵ Poverty & Equity Brief Republic of Yemen Middle East & North Africa (World bank, October 2020), <https://rb.gy/hvqzup>, 1,2.

⁶ Central Statistical Organization, "Indicators of Production Quantities of Main Energy, Electricity and Water." (Sana'a, December 2015), Energy & Industry excel file.

⁷ Poverty & Equity Brief Republic of Yemen Middle East & North Africa (World bank, October 2020), <https://rb.gy/hvqzup>, 1,2.

⁸ Author's computations depend on (CSO).

growth of Real GDP started to decline from 2011-2021 with -2.1% as the oil decreased to (12.5 Million/barrel) and the natural gas exports stopped, Thus, the Yemeni government also stopped to pay the salaries to all state's employees, therefore the purchasing power parity (PPP) of Yemenis decreased as well. Population growth in 2021, 2.23% with 30,490,639 people, ranked at 44 out of 235 countries⁹, Yemen's population considers as one of the fastest growing on the world¹⁰.



Figure 1.1: Three main oil and gas field¹¹

⁹ Countries by population growth rate 2021 (StatisticsTimes.com, August 24, 2012), <https://rb.gy/umskaq>.

¹⁰ "Yemen's Economy: Oil, Imports and Elites," Peter Salisbury (Chatham house, October 2011), <https://rb.gy/luae5d>, 3.f

¹¹ International - U.S. Energy Information Administration (EIA) (EIA, November 13, 2020), <https://rb.gy/skxenj>.

1.1.2 Energy Policy in Yemen

The oil sub-sector manages by Ministry of Oil and Minerals (MOM) to implement the processes of exploration and production, export, refining and marketing, and domestic consumption of the oil sub-sector as well as the gas sub-sector and minerals. Ministry of Oil and Minerals has the right to holds oil exploration and production agreements with foreign companies and decide the exploration blocks and an amount of production. The important process in MOM is exporting crude oil to export destinations which supports the Yemeni government revenues. There are two refineries in Yemen belong to MOM, Aden Refinery and Marib Refinery, which provide the domestic market with Oil and Gas (LPG) products. Yemen is rich in various minerals; thus, MOM is working to strengthen its studies in this field in order to increase mineral explorations, until it achieves self-sufficiency in building and ornamental stones that should cover the domestic market demand. The private sector in electricity generating appeared after the civil war, especially in Houthis' areas as a consequence of stopping power supplies from the primary electricity generating plant in Marib governorate. Before the war, the main supplier of electricity is Yemen Public Electricity Corporation (YPEC). YPEC controls the electricity market at a cheap price of the electricity (monopoly), on the other hand, a few hours of service that considered between 14-17 hours a day.

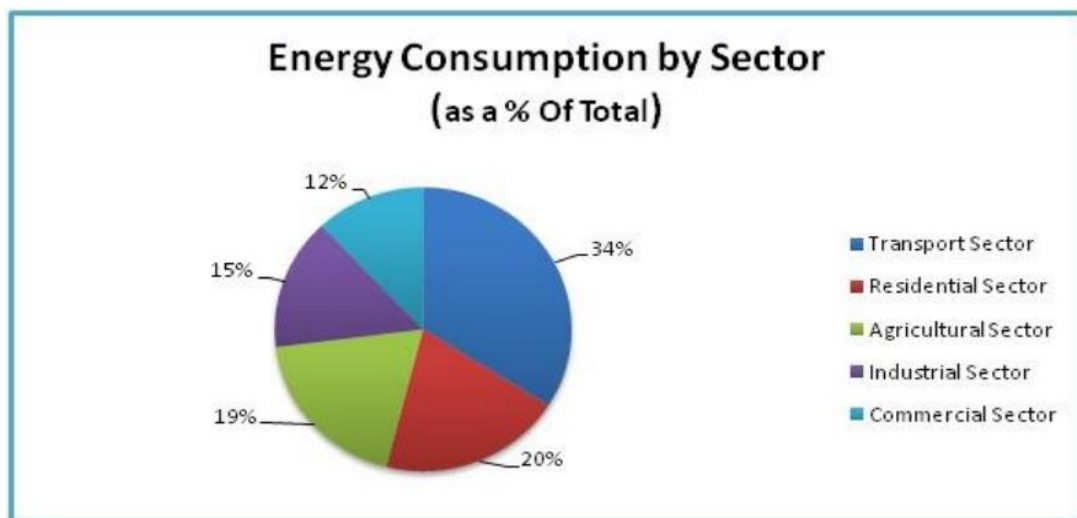


Figure 1.2: Energy consumption by sector¹²

The transport sector has the highest percentage of energy consumption, as shown in Figure 1.2, which presents the percentage of energy consumption by sector. The figure illustrates that the transport sector accounts for the largest share of energy consumption. In normal industry should to be the big consumer sector of energy but in Yemen, this sector satisfies its needs by own motor generators which means it is out the national grid. This information is important as it highlights the sector that may be most amenable to energy conservation efforts and the identification of alternative energy sources.

¹² Towfick Sufian, "Energy Charter," Energy Charter Secretariat, 2019, <https://rb.gy/79qgu6>, 17

1.2 Oil Sub-Sector

1.2.1 Introduction

Oil is essential to the Yemeni economy, much like oxygen is essential to the human body. There are a total of 100 oil blocks in Yemen, with 12 of them currently producing oil and being worked on by 10 international companies. Additionally, there are 38 exploration blocks being worked on by 16 international companies, and 50 potential blocks open for investment. There are two refineries in Yemen, both belonging to the Ministry of Oil and Minerals (MOM): the Aden Refinery, with a capacity of 150 thousand barrels per day, and the Marib Refinery, with a capacity of 10 thousand barrels per day. To facilitate the export of crude oil to international consumers and reduce the cost and time of transferring it from the production blocks, MOM has established three pipelines and three export ports. The first pipeline stretches 439 kilometers from 18 blocks in Marib to the Al-Hudaydah Port, the second pipeline runs 138 kilometers from 14 blocks in Masilah to the Ash-Shihr Port in the Hadramawt governorate, and the third pipeline for natural gas extends 210 kilometers from 14 blocks in the Shabwah governorate to the Balhaf Port in the same governorate. The oil industry is a significant contributor to the Yemeni economy, as it helps to reduce the fiscal and trade balance deficit and increase foreign currency reserves through oil revenue. The high price of crude oil allows the Central Bank of Yemen to obtain more foreign currency, which it can then use to intervene in the domestic exchange rate market in order to reduce inflation and stabilize prices in the domestic commodities market. Yemen is estimated to have 4.788 billion barrels of crude oil reserves, with 1.816 billion barrels remaining. There are two primary types of crude oil in Yemen: light Marib oil (44) and Masila oil crude (32). The government has stated that the southeast Masila Basin contains 80% of Yemen's total oil reserves. The Oil Sub-Sector (OSS) is a vital component of Yemen's development, as it contributes 74% to the public budget, 90% to Yemen's total exports in the trade

balance, and 30% to the country's GDP. As oil revenues increase, they can be used to support the development of vital sectors within the Yemeni economy¹³.

Table 1.1: Oil production in Yemen ¹⁴

Field name	Percentage of Yemen's oil production	Oil production in 2006 (million barrels/yr)	Oil production in 2015 (million barrels/yr)	Governorate
Masilah field	39%	51.7	12.9	Hadhramaut
Al-Jawf & Marib basin	19%	25.1	6.3	Marib
Hunt Jannah block	12%	15.8	4.0	Shabwah
Other blocks scattered	30%	39.7	9.9	others

Gas production in Yemen has been on the rise since the start of exportation in 2008. However, the most recent conflict in 2014 has severely impacted the country's economy, including the underutilization of natural gas due to a lack of gas pipeline infrastructure and low reliance on natural gas for power generation. In 2012, some oil companies in Yemen were unable to utilize approximately 4.27% of the produced natural gas, while others injected 44.2% back into the reservoir and only 3.32% was used for electricity generation in Marib and Hadhramaut power plants. The remaining 42.84% was exported¹⁵.

¹³ "Productive Sectors," Ministry of Oil and Minerals (MOM), accessed March 10, 2023, <https://rb.gy/tghhx9>.

¹⁴ Ahmed Abdullah, "Opportunities and Challenges for Restructuring Yemen's Post-Conflict Electricity Infrastructure Using CCGT with CCS for EOR" (dissertation, 2019), 8.

¹⁵ Ibid., p. 8

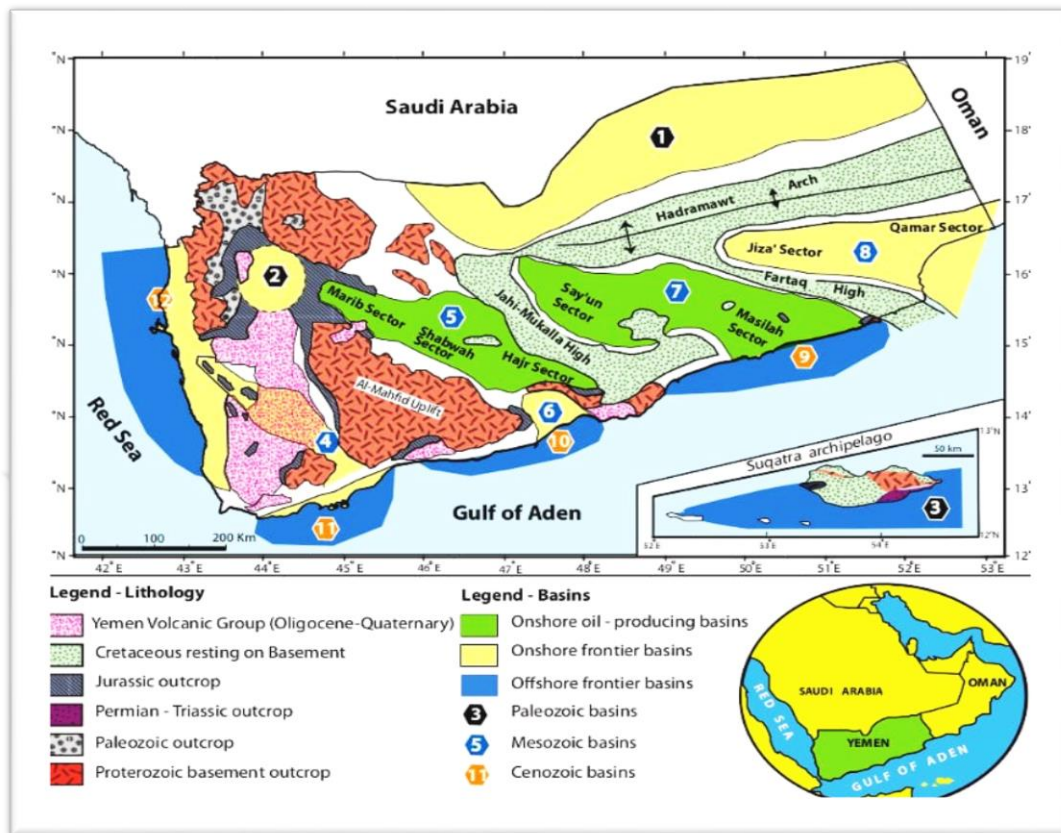


Figure1.3: Exploratory & Producing Blocks in Yemen

1.2.2 Cumulative Crude Oil Production from All producing blocks (1986-11)

From the period 2000 to 2010, crude oil production reached its peak level, with 14 producing blocks and operating companies. During this time, the amount of crude oil produced from all blocks increased from 143.24 in 1999 to 159.8 million barrels in 2000, due to the increase in production from all blocks and the number of blocks in operation. These significant changes led to improvements in the economy, prompting the government to develop a plan for economic and social development to reduce poverty for the period from 2006 to 2010 in August 2006. This plan aimed to capitalize on the country's comparative advantages and utilize its available and potential natural resources.

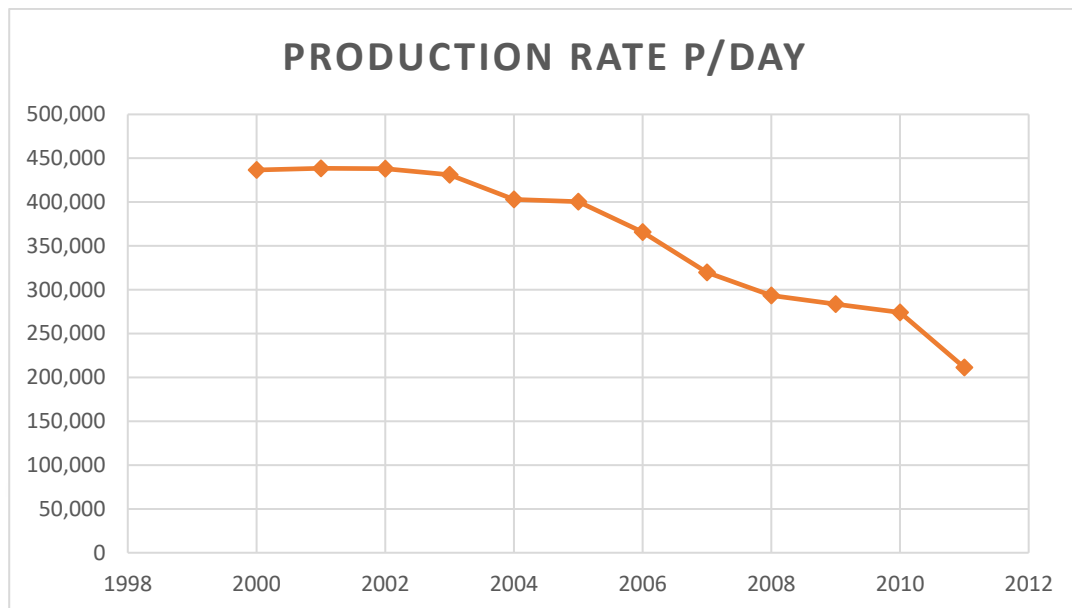


Figure 1.4: Cumulative Crude Oil Production from all producing blocks (1986-11)¹⁶

1.2.3 The Domestic Consumption of The Refined Products (2001-2007M.T)

The consumption of four types of fossil fuels (gasoline, diesel, kerosene, and fuel oil) in the Yemeni domestic market. The consumption of these fuels has been on the rise over time, with diesel and gasoline being the most heavily consumed. Specifically, the consumption of diesel has increased by 93.7% between 2001 and 2007. Overall, the consumption trend appears to be upward, likely due to increased demand from power plants to generate electricity. Kerosene is the least consumed fossil fuel in this market. The use of gasoline is only for cars and small generator motor. The Government of Yemen conducted a review of price regulations on petroleum products with the goal of further liberalization. The prices of turbine aircraft fuel and fuel oil were liberalized, and by the first quarter of 2010, Yemen had reduced subsidies and brought administered prices more in line with international prices. This resulted in an increase in the price per liter of petrol by 100%, diesel by 130%, and kerosene by 125%, and LPG prices per cylinder by 390% from their levels

¹⁶ Statistics Technical Committee, "Gas, Oil and Minerals Statistics," 11th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2011), 26.

prior to 2010. All other petroleum products were sold at international market prices. Alternative lighting devices, such as kerosene lamps (used by approximately 67% of non-grid electrified rural households) and Liquefied Petroleum Gas (LPG) lamps (used by approximately 5% of households), are commonly used by rural households that do not have access to electricity. This use of alternative lighting has significant environmental impacts. Additionally, there is a disparity in terms of access to electricity between rural and urban households. The demand for kerosene can be used as an indicator of the accessibility of electricity for rural households. When demand for kerosene decreases, it can be inferred that rural households have greater access to electricity, and conversely, an increase in demand for kerosene may indicate a decrease in access to electricity.

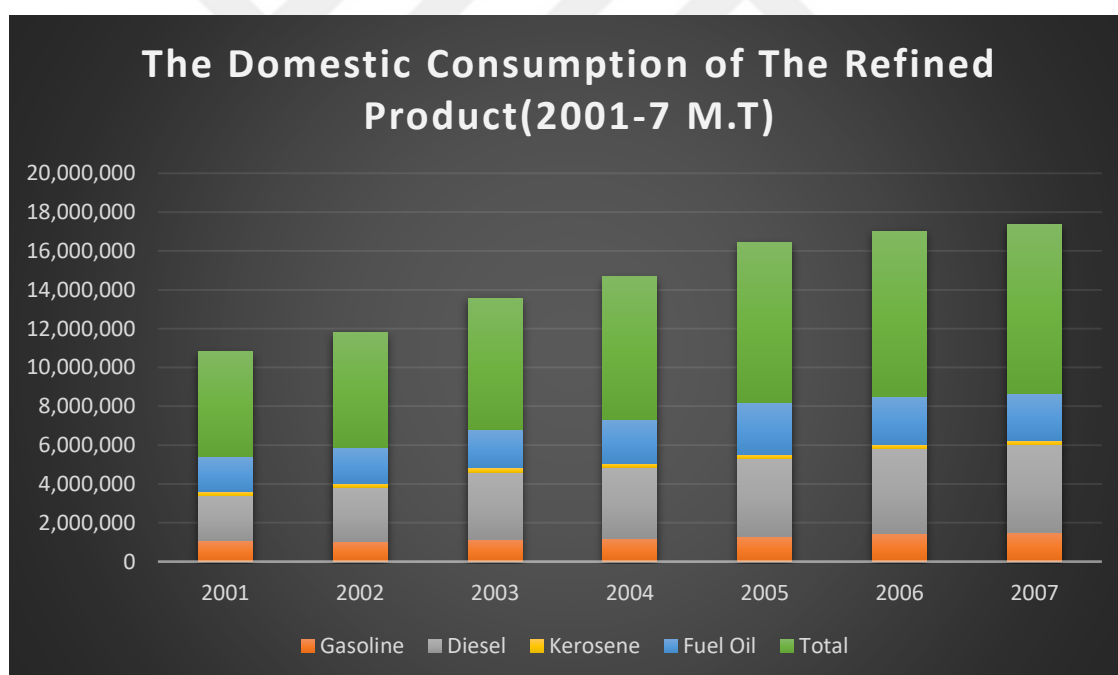


Figure 1.5: the Domestic Consumption of the Refined Products (2001-7M.T)

1.2.4 Comparison of Domestic Consumption of Refined Petroleum (2003, 2004 M.T.)

It has been acknowledged that 2003 and 2004 marked a significant change in domestic consumption patterns. According to data presented in Table 1.3, the growth in demand for refined petroleum during this period was 6.48%. This data suggests that the Aden and Marib refineries, which have capacities of 130 thousand and 1000 thousand barrels per day, respectively, were unable to meet the ongoing demand for oil products. As a result, it is recommended that the government consider constructing additional refineries to meet the needs of the Yemeni market for oil products.

Table 1.2: Comparison of Domestic Consumption of Refined Petroleum (2003, 2004 M.T.)¹⁷

Year	Domestic consumption	Avg. Monthly Domestic consumption	Avg. Daily Domestic consumption
2004 Consumption	4,559,912	379,993	12,459
2003 Consumption	4,282,594	356,883	11,733
Change in consumption volume	277,318	23,110	726
% change in consumption	6.48%	6.48%	6.18%

¹⁷ Statistics Technical Committee, "Gas, Oil and Minerals Statistics," 4th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2004), 51.

1.2.5 Crude Oil Export& Its Values (2001-2007)

Exporting crude oil can be an important source of revenue for countries that produce it. Many countries like Yemen rely on the export of oil which forms 90% of Yemeni exports to drive economic growth and fund various government programs and initiatives. As shown in figure 1.5, there is an inverse relationship between the quantity of exported oil and its value. As the quantity decreases, the revenues increase over time. For example, in 2001, approximately 67 million barrels of crude oil were exported for a total of 1.5 billion dollars. In 2007, despite exporting nearly half this amount, the total revenue was 2.7 billion dollars, due to the constant increase in crude oil prices rather than an increase in production. The highest revenue for the Yemeni government was achieved in 2006, with 3.2 billion dollars.

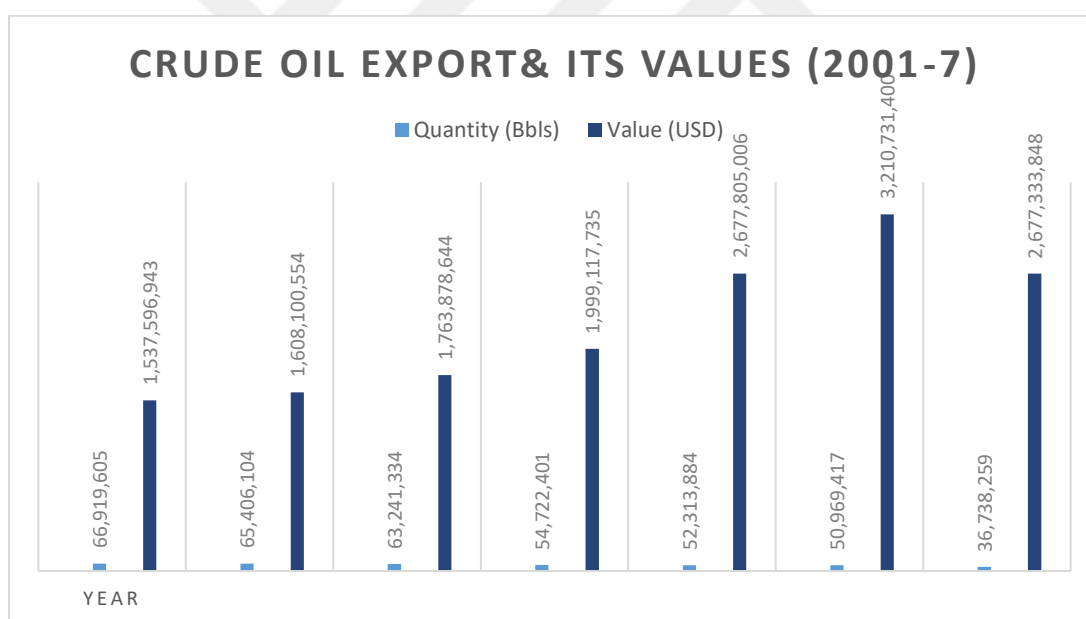


Figure 1.6: Crude Oil Export& its Values (2001-2007)¹⁸

¹⁸ Statistics Technical Committee, "Oil & Gas in Figures," 7th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2007), 16.

1.2.6 Oil Production & Government Share (2001-2007)

Oil production is often carried out by private companies, but governments may also have a stake in the industry through state-owned enterprises or revenue generated from taxes and royalties paid by private oil companies. The government share of oil production refers to the portion of production that is owned or controlled by the government. In Yemen, there are 11 foreign companies operating in 13 sectors of the oil industry. According to Table 1.4, these foreign companies on average control 40% of the Yemeni oil sector, with the remainder being the government's share. Of the total workforce in the industry, 87% are Yemeni¹⁹. However, despite the high proportion of Yemeni workers, they are often not employed in key positions in order to transfer knowledge and technology to them. If foreign companies operating in the Yemeni oil industry were to halt their operations due to political circumstances or the expiration of their contracts, the high proportion of Yemeni workers who are not employed in key positions could be left incapacitated and unable to operate the facilities without the assistance of the original operator. This situation would be disadvantageous for the Yemeni workforce, as it would hinder their ability to gain knowledge and experience in exploration and production technology.

Table 1.3: Oil Production & Government Share (2001-2007)²⁰

Year	Total Production (BBls)	Gov.Share (BBls)	Gov.Share %
2001	160,052,009	99,270,230	62.02%
2002	159,923,596	94,838,948	59.30%
2003	157,268,703	95,582,677	60.94%
2004	147,495,009	89,582,677	60.74%
2005	146,090,331	86,336,124	59.10%
2006	155,325,935	85,747,421	55.20%
2007	116,667,468	72,652,659	62.27%

¹⁹ Bu Statistics Technical Committee, "Oil & Gas in Figures," 11th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2011), 82.

²⁰ Statistics Technical Committee, "Oil & Gas in Figures," 7th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2007), 17.

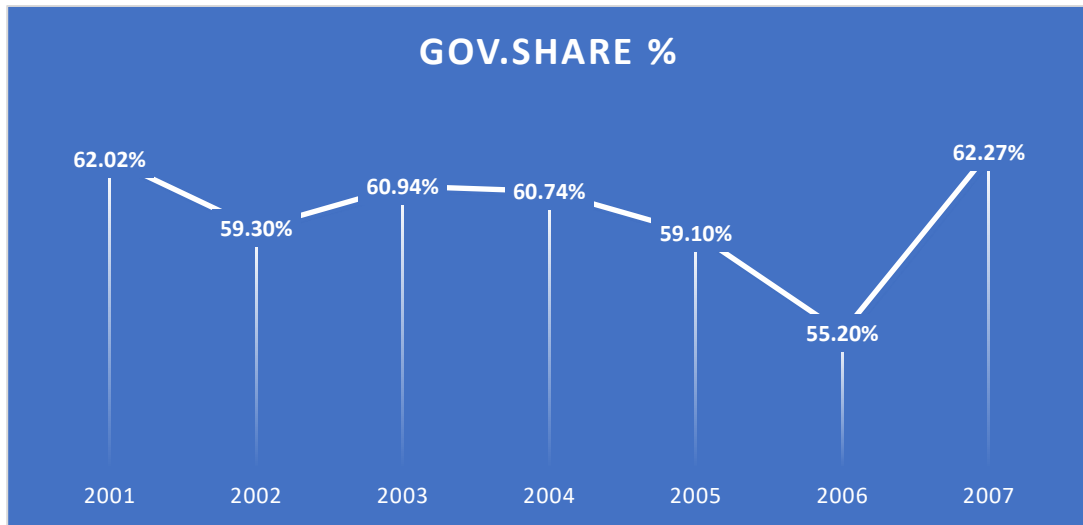


Figure 1.7: the growth of Government Share (2001-2007)

According to table 1.4, in 2007, the total exported quantity of crude oil is 116,667,468 BBls with value of \$6137.7 million, making up 86.1% of the total value of exports. This represents a decrease of \$595.7 million, or 8.8%, from 2006, primarily due to a decrease in production. When oil company shares are excluded, the government's share of crude oil exports fell by 23.1%, from \$4013.5 million in 2006 to \$3087.9 million in 2007. This was a result of a decrease in the export quantity from 175,000 barrels per day to 116,000 barrels per day, despite an increase in the average export price from \$63 per barrel to \$73 per barrel. The contribution of oil and gas revenues to total government revenues decreased from 74% in 2006 to 69% in 2007, and their ratio to GDP declined from 25.3% in 2006 to 19.8% in 2007. Oil and gas revenues include revenues from the export of crude oil and revenues from domestic oil and gas. Crude oil and gas are major drivers of economic growth in terms of state revenues and GDP in Yemen, as demonstrated by Figure 1.6, As the price of crude oil increases, government revenues and GDP also tend to increase, and vice versa. In 2007, the trade balance showed a deficit of \$81.3 million, compared to a surplus of \$1390.3 million

in 2006. This deficit was equivalent to 0.3% of GDP. The change from a surplus to a deficit is attributed to an increase in imports and a decrease in crude oil exports²¹.

1.3 Gas Sub-Sector

1.3.1 Introduction

The discovery of gas in Yemen coincided with oil explorations in 1984 in oil sector of the Marib/Al-Jawf Basin of both types associated with oil and dry gas. the previous oil agreements with international oil companies considered gas as a secondary commodity not as a national primary commodity in the exploration and production process, hence oil and minerals corporation needs to hold new Contracts, in case if it wants to produce gas, and as a result of these procedures, the new contracts will take a long time for developing the investment in the gas production. This made it urgent for the Ministry of Oil and Minerals to adopt the fifth-generation agreements and contract. This generation of the agreements are characterized by following the best contractual terms and more attractive incentives for investors in exploration and production operations of Gas sector. The Yemeni Gas Company (YGC) is one of the companies that belong to Yemeni Oil and Gas Corporation which It undertakes the task of supervising the production, distribution, and marketing of liquefied petroleum gas in the local and foreign market, as well as transporting and storing this substance in all governorates for the purpose of meeting the needs of local consumption. The company also contributes to the liquefied natural gas project on behalf of the Ministry of Oil and Minerals, along with foreign investors.

²¹ General Administration of Research and Statistics, "Annual Report," 7th ed., vol. 1 (Sana'a, Yemen: Central Bank of Yemen, 2007), 36, 37.

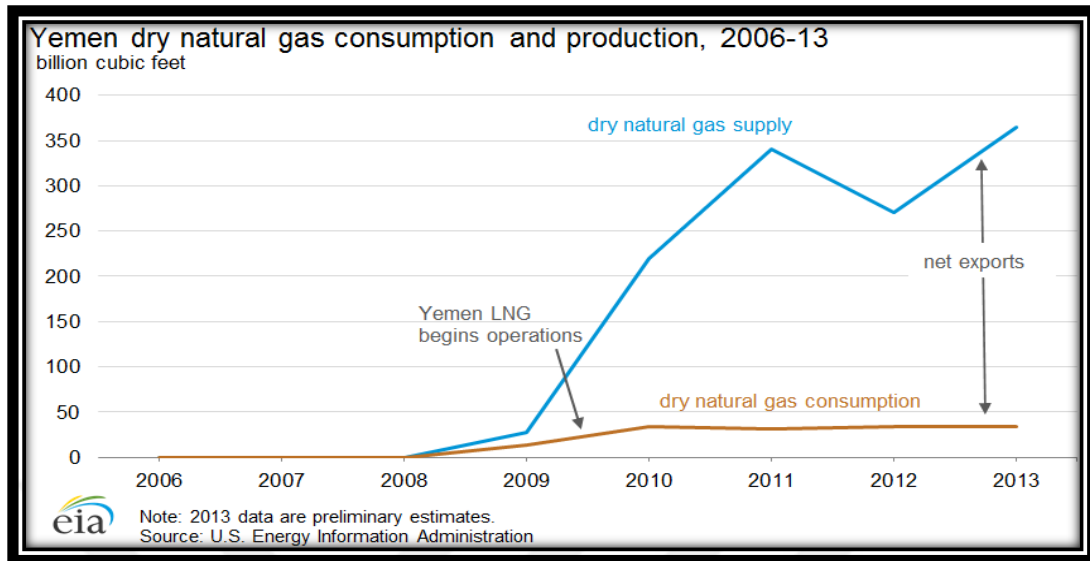


Figure 1.8: Yemen dry natural gas consumption and production (2006-13)

1.3.2 The Liquefied Natural Gas Project LNG in Yemen

The reserves of natural gas in Yemen are estimated at about 18.215 trillion cubic meters, 9.15 TCF proven has been allocated for LNG Project, in addition to 1 TCF reserved for domestic market. The independent consultants DeGolyer and MacNaughton recertified the reserves in May 2005²². The \$4.5 billion is Yemen LNG project cost, which consists of two liquefaction and purification trains with a total capacity of 6.7 Mmtpa²³, the export of the first shipment of LNG began in November 2009, through the pipeline with 320Km is transporting gas from sector 18 in Marib to the liquefaction facilities, and then exporting it from Balhaf Port to the global market. The project consists of seven shareholders under the name of Yemeni Liquefied Gas Company, consisting of the Yemeni government represented by the Yemeni Gas Company with a share of 16.73% and the General Authority for Social Security and Pensions with 5% and American Hunt Company, LLC with 17.22% and Korea Gas

²² Yemen LNG Company, "Project Components," Upstream, accessed March 11, 2023, <https://rb.gy/5ah4h0>.

²³ Hussein Ibish, "Will Yemen Be a Gas Exporter Again?" Arab Gulf States Institute in Washington (Colby Connelly, March 10, 2020), <https://rb.gy/auhhhw>.

Corporation with 6% and SK Corporation 9.55%, and Hyundai Corporation 5.88%, Finally, with the biggest stakeholder of the share of the project, which is Total France LNG Company, with 39.62%, The revenues of this project for the Yemeni government are estimated at 30-50\$ billion dollars over 20-25 years. The marketing of LNG relied on a combination of sales, namely the Asian markets, which provide a fixed price, and the American markets, which provide unstable prices based on various changes, particularly immediate sale prices. As a result, the Yemeni LNG Sale Agreement was signed in 2005 with the following customers: KOGAS will purchase 2 million tons, SUEZ-TRACTABLE SA will purchase 2.5 tons, and TOTAL France Company will eventually purchase 2 tons²⁴. In late 2012, Yemen LNG began negotiations with Suez and France's Total Company to revise its contracts due to concerns that the prices received for LNG were lower compared to other global markets. As of July 2014, no agreement had been reached on a new price with TOTAL France Company, the big stakeholder of the Yemen LNG project. In contrast, KOGAS agreed to increase its contract price in 2013. The corruption of Yemeni government is the main reason to let one company controls about 40% of the project whereas the government share is only 21.73% , while Yemeni regulations declares that the contribution of non-Yemeni capital to the company's paid-up capital must not exceed 40%²⁵. Yemen LNG is also reportedly in discussions with Turkey's Petroleum Pipeline Corporation (BOTAS) about a potential agreement to export up to 35 billion cubic feet of LNG to Turkey annually²⁶.

²⁴ "Gas," (Ministry of Oil and Minerals), accessed March 11, 2023, <https://rb.gy/hkptsk>.

²⁵ "Investment Law (In Arabic)," قانون الاستثمار (National Information Center, July 20, 2002), <https://rb.gy/ki1kcu>.

²⁶ "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis," International -U.S. Energy Information Administration (EIA) (EIA, November 13, 2020), <https://rb.gy/skxenj>.

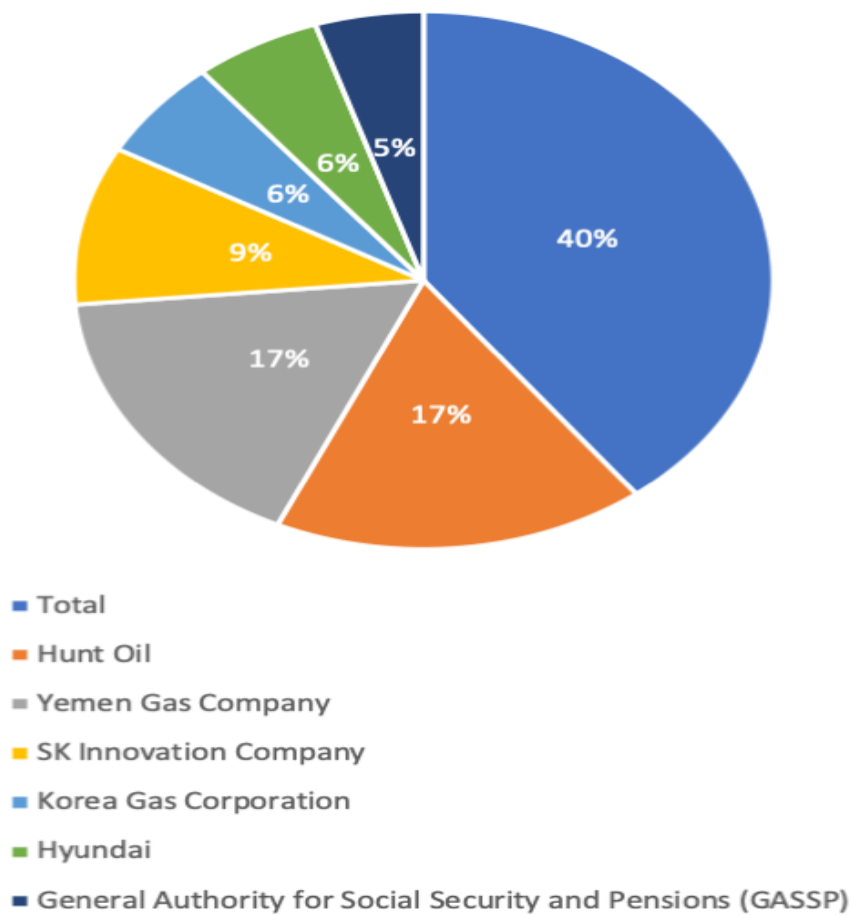


Figure 1.9: Yemen LNG Stakeholders²⁷

²⁷ Ali Alfoneh et al., “AGSIW: Homepage,” Arab Gulf States Institute in Washington, March 9, 2023, <https://agsiw.org/>.



Figure 1.10: Safer E&P Operations Company (SEPOC)²⁸

SAFER Exploration & Production Operations Company, known internationally as SAFER, is the premier national oil and gas company in Yemen. As the exclusive enterprise with rights to Yemen's premier Block 18, SAFER has become the largest producer of natural gas and the second largest producer of oil in Yemen. SAFER is a comprehensive service provider that produces 40,000 barrels of oil per day, 2.4 billion cubic feet of natural gas per day, and 28,000 barrels of liquefied petroleum gas per day as of 2013. This output, valued at over \$1 billion per year, is a significant contributor to the economy of Yemen and serves as the utilities, logistics, and economic foundation of the country²⁹. The natural gas and oil infrastructure, including pipelines, are frequently targeted in attacks. These attacks can have significant consequences, as demonstrated in 2012 when Yemen LNG was shut down for over half a year due to damage to the natural gas system. This led to the loss of multiple cargos. While there were further attacks on the infrastructure in 2013, there were no recorded decreases in production or exports. However, in September of that year, militants caused the shutdown of a 360MW gas-fired power plant, which provided

²⁸ "Production," Safer (SAFER Exploration & Production Operations Company, 2022), <https://rb.gy/yfcb9>.

²⁹ "Safer," safer (SAFER Exploration & Production Operations Company), accessed March 11, 2023, <https://rb.gy/yhtwyf>.

electricity to western regions of the country and contributed to power outages across the nation³⁰.

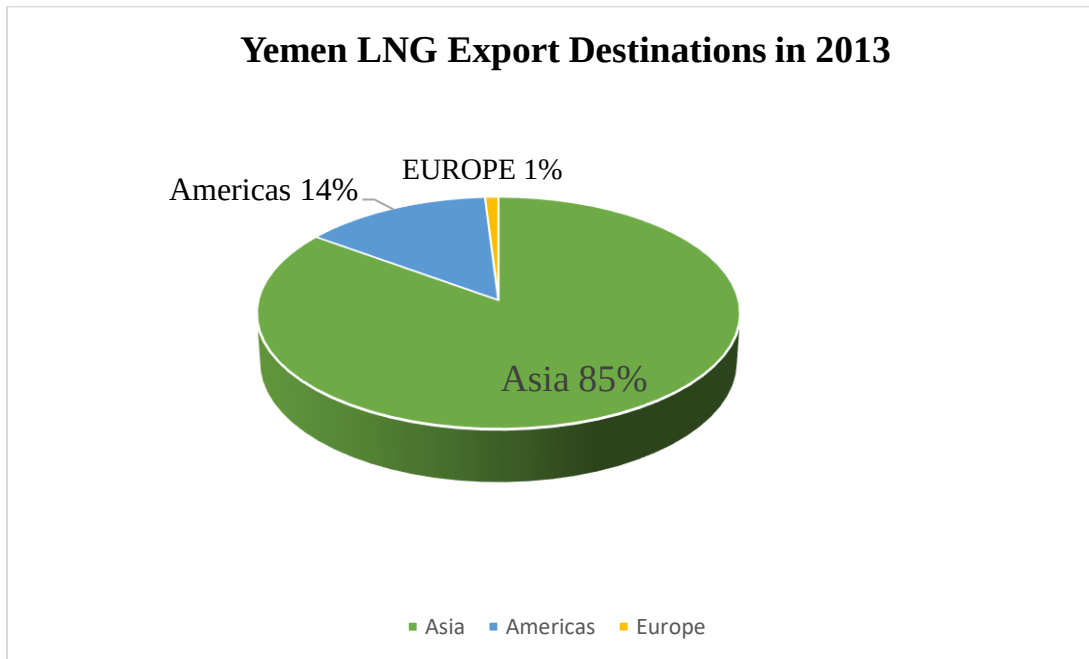


Figure 1.11: Yemen LNG Export Destinations in 2013³¹

As shown in the figure 1.10, the majority of Yemen's exported liquefied natural gas (LNG) is destined for the Asian market, accounting for 85% of the total exported amount. This is due in part to the presence of large governmental facilities in the region. The Americas market receives 14% of the exported LNG, while the European market receives only 1%. These data demonstrate the significant influence of the Asian market on Yemeni LNG exports³².

³⁰ Mohammed Mukhashaf, "Yemen Gas Pipeline Blown up, Output Halted after Drone Attack," Reuters (Thomson Reuters, March 30, 2012), <https://rb.gy/tokgij>.

³¹ "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis," International - U.S. Energy Information Administration (EIA) (EIA, November 13, 2020), <https://rb.gy/9yn9it>.

³² Ibid.

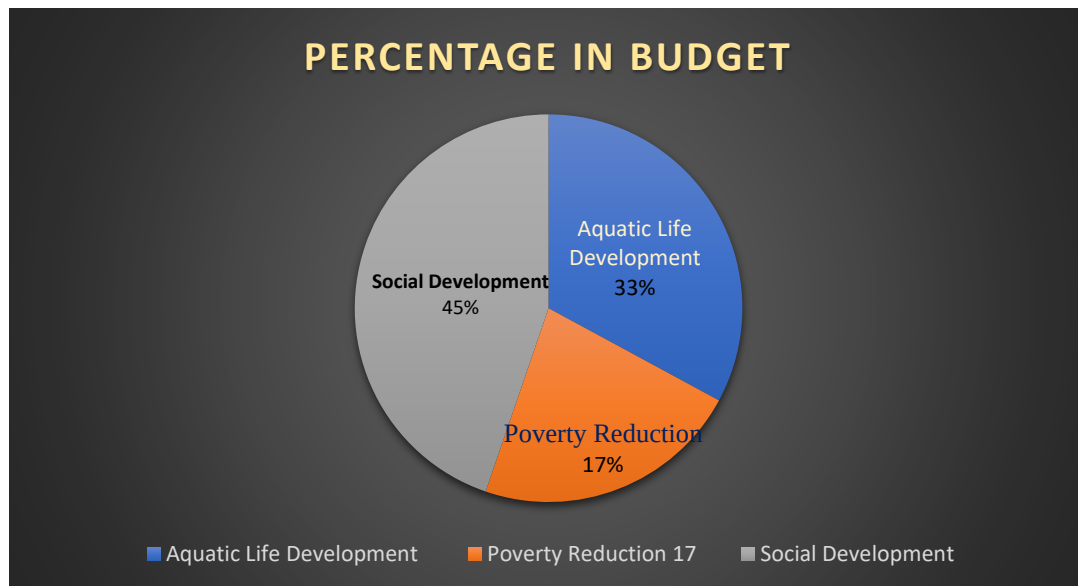


Figure 1.12: the long-term strategic program for sustainable development³³

The Yemen Liquefied Gas Company has developed a long-term, sustainable development program with a budget of \$26 million from LNG project revenues. This program includes the following allocation of funds: 25% for supporting marine fishing and aquatic life development, 17% for poverty reduction, and 34% for social development. These initiatives aim to promote sustainable growth and improve the quality of life for Yemenis³⁴.

1.3.3 Updated primary gas reserve in the productive blocks in 2011

Primary gas reserves are underground deposits of natural gas that can be extracted and used as an energy source. These reserves are typically found in rock formations or reservoirs, and can be accessed through drilling or other methods of exploration. Natural gas is a fossil fuel that is formed over millions of years from the decomposition of organic matter. It is composed mainly of methane, but may also contain small amounts of other hydrocarbons such as ethane, propane, and butane. Primary gas reserves are an important source of energy for many countries around the world, and are often used to generate electricity, heat buildings, and fuel vehicles.

³³ Statistics Technical Committee, "Oil & Gas in Figures," 39th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2010), 39.

³⁴ Ibid.

Primary gas reserves are important for several reasons which are Energy security, Economic benefits, Environmental benefits, Versatility and Reliability. According to the International Energy Agency (IEA), energy security is defined as the availability of energy sources at an affordable price without interruption. This concept can be divided into two categories: long-term energy security, which concerns the timely investments needed to supply energy in accordance with economic development and environmental requirements, and short-term energy security, which focuses on a system's ability to quickly respond to sudden shifts in the supply and demand balance. Overall, energy security is a multifaceted issue that requires attention to both long-term and short-term considerations³⁵. The use of primary gas reserves economically for the production of electricity and transportation can help to stimulate economic growth and create jobs in the regions where the reserves are located. In countries like Yemen, where the foreign currency reserves may be drain by the need to import oil products, and utilizing domestic primary gas reserves can reduce the burden on these reserves and contribute to the local revenues that support to pay salaries of schools and government's expenditures³⁶. According to Ministry of Oil and Minerals (MOM), the Yemeni gas reserves increase from 18.215 TCF in 2015 to 18.289 in 2018, but while the gas reserves increased, the foreign oil companies leave Yemen because the Yemeni' conflict. Natural gas is a cleaner-burning fossil fuel compared to coal or oil, can have environmental benefits. When used to generate electricity, natural gas can help to reduce greenhouse gas emissions³⁷. As a stored energy source that can be accessed as needed, natural gas is known for its reliability. Keeping natural gas underground reservoirs make it a valuable resource for meeting the constant demand for energy.

³⁵ IEA, "Energy Security – Topics," IEA (IEA, October 2, 2023), <https://rb.gy/j6hntr>.

³⁶ "Economic Impact" (NGSA), accessed March 11, 2023, <https://rb.gy/mg5cpg>.

³⁷ "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis," Natural gas and the environment - U.S. Energy Information Administration (EIA) (EIA), accessed March 11, 2023, <https://rb.gy/xcqyt1>.

Table 1.4: Updated primary gas reserve in the productive blocks in 2011

The Name of Sector	The Proven Updated Gas Reserve TCF
Sector 18 Marib	14.79
Sector 5 Jannah	1.282
Sector S1 (DAMS)	0.606
Sector 51) east of the Hajar)	0.053
Sector S2 (Al euqla)	0.548
Sector 43 (South Hawarim)	0.028
Sector10 (east of Shabwa)	0.449
Sector 32 (Hawarim)	0.014
Sector 9 (malik)	0.229
Sector 53 (east of the Sar)	0.003
Sector 14 (Al Musila)	0.213
Total Amount	18.215

1.3.4 Production and Distribution of Associated Natural Gas (1986-2004 MCF)

As it mentioned above, the reason why Yemenis don't benefit from gas reserves is the previous oil agreements with international oil companies considered gas as a secondary commodity not as a national primary commodity in the exploration and production process, hence oil and minerals corporation needs to hold new Contracts, in case if it wants to produce gas, and as a result of these procedures, the new contracts will take a long time for developing the investment in the gas production. This made it urgent for the Ministry of Oil and Minerals to adopt the fifth-generation agreements and contract. This generation of the agreements are characterized by following the best contractual terms and more attractive incentives for investors in exploration and production operations of Gas sector. As can be seen from figure 1.12, the high burning of gas started from 1986,87,88,89 and then started to be same as gas production from 1990, finally decreased from 1991 until 2005. According to recent data of the World

Bank, the United States experienced a significant increase in gas flaring, with a rise of nearly 50% from 2017 to 2018. This increase can be attributed to the concurrent 33% increase in oil production. In contrast, countries facing political turmoil and conflict often see an increase in gas flaring as result of this weakness in Yemen's government, oil companies continue to burn Gas in the air instead to use gas in generating electricity. For instance, Venezuela has recently witnessed a surge in gas flaring, even as oil production has sharply declined. This trend is similar to those observed in Syria and Yemen in the past and may indicate a state of crisis³⁸. Yemen It has been observed that energy companies in Yemen frequently engage in the practice of gas flaring as a means of reducing costs. This is particularly common in situations where the extraction of gas is taking place in remote locations Rather than incurring the expenses associated with the collection and transportation of the gas, these companies select to burn it off, leading to the emission of greenhouse gases and other pollutants into the atmosphere. This practice, while decreases the cost-effective for the companies involved, has negative economic and environmental impacts on Yemeni community³⁹.

³⁸ "Global Gas Flaring Inches Higher for the First Time in Five Years" (World Bank Blogs), accessed March 11, 2023, <https://rb.gy/n8qqb8>.

³⁹ "Gas Flaring: What Is It and Why Is It a Problem?," BBC News (BBC, September 29, 2022), <https://www.bbc.com/news/science-environment-63051458>.

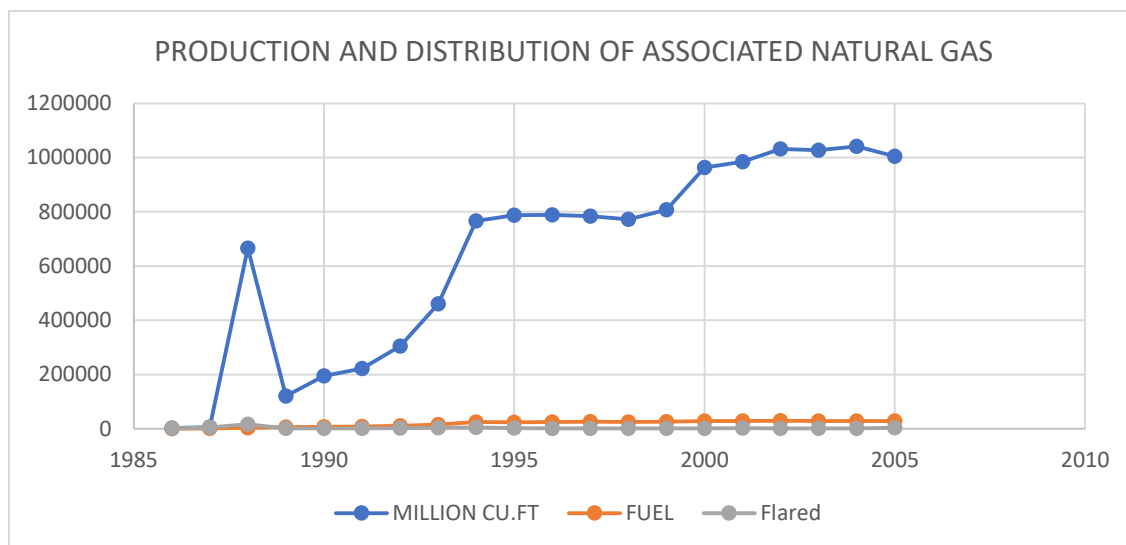


Figure 1.13: Production and Distribution of Associated Natural Gas⁴⁰

1.3.5 Marketing of Yemen Republic LPG Domestically (2002-15M.T)

There are a total of five gas production and processing plants located in Safer, each of which has two production units. The output from these plants is then transferred to locomotive loading tanks and subsequently distributed to filling stations. It is noted that the gas plant experienced a temporary halt in operations for a period of two months due to issues at the Balhaf facility and Yemen LNG Company. However, efforts made by the Yemen Gas Company and the Safer Company allowed for the plant to be restarted and for necessary maintenance to be performed on other plants. Additionally, an older gas plant was also shut down due to a disruption in the pumping of gas to an electric gas station. According to the table 1.6, the drawing of LPG gas reached its peak level in 2014 with estimated amount (821,868 T.M) which equivalent to 70,680,648 Cylinders and lowest drew quantity in 2011 with (583,500 T.M) due to political conflict in that time. There was a notable increase in the number of liquefied petroleum gas filling stations available to consumers and motorists in 2015, with a total of 184 stations recorded for the year. This represented an increase of 26 stations

⁴⁰ Statistics Technical Committee, "Oil, Gas and Minerals Statistics," 4th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2004), 17.

from the previous year, indicating a growth in domestic consumption. The Yemeni gas market has a competitive advantage in the transition from oil products to LPG gas, as demonstrated by the total quantity of LPG gas consumed from 2002 to 2015, which was 352.8 million cubic feet. This amount represents a small fraction (0.00437416%) of the country's total gas reserve of 8.065 trillion cubic feet⁴¹.

Table 1.5: Marketing of Yemen Republic LPG Domestically (2002-2015M.T)

Year	Yemen Gas CO. Sales (safir)	Aden Refinery Sales	Imported	Aid (Ton)	Total
2002	592,944.00	968	0		593,912.00
2003	627,280.00	6,836.00	0		634,116.00
2004	658,768.00	16,157.00	0		674,925.00
2005	650,285.00	36,000.00	20,000		706,285.00
2006	654,964.00	54,223.00	0		709,187.00
2007	653,794.00	82,974.00	0		736,768.00
2008	672,366.08	85,192.00	0		757,558.08
2009	658,618.00	76,873.42	0	7,197	735,491.42
2010	651,177.00	58,369.00	18,357.00	1,657	727,903.00
2011	378,349.75	36,717.00	167,252.00	0	582,318.75
2012	495,203	12,220	78,337	114,734	700,494
2013	686,677	49,152	42,636	0	778,465
2014	781,563	37,779	2,526	0	821,868
2015	662,011	8,076	0	0	670,087
Total	8,823,999.8 3	561,536.42	329,108.00	123,588	9,829,378.25

⁴¹ Calculated by Author

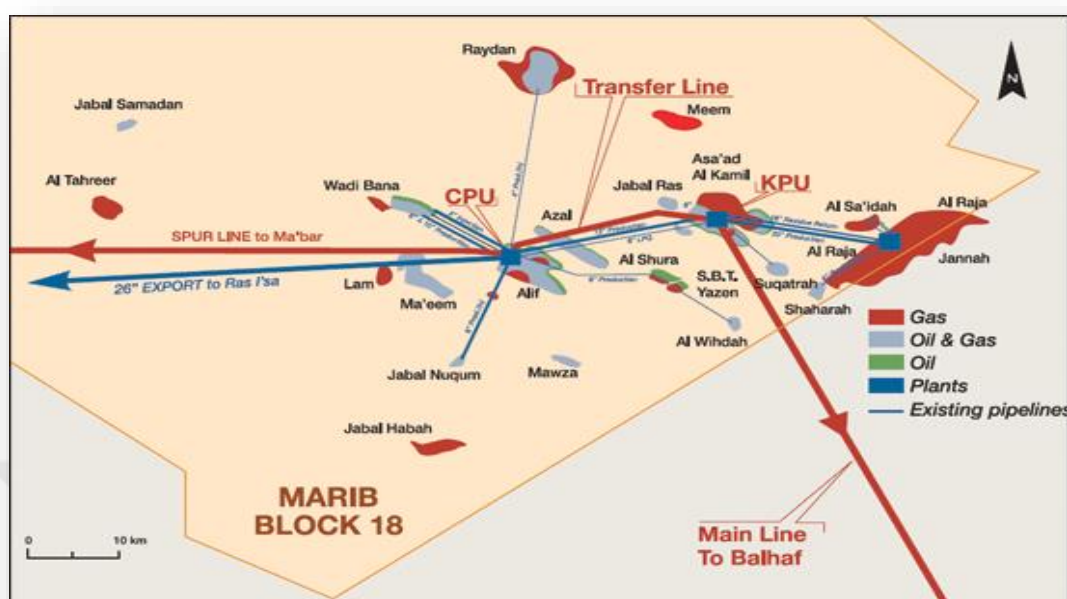


Figure 1.14: Marib fields, Central Processing Unit (CPU) and Kamil Processing Unit (KPU)⁴²

1.3.6 Yemen LPG Consumption and Production (2009-15 M.T)⁴³

According to table 1.5 and Figure 1.14, the total quantities withdrawn of liquefied petroleum gas for local consumption from Safer and Aden refineries during the year 2015 amounted to approximately 670.087 thousands metric tons of gas. Total quantities withdrawn from SAFER from 2009-2015 are 4.340 million metric tons divided to two sectors: The total quantities withdrawn from Safer (public sector) 47.39 thousands metric tons for 7 stations. The total quantities withdrawn from Safer (private sector) 560.207 thousands metric tons for 161 stations. Finally, the quantities withdrawn from Safer (for cars) are (54.422.740) thousands metric tons for 161 stations. Total quantities withdrawn from Aden Refinery from 2009-2015 are

⁴² "Project Components," Upstream (Yemen LNG Company), accessed March 11, 2023, <https://rb.gy/5ah4h0>.

⁴³ Planning and follow-up department, "The Annual Report on the Company's Activities and Achievements," vol. 1 (Sana'a, Yemen: Yemen Gas Company, 2015), 8.

(252.031) thousands metric tons. Total quantities withdrawn from Aden Refinery in 2015 are (8.075) thousands metric tons for public sector (3.118.375) thousands metric tons and for private sector (4.957.590) thousands metric tons. In financial activity, the total financial revenues of the state (the share of the Ministry of Finance) as a result of liquefied petroleum gas sales locally to the public and private sectors during the year 2015 amounted to 670,087 metric tons equal to 57.7 million Cylinders (one ton= 86 cylinders), amounting to approximately (30.9) billion Yemeni riyals equal to \$143.8 million with exchange rate \$1/214.89 that means \$2.49 is the cost of one cylinder in 2015 while in 2004 the one cylinder is cost \$1.11⁴⁴, if \$15.2 million adds to this amount of money could build one power plant with 341MW to feed the households with electricity.

Table 1.6: Yemen LPG Consumption and Production (2009-15 M.T)⁴⁵

Year	Withdrawn Quantities from (safir)	Withdrawn Quantities Aden Refinery	Imported+Aid Quantities	Total Domestic consumption
2009	658,619	48,610	28727	735,956
2010	651,179	59,514	18320	729,013
2011	378,350	36,680	168470	583,500
2012	495,203	12,220	193071	700,494
2013	686,677	49,152	42636	778,465
2014	781,563	37,779	2526	821,868
2015	662,011	8,076	-	670,087
Total	4,340, 602	252,031	453750	5,019,383

⁴⁴ Planning and follow-up department, "The Annual Report on the Company's Activities and Achievements," vol. 1 (Sana'a, Yemen: Yemen Gas Company, 2015), 13.

⁴⁵ Ibid., p. 8.

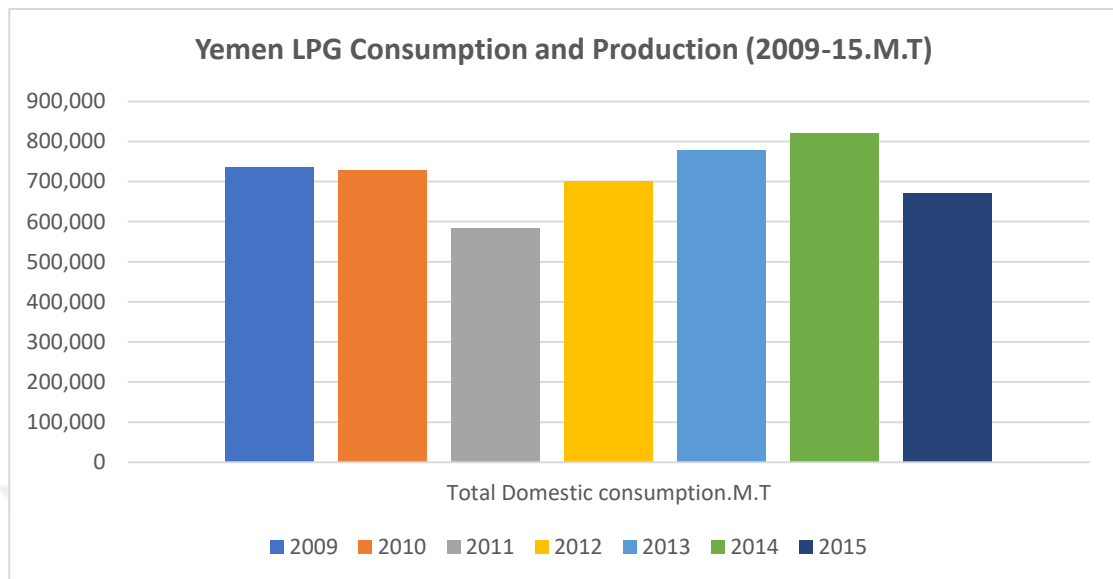


Figure 1.15: Yemen LPG Consumption and Production (2009-15.M.T)

1.3.7 LPG Domestic Consumption Growth (2001-2007)

The annual increase in Yemen population is 2.5%. To keep the same pace, the Yemeni market supply of LPG should also rise at the same rate. However, the gap between the demand and supply of LPG is widening, causing an increase in LPG prices due to demand-pull inflation. This happens when aggregate demand surpasses aggregate supply in the economy. Despite this trend, LPG prices in Yemen remain steady until 2014 as it is a government-supported commodity⁴⁶, after 2014 the political conflict divided Yemen into two areas, North under control of Houthi (Ansar Allah) and South under control of legality government, in the Houthi areas the LPG prices change from \$2.89 in 2014 to \$8.92 in 2022, while in legality government areas is \$1.11 in 2004 to \$3 in 2021⁴⁷. Data in Table 1.7 and Figure 1.15 from 2001-2007 shows a sustainable growth in LPG domestic consumption, suggesting that the

⁴⁶ Admin, "Difference between Demand Pull and Cost Push Inflation," BYJUS (BYJU'S, March 24, 2021), <https://rb.gy/zvetcz>.

⁴⁷ "Anadolu Ajansı," Yemen political conflict (Anadolu Ajansı), accessed March 11, 2023, <https://www.aa.com.tr/>.

government should take measures to increase LPG supply and improve processing units at SAFER and Aden refineries.

Table 1.7: LPG Domestic Consumption Growth (2001-2007)⁴⁸

Description	Years						
	2001	2002	2003	2004	2005	2006	2007
Volume (M.T)	505,823	588,962	631,649	674,925	686,782	707,684	737,567

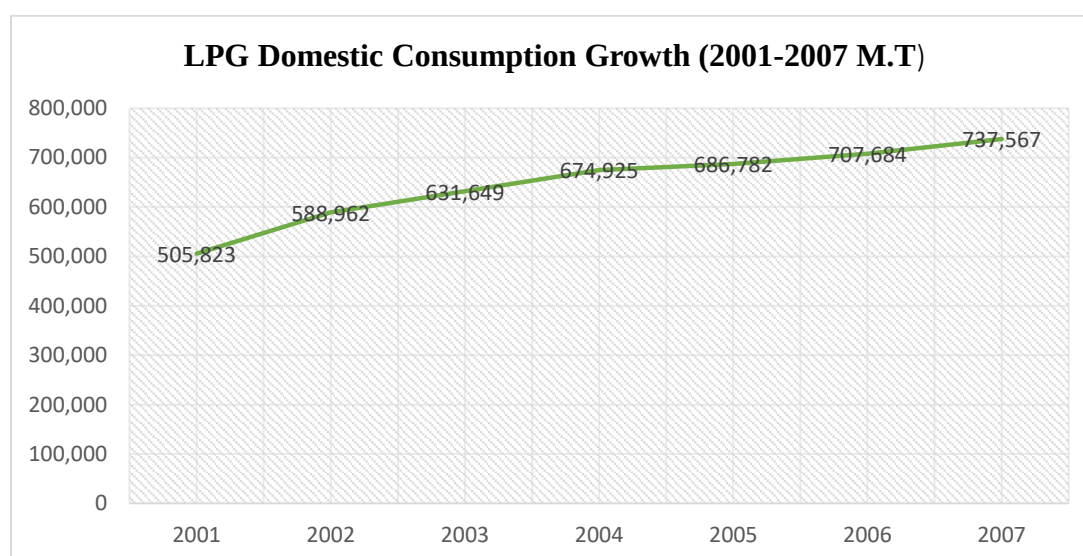


Figure 1.16: LPG Domestic Consumption Growth (2001-2007 M.T)

1.3.8 Revenues of LPG Domestic Sales (1999-2004)⁴⁹

In Yemen, the income generated from the domestic sales of liquefied petroleum gas (LPG) has been affected by changes in demand, supply, and pricing. LPG is considered a cleaner energy source, and as a result, its production and distribution have been impacted by the ongoing political and economic crisis in the country.

⁴⁸ Statistics Technical Committee, "Oil & Gas in Figures," 7th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2007), 20.

⁴⁹ Statistics Technical Committee, "Annual Report of 2004," 4th ed., vol. 1 (Sana'a, Yemen: Ministry of Oil and Minerals, 2004), 55, 61.

Despite these challenges, a total of 26,687 trailers were produced, with 11,948 trailers being distributed to regions liberated from Houthi control and 14,739 trailers being sent to areas under Houthi control. These locations under Houthi control received 55% of the total production, which equates to 32.45 million gas cylinders. To meet the increasing domestic demand, the Yemen Gas Company stopped LPG exports from Safir in 2003. The total LPG exported quantities were 14,575 metric tons. In terms of pricing of gas cylinders, it can be seen from Table 1.9 that there was no change in the selling price of LPG in Yemeni Riyals, but the selling price changed in USD due to fluctuations in exchange rates. Additionally, as shown in Figure 1.16, the revenues from LPG sales had a steady growth from 1999 to 2004, with the largest percentage change growth in these revenues happening in 2002 at 16.46% and in 2004 at 10.12%.

Table 1.8: Revenues of LPG Domestic Sales (1999-2004)

Year	Revenues	Selling Price/Cylinder	
	Million Y.R.	Y.R.	US\$
1999	7243	205	1.28
2000	8099	205	1.25
2001	8878	205	1.21
2002	10339	205	1.17
2003	10999	205	1.11
2004	12122	205	1.11

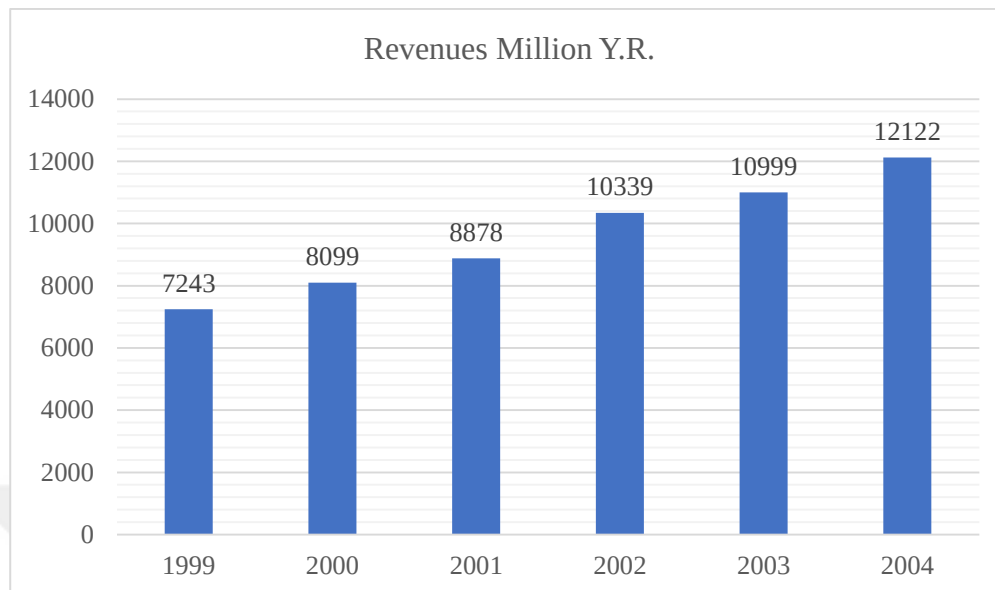


Figure 1.17: Revenues of LPG Domestic Sales (1999-2004)

1.3.9 Percentage of Annual Growth in LPG Quantities in Domestic Consumption (2009-15)

The annual growth of liquefied petroleum gas (LPG) quantities consumed domestically can be influenced by various factors, including changes in demand for LPG, government policies, and economic conditions. These factors can impact the importation, production, and distribution of LPG, and have an effect on the growth in quantities consumed domestically. Similarly, state revenues and the cost of LPG cylinders can be affected by the same factors. However, in Yemen, these factors do not affect the prices of oil products due to government subsidies for these goods. The decline in LPG consumed quantities from 2009 to 2011 should not be seen as a decrease in demand, but rather as a result of the Houthi insurgency in the Saada governorate, security situations in southern Yemen in 2009, the 2011 Yemen's Youth Revolution, and finally the Houthi takeover in the north of Yemen in 2014, these events affected LPG supplies, which led to a contraction in growth of the revenues in this sector at the beginning negatively of 2009 by 1% and 19% in 2011. From 2012 to 2014, the growth rates were positively, 20, 11, and 4, respectively.

Table 1.9: Annual Growth in LPG Quantities in Domestic Consumption (2009-15)⁵⁰

Years		The Consumed Quantity (T.M)		The Increased Amount (T.M)	% of growth
2009	2010	735,956	729,013	-6,943	-1%
2010	2011	729,013	583,500	-145,513	-19%
2011	2012	583,500	700,494	116,994	20%
2012	2013	700,494	778,465	77,971	11%
2013	2014	778,465	821,868	43,403	4%
2014	2015	821,868	670,087	-151,781	-18%

1.4 Electricity Sub-Sector

1.4.1 Introduction

Electricity is an essential aspect of daily life, and plays a significant role in promoting economic, educational, and social progress. It is important for powering homes, businesses, and industries, and enables the use of various technologies that are necessary for daily living. It enables the use of appliances, lighting, heating and cooling systems and also the powering of public services like hospitals and schools. Furthermore, reliable access to electricity can help to improve education and healthcare, boost economic growth and productivity, and promote social development. It is an important element for the sustainable development, where it is available and reliable, it can help to drive economic growth and improve the standard of living for people. As such, it is important for the government to prioritize the construction of Yemen's electricity infrastructure in post-conflict reconstruction efforts. Electricity is the engine of the most elements of daily life and is a significant The beginning of the entry of electric power into Yemen was in the city of Aden in 1926, to cover the needs of the military base of the British colonizer at that time, a steam station was established with a capacity of (3) MW in the south, in the north, the first entry of electric power into the city of Hodeidah began in 1950, through two

⁵⁰ Planning and follow-up department, "The Annual Report on the Company's Activities and Achievements," 15th ed., vol. 1 (Sana'a, Yemen: Yemen Gas Company, 2015), 9.

small generators, each with a capacity of (150) k.m⁵¹. These plants have been built for feeding the British colonizer in Aden and the palaces of the royal family in the north. Yemen has lowest electric power consumption, where average electricity consumption is at best 129 kWh/capita, compared with a global average of 3132 kWh/capita⁵² which is lowest than the world average by 184.18%. The population average 2.1%⁵³, hence the demand in Yemen should be increase nearly at the same ratio, with no more generating power plants the electricity sector deficit in power supply is increasing day by day. The main kinds of fossil fuels for transportation and generating electricity are oil and natural gas, but because of the conflict in Yemen, solar and wind energy became more accessible and affordable to Yemeni people at first for lighting home and then generating electricity. Yemen has 21 primaries electricity generation plants and 38 secondary electricity generation plants in 14 governorates to produce an electricity for secondary cities. The developing of electricity has two phases, first phase is after 1962 revolution in the north and 1963 revolution in the south, and second phase after the unity of the south with the north in 1990. as a good solution of energy deficit in Yemen is to shift all fossil fuel power plants and transportation to gas power plants by its new technologies which have become one of the most significant, efficient, clean, and promising sources of energy to meet the over-increasing energy consumption would lead to fulfill the gap in electricity demand. The World Bank In 2018, conducted survey, and the survey showed that the business sector in Yemen was exposed to 95% of frequent interruptions in electricity service from the government network, which led the business sector to purchase backup generators and increase generation costs, thus affecting daily life and economic activity.

⁵¹ وزارة الكهرباء والطاقة، "عن الوزارة" (Ministry of Electricity and Energy), accessed March 11, 2023, <https://rb.gy/2lsda7>.

⁵² "Electric Power Consumption (Kwh per Capita) - Yemen, Rep.," Data (World Bank and IEA Statistics © OECD/IEA, 2014), <https://rb.gy/3pxa0q>.

⁵³ "Yemen Population Growth Rate 1950-2023," MacroTrends, accessed June 9, 2023, <https://rb.gy/4qb4k>.

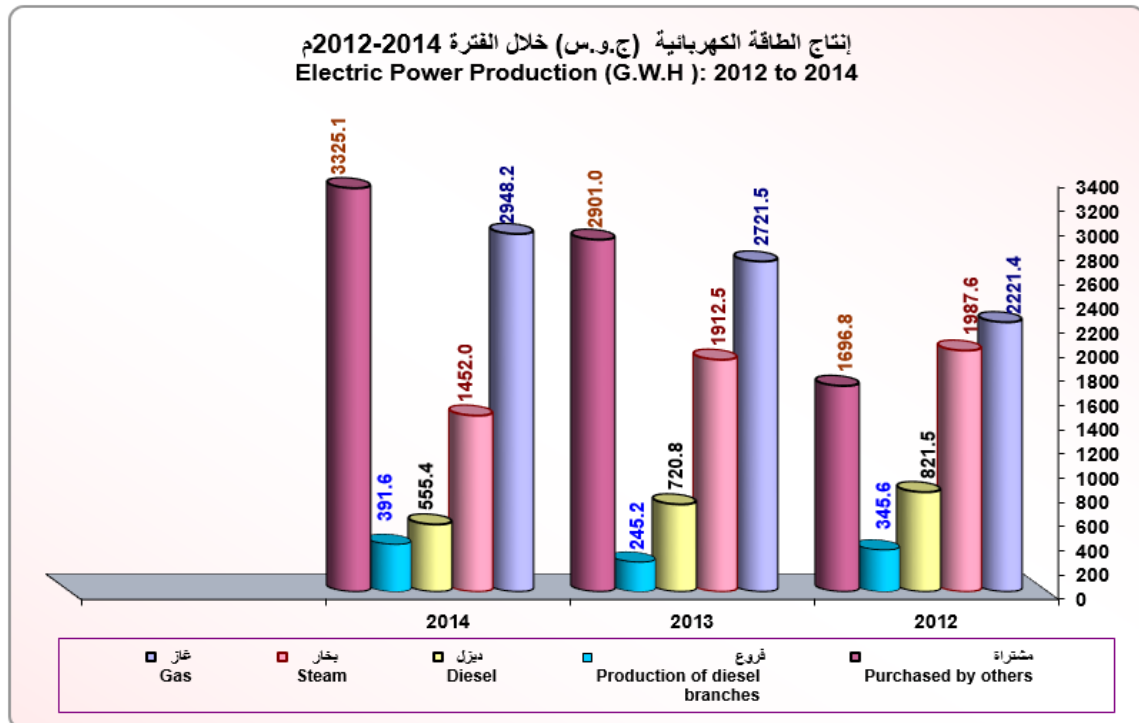


Figure 1.18: Electric Power Production (G.W.H): (2012-14)

1.4.2 Arriving of Electricity in Yemen.

The Arabian Peninsula doesn't know electric energy until 1907 when the first electric station entered Saudi Arabia, which was powered by coal and kerosene with a capacity of 20 K.W, in addition to a battery that is charged from the generator during its operation and used to light the Prophet's Mosque during the Fajr Prayer, and then came the Aden Steam Station in the south of Yemen, which was established by the British colonizer in 1926 in order to increase the British military base with electricity with a capacity of 3 MW, and finally the State of Bahrain station established in 1930 at the cost of 20 thousand pounds sterling and with a capacity of 2 k.w. Yemen has been ruled by two different forces, the first in southern Yemen, which is the British occupation, and the second is the ruling Mutawakkilite Kingdom (AL-Imam). The

beginning of the entry of electric power into the north of Yemen in the city of Hodeidah was in 1950, through two small generators, each with a capacity of (150) k.m⁵⁴. This plant has been built for the palaces of the royal family in the north of Yemen. As for the city of Taiz, the electricity began in the year 1955 with small generators in the Imam's facilities⁵⁵, with a capacity of (980) K.W. A similar company was established in Sana'a in the year 1987, and it was called the National Company for Electricity and Water, and it is the third domestic company. A small power plant was also established with a capacity of (315) K.W, but all of them had modest generating capacities, where the total production capacity of the companies in the three cities (Al-Hodeidah, Taiz and Sana'a) before the September 16, 1962, revolution reached (1.6) MW, and the number of beneficiaries in the three cities reached (10,000) subscribers⁵⁶.

1.4.3 Types of Energy Resources:

1.4.3.1 Fossil fuels Resources (FFR)

Fossil fuels, such as oil, coal, and natural gas, are non-renewable energy sources formed over millions of years from the remains of prehistoric plants and animals. These fuels are extracted through drilling or mining and are used to generate electricity or power various forms of transportation. However, burning fossil fuels releases carbon emissions, which can contribute to climate change. In the past 20 years, approximately three-quarters of human-caused carbon emissions have come from burning fossil fuels. While some fossil fuels, such as coal and natural gas are

⁵⁴ "وزارة الكهرباء والطاقة" عن الوزارة, (Ministry of Electricity and Energy), accessed March 11, 2023, <https://rb.gy/2lsda7>.

⁵⁵ Imam is a religious nickname which means King

⁵⁶ Al-Matari, Waleed. "Developing Electric Power Management to Advance Economic and Social Development in the Republic of Yemen in Arabic." Thesis, National Information Center, 29

abundant and relatively inexpensive, others, such as oil, can be more expensive and subject to geopolitical issues due to their geographic distribution.⁵⁷

They are three main types of fossil fuels:

1- Coal is the most abundant fossil fuel and is primarily used for electricity generation. It is formed from the remains of plants that lived millions of years ago and is classified into different types, such as anthracite, bituminous, and lignite, based on its carbon content and energy density⁵⁸. In 2010, at the request of the Yemeni government, consulting McKinsey firm prepared a feasibility study on the country's energy sector, the study emphasized the potential benefits of incorporating new technologies for generating electricity by coal, mainly using coal as a low-cost-effective alternative, whereas the government supports the energy sector especially oil products with \$550 million annually. The report highlighted coal's potential as a viable option for generating power in Yemen. The Yemeni Government of National Accord (YGNA) has signed a memorandum of understanding in 2012 with the Chinese National Corporation for Electrical Equipment (CNEEC) to construct two power plants in Yemen⁵⁹. The first plant, located in Aden, will have a capacity of 600 MW, while the second plant, located in Hodeidah, will have a capacity of 600 MW. Both power plants will utilize "filtered coal" technology, which is considered more environmentally friendly than traditional coal-fired power generation methods. These new power plants will help address Yemen's energy needs and support its growing economy. The private sector in Yemen has been encouraged to invest in the development of the country's energy sector. As a result, the first factory for the production of coal and wood has been established in the industrial zone of Hodeidah. The factory covers an

⁵⁷ "Fossil Fuel Energy," Student Energy Fossil Fuel Energy Source (studentenergy.org), accessed March 11, 2023, <https://rb.gy/515w4d>.

⁵⁸ "Coal," Education (education.nationalgeographic.org), accessed March 11, 2023, <https://rb.gy/vxvx4r>.

⁵⁹ Mass Company, "Coal," National Cement Company - Coal (Yemen National Cement Company), accessed March 11, 2023, <https://nccyemen.com/en/Coal.php>.

area of four hectares and has a cost of 5 million dollars. During its first phase, the factory is expected to produce 1,500 tons of coal and 21,000 tons of wood per year. These products will be supplied to the local market, with the potential for exporting to other Arab and regional markets in the future. The National Cement Company is the first company in Yemen to utilize coal for generating electricity and to produce cement using clean technology. This marks an important step forward for the country's energy sector and for promoting sustainable industrial practices⁶⁰.

- 2- **Oil**, also known as petroleum, is a liquid fossil fuel that is extracted from the ground and refined into various products, such as gasoline, diesel, and heating oil. It is primarily used for transportation and is the world's leading source of energy. Natural Gas has the same process as oil, but the natural gas process takes longer and more amounts of heat and pressure, causing more decay.
- 3- **Natural gas** is a fossil fuel that is composed primarily of methane and is often found in association with oil deposits. It is a clean-burning fuel that is used for a variety of purposes, including electricity generation, heating, and cooking. Natural gas prices in the United States declined to their lowest level in nine months due to a milder weather forecast and an increase in wind power, which reduced demand for gas-fired electricity generation. According to the latest report from the US Energy Information Administration (EIA), utilities withdrew 87 billion cubic feet (bcf) of gas from storage, which was below the market expectation of 93 bcf and the five-year average decline of 124 bcf. The Freeport LNG export plant in Texas, which was forced to shut down in June due to a fire, plans to resume operations by the end of the year. However, the company still has to complete various tasks to satisfy federal regulators before the plant can restart. Fossil fuels are a major source of energy for the world and have been instrumental

⁶⁰ Press Statement (The official Yemeni channel and Yemeni news agency Sheba), accessed March 11, 2023, <https://rb.gy/jzxzil>.

in driving economic growth and development. However, their use also has significant environmental and health impacts, including the release of greenhouse gases and other pollutants into the atmosphere. As a result, there is increasing emphasis on transitioning to cleaner, renewable energy sources.

1.4.3.2 Renewable Energy Resources (RER)

Renewable energy resources are sources of energy that are constantly replenished and are therefore considered to be inexhaustible. Examples of renewable energy resources include solar energy, wind energy, hydroelectricity (energy generated from water), and geothermal energy (energy generated from the Earth's heat). One of the major advantages of renewable energy sources is that they are generally cleaner and more sustainable than non-renewable energy sources, such as fossil fuels. Unlike fossil fuels, which release greenhouse gases and other pollutants into the atmosphere when they are burned, renewable energy sources produce little to no air pollution and have a less levelized cost of electricity as time passes. This makes them an attractive option for addressing the global problem of climate and fossil fuel prices changes. Another advantage of renewable energy is that it can be generated from a variety of sources, including the sun, the wind, and water. This means that it is possible to generate renewable energy in a wide range of locations, making it a more reliable and resilient source of energy than non-renewable sources, which are often concentrated in specific geographic areas. Despite these advantages, there are also some challenges associated with renewable energy. One of the biggest challenges is the high upfront cost of installing renewable energy systems, such as solar panels or wind turbines. These costs can be prohibitive for many individuals and communities, especially in developing countries. In addition, the intermittent nature of some renewable energy sources, such as wind and solar power, can make them less reliable than non-renewable sources. This means that they may not always be available when needed, and backup systems may be required to ensure a consistent supply of energy. Overall, renewable energy is an important part of the global energy

mix and will play a crucial role in helping to address the challenges of climate change and energy security. While there are challenges to be overcome, the development and deployment of renewable energy technologies is essential for creating a sustainable and equitable global energy system.

Some of the most common types of renewable energy include solar, wind, hydro, and geothermal.

1- Solar Energy is generated by capturing the sun's rays and converting them into electricity. This can be done through the use of photovoltaic (PV) cells, which convert sunlight directly into electricity, or through the use of concentrated solar power (CSP) systems, which use mirrors or lenses to concentrate sunlight onto a small area to generate heat that is then used to create electricity. In Yemen, solar energy is an important and abundant resource that is crucial for the country's sustainable future. According to Ministry of Electricity, the yearly average solar insolation in Yemen typically falls within the range of 5.2-6.8 kWh/m²/day. Unlike wind energy, solar PV plants can be located almost anywhere. By utilizing the few locations where wind energy is viable and expanding the proposed PV plants to a capacity of over 20 MW, it will be possible to create a low-cost, renewable energy portfolio that increases energy security⁶¹.

2- Wind energy is generated by using the wind to turn turbines, which in turn generate electricity. Wind turbines are typically located in windy areas, such as along coastlines or on top of hills or mountains. In Yemen, There are technically attractive sites for producing energy from wind energy that have the potential to generate more than 3000 full-load hours or have a capacity factor of over 35% which means it's producing power with 8 hours a day as minimum. According to a lecture given by the Minister of Electricity and Energy of Yemen, the country has the potential to harness around 17,000 MW of wind energy from the Al-

⁶¹Ahmed Abdullah, "Opportunities and Challenges for Restructuring Yemen's Post-Conflict Electricity Infrastructure Using CCGT with CCS for EOR" (dissertation, 2019), 88.

Khoukh region to the city of Hodeidah at its peak times. However, during off-peak seasons, this amount decreases to between 2,000 and 3 thousand MW. The government had plans to build a wind farm in Mocha, with a capacity of 60 MW and a cost of \$125 million. Unfortunately, due to the outbreak of political conflict in 2014, the project was put on hold and has yet to be resumed until now.⁶² Economically attractive sites, on the other hand, are those with more than 3500 full-load hours or a capacity factor of around 40%. These sites have the potential to generate about 2,507 MW of electricity and produce around 8,293 GWh of electricity per year. It should be noted that these estimates are preliminary and based on limited data. In Yemen, areas with high power concentration, such as high capacity factors and full-load hours, can be found in the coastal plains from the south of Hodiedah Governorate to Taiz, Lahej, Aden, and some parts of Abyan, as well as mountain areas in Saadah and Amran, north of Sanaa, Dhamar, Al-Beida, and Al-Dhalee. The coastal plains from central Hodiedah up to the northern tip of Hajjah as well as Abyan and Shabwa also have good potential for wind power development⁶³.

- 3- Hydroelectric energy** is generated by using the power of falling water to turn turbines and generate electricity. This is typically done by building dams on rivers, which create reservoirs of water that can be released through channels to turn the turbines. Yemen is relatively underdeveloped compared to other forms of power generation. In comparison to other forms of power generation, hydroelectric energy in Yemen is underutilized. Although there are a number of weirs present in the country, currently, there are no operational hydroelectric plants. However, the mountainous regions of Yemen hold significant potential for hydroelectric power development. The government of Yemen has recognized the potential for

⁶² The Reality of Electricity in Yemen in Arabic (SuhailChannel-YouTube, 2013), <https://rb.gy/hcf3lm>.

⁶³ Lahmeyer International GmbH, "RENEWABLE ENERGY STRATEGY AND ACTION PLAN," RENEWABLE ENERGY STRATEGY AND ACTION PLAN (MINISTRY OF ELECTRICITY, August 2006), <https://rb.gy/t1ifqc>

hydroelectric power and has plans to develop more hydroelectric projects in the future. However, due to the ongoing civil war, lack of resources and stability in the country, development of hydroelectric power has been slow.

4- Geothermal energy is generated by harnessing the heat from the Earth's core. This can be done through the use of geothermal power plants, which use steam from underground reservoirs to turn turbines and generate electricity. In addition to these common types of renewable energy, there are also other less well-known forms of renewable energy, such as tidal and wave energy, which harness the power of the oceans, and biomass energy, which uses organic materials such as wood or agricultural waste to generate electricity.

1.4.4 The Primary and Secondary Electricity Generation Plants in Yemen

The primary electricity generation plant is the first stage in the process of generating electricity. It typically involves the conversion of some form of energy, such as fossil fuels, nuclear energy, or renewable energy, into electricity, while the secondary electricity generation plant, also known as the power plant, is the next stage in the process of generating electricity. It typically involves the transmission and distribution of electricity from the primary generation plant to end users. The specific types of primary and secondary electricity generation plants that are used in a given location can vary depending on a number of factors, such as the availability of different energy sources and the technology that is in place. For example, a country that has access to abundant coal deposits may use coal-fired power plants for primary electricity generation, while a country with strong winds may use wind turbines for primary electricity generation. The secondary electricity generation plant in either case would then be responsible for transmitting and distributing the electricity to end users.

1- The Primary electricity generation plants⁶⁴

Electric power plants Secretariat's Capital:

The Amanat Al-Asimah Sanaa has six power plants that utilize internal combustion, specifically by burning diesel and diesel fuel. Two of these stations:

- 1- Dhahban plant (1):** has an installed capacity of 17 MW and consists of four units, including two generation units with a capacity of 2.2 MW each and a unit with a capacity of 3 MW, as well as a gas turbine with a capacity of 1 MW.
 - 2- Dhahban Plant 2,** on the other hand, has an installed capacity of 31 MW and is made up of five generating units, each with a capacity of 6 MW. This station began operation in 2011 and is situated on the Sana'a-Amran road, near the older Dhahban 1 station.
 - 3- Hezyez area that was recently established in three phases:**
 - A. Hazyez power plant 1:** was established in 2003 with an installed capacity of 31 MW, consisting of 6 generating units with a capacity of 2 MW each.
 - B. Hezyez power plant 2,** was established the following year in 2004 and has an installed capacity of 11 MW, consisting of a single generating unit with a capacity of 71 MW.
 - C. Hezyez power plant 3,** was established in 2006 and has an installed capacity of 31 MW, consisting of 6 generating units with a capacity of 2 MW each.
- Additionally, the city has an older power station in the Al-Qaa neighborhood, called the Sana'a plant. This station was established long ago and has an installed capacity of 79.2 MW, consisting of 6 generating units, including two units with a capacity of 2 MW each, two units with a capacity of 1.2 MW each, one unit with a capacity of 7

⁶⁴ Al-Matari, Waleed. "Developing Electric Power Management to Advance Economic and Social Development in the Republic of Yemen in Arabic." Thesis, National Information Center, n.d.48-53

MW, and one unit with a capacity of 3 MW. The station is surrounded by urbanization on all sides.

The power stations in Aden Governorate⁶⁵:

There are 19 power plants in Aden governorate 6 of them out of the service in this part the 5 power plant going to define as follows⁶⁶: Al-Mansoura Station 1 and Al-Mansoura 2 station, which both utilize combustion by burning diesel and fuel oil.

- 1- **Al-Mansoura Station 1:** is located in the Al-Mansoura district and was established in 1982 with an installed capacity of 64 MW with available capacity now of 5 MW unfortunately, current it is out of service. It is made up of 8 generating units, each with a capacity of 8 MW.
- 2- **Al-Mansoura station 2,** on the other hand, is located in the same district and is the largest diesel station in terms of capacity. It was established in 2006 and has an installed capacity of 70 MW with available capacity now of 23.3 MW, consisting of 10 generating units, each with a capacity of 7 MW. It is located on the road leading to Al-Haswa station and Al-Buraiqa area, 18 km east from the Aden refinery.
- 3- **The Khor Maksar Station,** which also utilizes combustion by burning diesel and fuel oil, is located in the Khor Maksar region of the city of Aden and was established in 1974. It has an installed capacity of 25 MW with available capacity now of 5 MW and is made up of 4 generating units, each with a capacity of 5 MW, and 3 other units, each with a capacity of about 1.5 MW.
- 4- **The Al-Tawahi station** is located in the Al-Tawahi district of the Aden Governorate. It uses combustion to generate power, burning both diesel and fuel oil. With an installed capacity of 6.3 MW with available capacity now of 2 MW, it has two generating units with a capacity of 3.15 MW each. This station is considered one of the oldest in the region.

⁶⁵ وزارة الكهرباء والطاقة "Ministry of Electricity and Energy), accessed March 11, 2023, <https://moee-ye.com/site-ar/loads/>.

⁶⁶ Al-Matari, Waleed. "Developing Electric Power Management to Advance Economic and Social Development in the Republic of Yemen in Arabic." Thesis, National Information Center, n.d.48-53

- 5- **The Al-Hiswa station**, located in the middle of the northern coast of Tawahi in the Al-Hiswa area of the city of Aden and 8 km to the northeast of the Brega region, is a thermal station that runs on diesel fuel. Established in 1986, it has two generating units with a capacity of 12 MW each. In 2009, an additional generation unit was added to the station with a capacity of 60 MW, bringing the total installed capacity of the station to 185 MW with available capacity now of 40 MW.

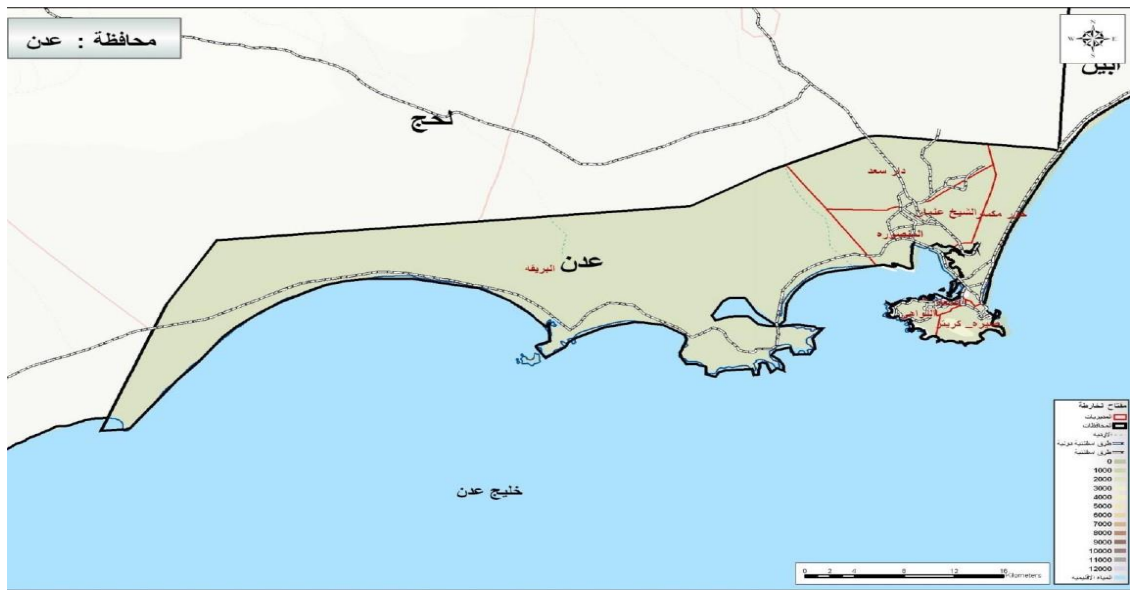


Figure 1.19: the power stations in Aden Governorate(covered areas by red lines)⁶⁷

Electric power plants in Taiz governorate:

Since 2015, the entire Taiz governorate has been without electricity service due to the disruption of main stations outside the governorate and the Osifra power station located within the city, as a result of the ongoing war. The total estimated cost of the damages is around \$21.7 million. In Taiz governorate, there are two electric power plants that have been built as follows:

- 1- **Asifrah station**, which is an internal combustion station that utilizes diesel fuel. It is located in the Asifrah district of Taiz city and is situated 1 km away from the city center. This station has a capacity of 16 MW and was established in 1979. It is made

⁶⁷ "تقارير", Reports and studies of Electricity (Ministry of Electricity and Energy, 2019), <https://rb.gy/kqplu9>.

up of two units with a capacity of 5.5 MW each and two units with a capacity of 2.5 MW each.

2- **Al-Mokha Steam power Station**, which is a central steam station that also relies on diesel fuel. This station was established in 1987 and is considered the largest generation station in terms of its installed capacity, with a total capacity of 160 MW.

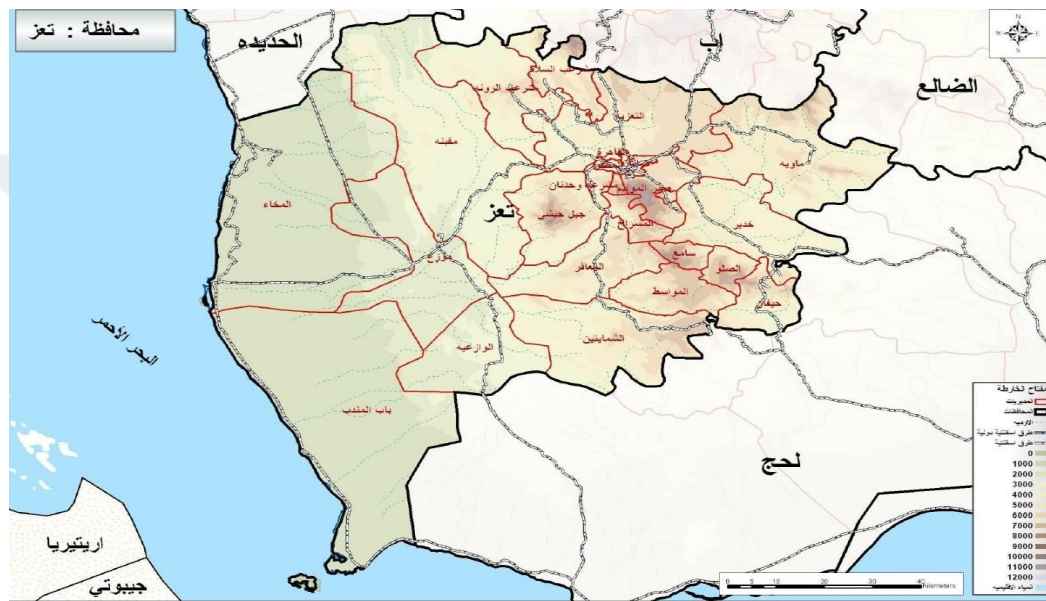


Figure 1.20: the power stations in Taiz Governorate(covered areas by red lines)⁶⁸ of 40 MW. It is located on the Red Sea coast, 7 km north of the city of Mocha. In 2018, Al-Mokha station generated 42.27 million riyals in total revenue, however, there was a significant distribution loss of 74%⁶⁹. This resulted in a significant loss of revenue for the state.

⁶⁸“تقارير”, Reports and studies of Electricity (Ministry of Electricity and Energy, 2019), <https://rb.gy/kqplu9>.

⁶⁹ “Annual Report of the Activities of the Liberated Areas for the Year 2018-Taiz” (Ministry of Electricity and Energy, 2018), <https://rb.gy/nwut1f>, Taiz file.

Electric power plants in Hadramout governorate:

- 1- **Hadramout Coast Station:** An independent system with an installed capacity of 125.5 MW, it operates by internal combustion using diesel and fuel oil. In 2018, Hadramout Coast Station generated 2.08 billion riyals in total revenue, however, there was a significant distribution loss of 43.45%⁷⁰. This resulted in a significant loss of revenue for the state.
- 2- **Wadi Hadramout station:** An independent system with an installed capacity of 54 MW, it also operates by internal combustion using diesel and fuel oil. In 2018, Wadi Hadramout Station generated 4.349 billion riyals in total revenue, however, there was a significant distribution loss of 31.46%⁷². This resulted in a significant loss of revenue for the state.



Figure 1.21: the power stations in Al-Hudaydah Governorate(covered areas by red lines)⁷³

⁷⁰ "تقارير", Reports and studies of Electricity (Ministry of Electricity and Energy, 2019), <https://rb.gy/kqplu9>

⁷¹ "Annual Report of the Activities of the Liberated Areas for the Year 2018-Taiz" (Ministry of Electricity and Energy, 2018), <https://rb.gy/u4m2n9> , Coast of Hadramout Abyan Governorate

⁷² Ibid.

⁷³ Ibid.

Electric power stations in Al Hudaydah Governorate:

1- Ras Katheeb Steam Station: located in Al-Hodeidah in Ras Kathneeb, in the northwest of the city of Al-Hodeidah, at a distance of 18 km from it, it is a steam plant consisting of 5 generating units, each with a capacity of 30MW. It relies on diesel fuel to cover its fuel requirements, it comes in second place in terms of installed capacity, with a capacity of 150 MW.

2- Al-Hali station: located in Al-Hali area in the north of the city of Al-Hodeidah, on the Al-Hodeidah-Jizan road, 4 km from the city center, it was established in 1980, with a capacity of 15.75 MW and consists of 3 generating units, each with a capacity of 5.25 MW, it operates by internal combustion by burning diesel.

3- The Corniche station: located on the Corniche road west of the city of Hodeidah, overlooking the Red Sea coast, it operates by internal combustion by burning diesel, its installed capacity is 7.5 MW, consisting of 3 generating units, each with a capacity of 2.5 MW.

The electric power plant in Marib governorate:

Marib Gas Station 1: It is a generation station that uses gas fuel, which has a lower cost compared to liquid fuel. It is located in Marib Governorate, it is the latest strategic station that aims to contribute to covering the deficit in generation capacity, and to meet the increasing demand for electric power. It consists of 3 units (gas turbines) with a total capacity of 341 MW with all its equipment. The gas consumed for gas station 1 for the year 2010 was 22.6 million (BTU), with a value of 15.8 billion riyals.

Marib Gas Station 2: it was supposed to enter service within the network of the unified electric power system in the Republic of Yemen in three phases, starting from December 2014, so that its official entry would be in March 2015, according to the statements of the Minister of Electricity and Energy at the time, Eng. Ali Al-Akwaa. However, it was stopped due to political and military events in the country and the electricity sector stopped working.

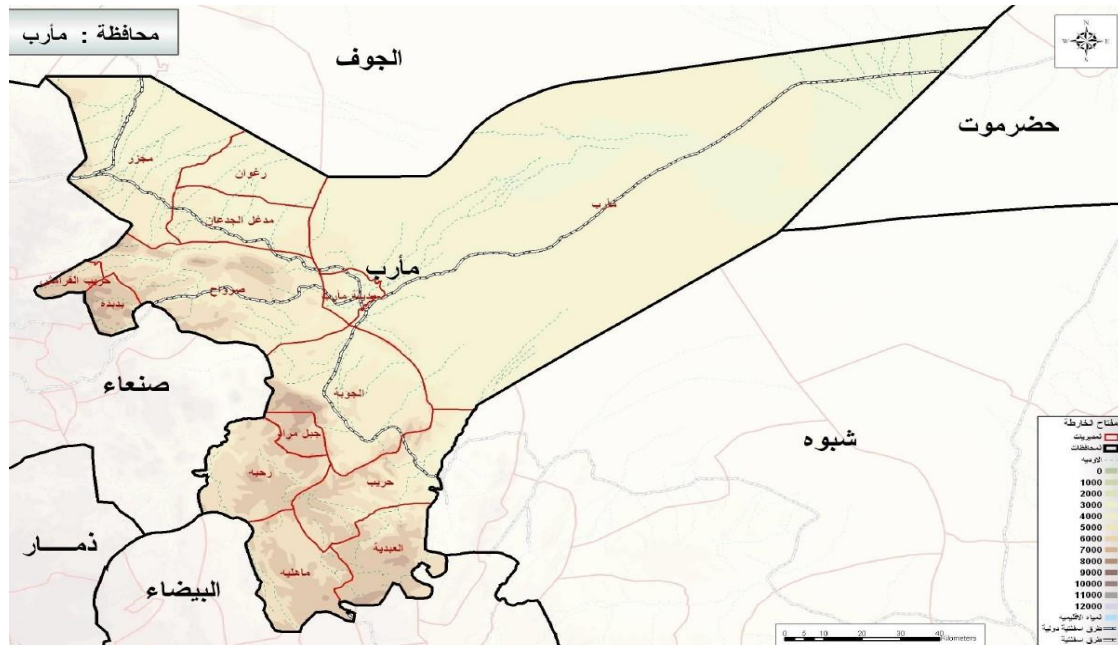


Figure 1.22: the power stations in Abyan Governorate(covered areas by red lines)⁷⁴

The electric power plant in Abyan Governorate:

In the Abyan Governorate, there is one electric power plant that has been built, the Jaar station. This is an internal combustion station that utilizes diesel fuel, the station has consumed 7.8 million Liter of diesel fuel with average of 0.289 liter for one KWH⁷⁵. The station is located in the city of Jaar, 14 km north of Zanzibar, and the capital of the Abyan Governorate. It was established in 1981 and has a total capacity of 7.4 MW with available capacity now of 2.1 MW. The station is made up of 4 units, with two units having a capacity of 2.2 MW each and two units having a capacity of 1.5 MW each.

2. Secondary Electricity Generation Plants in Yemen

In the Republic of Yemen, there are sub-generation stations in secondary cities that are not connected to the national power grid. These stations are small in size and are located in various areas in order to provide electricity to population centers in

⁷⁴ "تقارير", Reports and studies of Electricity (Ministry of Electricity and Energy, 2019), <https://rb.gy/kqplu9>

⁷⁵ "Annual Report of the Activities of the Liberated Areas for the Year 2018-Taiz" (Ministry of Electricity and Energy, 2018), <https://rb.gy/hw3hv4>, Abyan Governorate

secondary cities. There are a total of 39 of these stations spread throughout 14 governorates in the Republic. The dispersed population centers in the Republic of Yemen have led to the establishment of these stations which are small in size and spread geographically.

1.4.5 Stages of Developing Electricity in Yemen

There are several key stages in the development of electricity. These include the discovery of electric phenomena, the development of the first electrical devices and systems, the discovery and study of the fundamental principles of electricity, the invention of the first electrical generators and motors, and the growth of the electrical industry and the widespread adoption of electricity in many areas of daily life. The earliest known observations of electric phenomena date back to ancient times when people noticed that certain materials, such as amber, could produce sparks and attract small objects when rubbed with certain other materials, such as fur. This phenomenon, known as static electricity, was studied more systematically in the 17th and 18th centuries by scientists such as Robert Boyle and Stephen Gray, who conducted experiments to understand its properties and behavior. In the 19th century, a number of important developments in electricity took place. The most significant of these was the work of Alessandro Volta, who invented the first battery, known as the voltaic pile, in 1800. This device was able to generate a steady electrical current, which paved the way for the development of many other electrical devices and systems. Michael Faraday and André-Marie Ampère also made significant contributions to the study of electricity. Faraday's experiments with electromagnetic induction led to the creation of the first electric generators, while Ampère's work on the mathematical principles of electricity laid the foundation for the science of electrodynamics. As our understanding of electricity grew, so did its practical applications. In the late 19th and early 20th centuries, the electrical industry expanded rapidly, and electrical devices and systems became more common in everyday life. Today, electricity is an essential part of modern life, powering everything from computers and phones to cars and trains. The republic of Yemen has a long history of electricity development, which has gone through several stages. Below are the main stages of electricity development in Yemen:

Early Electricity Development: In the early 20th century, the first attempts at generating electricity in Yemen were made using small diesel generators. These generators were primarily used to power street lighting in the main cities.

Expansion of Electricity Generation: In the 1960s, Yemen began to expand its electricity

generation capacity by building larger diesel power plants were located in the main cities.

National Grid: In the 1970s, Yemen developed a national grid system to transmit electricity from the power plants to the main cities and towns. The national grid was initially powered by hydroelectric and diesel power plants, but it was later expanded to include natural gas-fired power plants as well. The loss in the unified network reached 26% in 2014, while in Turkey it reached 15% in the same year⁷⁶

Renewable Energy: In recent years, Yemen has started to focus on developing renewable energy sources such as solar and wind power. These renewable energy sources are expected to play a significant role in meeting the country's growing energy demand in the future.

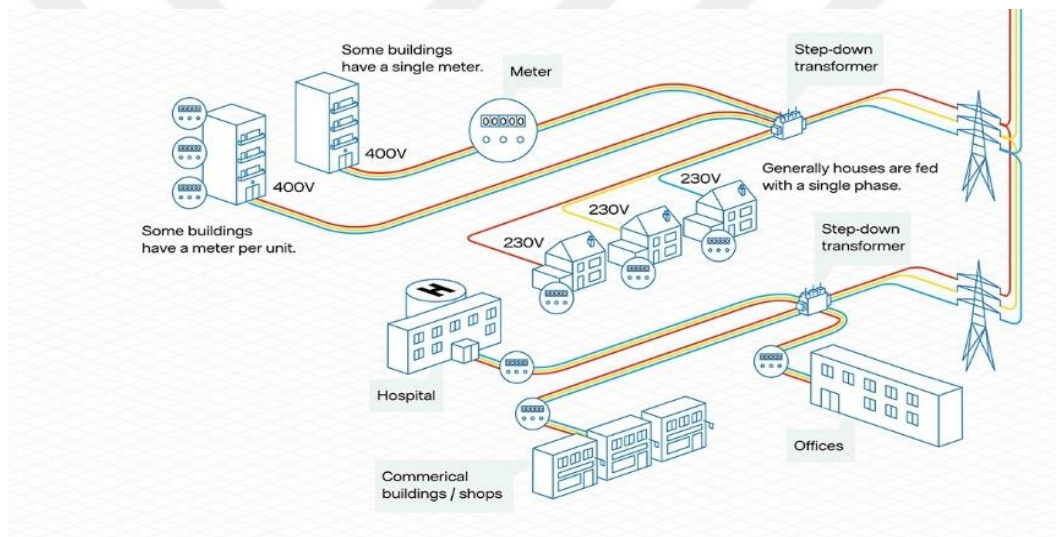


Figure 1.23: Distribution Networks Model⁷⁷

Power Outages: Despite the progress made in electricity development, Yemen still experiences frequent power outages approximately from 10-17 hours in main cities due to a combination of technical issues and political instability. These power outages can have a major impact on the daily lives of people in Yemen and the country's economy.

⁷⁶ "Electric Power Transmission and Distribution Losses (% of Output)," Data (World Bank, 2018), <https://rb.gy/xq1ha7>.

⁷⁷ "How the National Grid Works - Vattenfall IDNO - Independent ...," National Grid power sources (Vattenfall), accessed March 11, 2023, <https://rb.gy/9gs5af>.

CHAPTER TWO

ECONOMIC DEVELOPMENT & ENERGY SECTOR

2.1 The Concept of Economic Development & Growth and the difference between them.

Economic development refers to the process by which a country or region's economy improves in terms of productivity, diversification, and overall standard of living. It often involves efforts to increase economic growth, but can also include other factors such as reducing poverty and inequality, and improving infrastructure and social services. Economic growth, on the other hand, refers specifically to an increase in a country or region's GDP (gross domestic product) or per capita income over a period of time. It is often measured in terms of the percentage increase in GDP or per capita income. In summary, economic development is a broader concept that includes economic growth but also encompasses other factors that contribute to overall well-being and improvement in the quality of life. Economic growth is a narrower concept that focuses solely on the increase in a country or region's GDP or per capita income over time.

2.2 The Natural Resource Curse phenomenon

The Resource Curse, also referred to as the Paradox of plenty, is the phenomenon where countries with an abundance of natural resources, such as oil, minerals, and timber, tend to have weaker economic growth and worse development outcomes compared to countries without those resources. This can happen for a variety of reasons, including corruption and economic distortion created by the resources, as well as a dependency on resource exports which discourages the development of other industries⁷⁸.

⁷⁸ "NRGI Reader - Natural Resource Governance Institute," The Political and Economic Challenges of Natural Resource Wealth (Natural resource governance institute, March 2015), <https://rb.gy/6zewpd>, 1.

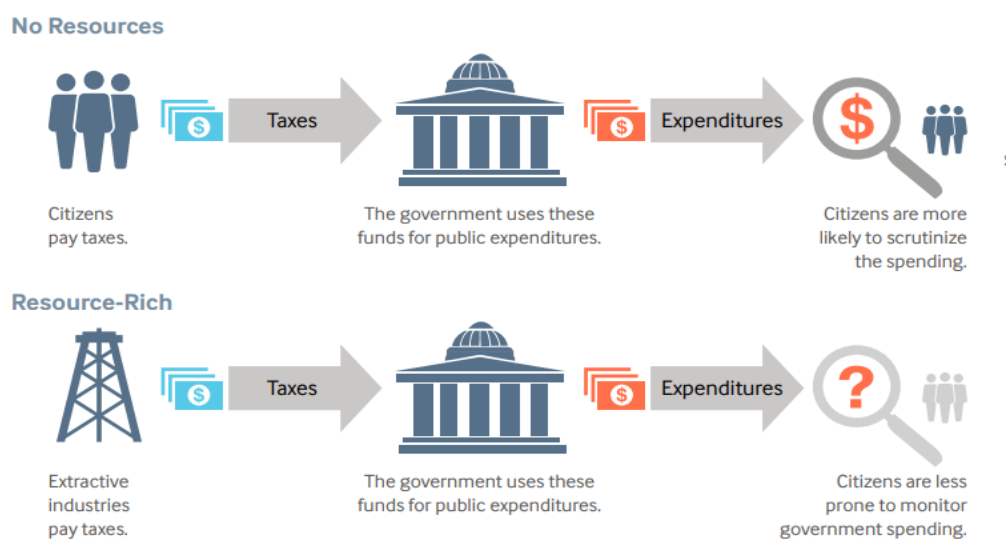


Figure 2.1: Oversight incentives in resource-rich and resource-poor countries.

(Source: NRG)

Furthermore, according to Natural Resource Governance Institute, a large increase in natural resource revenues can also lead to what is known as the Dutch Disease, which can hurt other sectors of the economy, particularly export-based manufacturing, by causing inflation or exchange rate appreciation and shifting labor and capital from the non-resource sector to the resource sector⁷⁹. In the case of Yemen, the resource curse is evident through the country's political and economic situation.

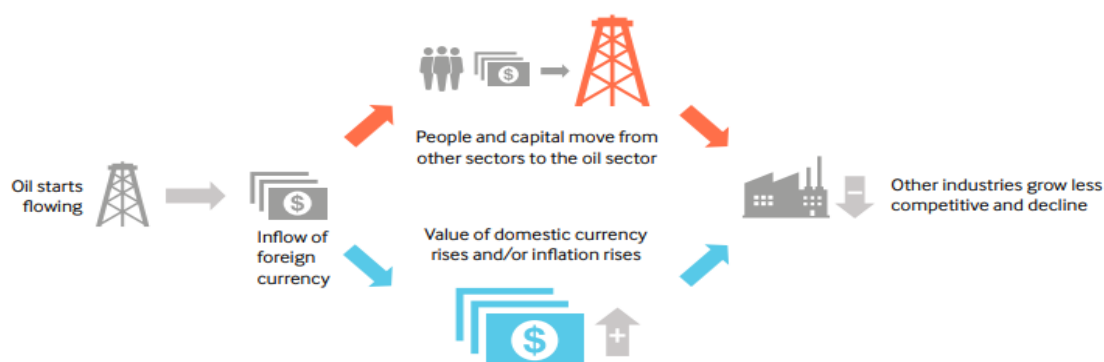


Figure 2.2: Dutch Disease (Source: NRG)

⁷⁹ “NRGI Reader - Natural Resource Governance Institute,” The Political and Economic Challenges of Natural Resource Wealth (Natural resource governance institute, March 2015), <https://rb.gy/6zewpd>, 1.

As previously mentioned, the political conflict in Yemen has resulted in the division of the country into two areas, with the North controlled by Houthi (Ansar Allah) and the South controlled by the internationally recognized government (IRG). And due to competing monetary policies implemented by these conflicting authorities, there has been a significant divergence in the exchange rate of the Yemeni Riyal. According to figure 2.3 in the southern governorates, the Riyal depreciated by over 100% against the US dollar by early December 2021. However, the introduction of a foreign exchange auction mechanism in mid-November 2021, along with the appointment of new central bank management in Aden on December 6, 2021, helped stabilize the situation, allowing the Riyal to stabilize since January 2022. Additionally, the currency has also improved due to expectations that a portion of the recent allocation of IMF Special Drawing Rights (SDRs) to Yemen will be converted in near future. Specifically, the expected conversion of \$660 million of the total \$937.6 million SDRs is expected to take place soon⁸⁰⁸¹. “The SDR allocation will boost Yemen's foreign exchange reserves by over 70%, providing much needed support to help address the crisis, including with the many urgent food and medical needs of the population,” IMF regional representative Gazi Shbaikat said in a statement to Reuters. In the northern governorates, the exchange rate against the US dollar has remained relatively stable, as a result of cash budgeting and a ban on the use of new banknotes printed after 2016. However, the sharp depreciation and rising global food prices have substantially strained the humanitarian crisis, which was already dire. Notably, food access is significantly worse in the southern governorates, where the Riyal saw substantial depreciation during most of 2021.

⁸⁰ Person, “Yemen to Get \$665 Mln of IMF Reserves in New SDR Allocation,” Reuters (Thomson Reuters, August 23, 2021), <https://rb.gy/xxafei>.

⁸¹ “2021 General SDR Allocation,” SPECIAL DRAWING RIGHTS (IMF, August 23, 2021), <https://rb.gy/97nfxn>.

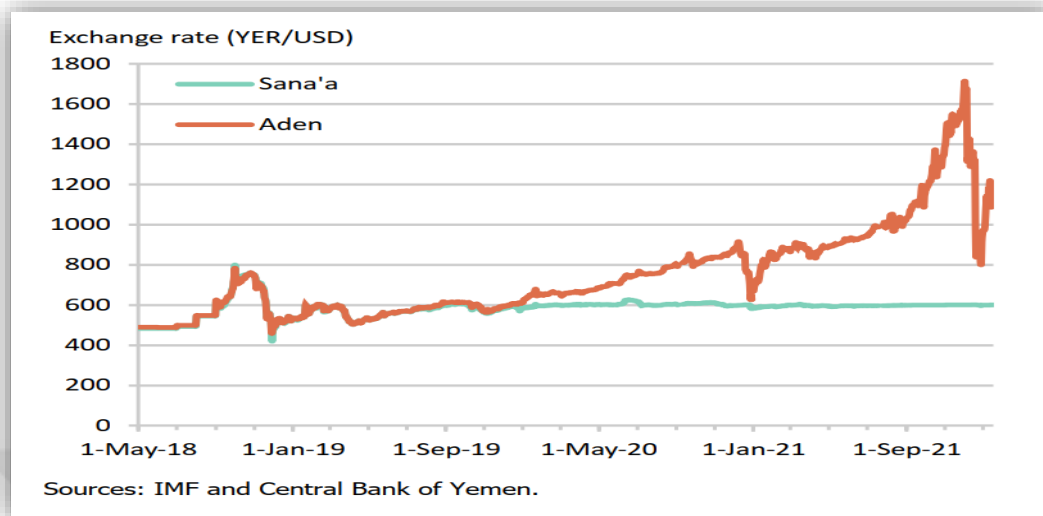


Figure 2.3: Exchange rate trend: Yemen (Sana'a and Aden bank)⁸²

Finally, as we defined a Resource Curse and Dutch disease, we should know why and when these issues happened to the state, but first let us know what is mean by the state that depends on natural resources, this type of a state called Rentier State which defined by Hossein Mahdavy: a country that receive on a regular basis substantial amounts of external rent. External rents are in turn defined as rentals paid by foreign individuals, concerns or governments to individuals, concerns or governments of a given country⁸³. Rentier states are characterized by three key features; first, the government receives rent in the form of oil revenues, as the relationship between production price and market price is weak due to oil being a strategic commodity. Second, the oil revenues are generated externally through global market activities. Third, the revenues are directly controlled by the state. However, there is no clear consensus on the exact definition of rentier states. Some measure it by the percentage of government revenue generated by oil rent. For example, Luciani proposed that states that rely on oil for at least 40% of their economic revenue can be classified as rentier states. According to this definition, Michael Herb identified the following Middle Eastern countries as rentier states for the period between 1972 and 1999: Kuwait (88%), Qatar (87%), UAE (84%), Oman (81%), Saudi Arabia (80%), Bahrain (59%), Libya (58%), Iraq (n/a), Iran (55%), Algeria (53%), Yemen (46%)⁸⁴. In recent

⁸² "Macro Poverty Outlook" (Washington DC 20433, USA: World Bank, 2022), 1.

⁸³ hossein mahdavy, "Patterns and Problems of Economic Development in Rentier States : The Case of Iran, (Harvard)" (Taylor & Francis, December 22, 2015), <https://rb.gy/duiqch>.

⁸⁴ Meliha Benli Altunışık, "Rentier State Theory and the Arab Uprisings: An Appraisal" (Uluslararası İlişkiler Konseyi Derneği, 2014), <https://rb.gy/heq9nj>, 77.

years, the percentage of Yemen government revenue generated by oil rent has heavily relied on revenues from crude oil, which accounts for a significant portion of the government's budget, a majority of the country's total exports, and a significant proportion of the gross domestic product. Specifically, crude oil revenues increased from 46% to 70% of the state's public budget, 63% of the country's total exports, and 30% of the gross domestic product⁸⁵.

2.3 Economic Development Indicators and its relation with Energy Sector

Economic development indicators are metrics used to measure the economic growth and progress of a country or region. Examples of such indicators include gross domestic product (GDP), unemployment rate, and per capita income, also, economic development indicators are closely related to the energy sector as the energy sector is a key driver of economic growth and development. The energy sector plays a crucial role in economic development, as access to reliable and affordable energy is a key driver of economic growth and poverty reduction. Energy is used in the production of goods and services, and is therefore essential for economic activity. The energy sector can also be a major source of employment and government revenue. Energy consumption is positively correlated with economic growth, as countries with higher levels of energy consumption tend to have higher levels of economic activity. However, the relationship between energy and economic growth can be complex, as factors such as energy efficiency and the mix of energy sources can also have an impact. There are many ways that energy policy can be used to promote economic development. For example, investing in renewable energy can create jobs and stimulate economic growth, while increasing energy efficiency can lower energy costs and increase competitiveness. On the report of the performance of the Yemen national economy during the year 2018, The Yemen real GDP in 2017 has the lowest percentage growth which has decreased respectively with (2177.7 billion Riyal), (724.5 billion Riyal) than (423.8 billion Riyal) at lower rates of (30.5%), (14.6%), (10%) respectively in the years of 2015, 2016 and 2017 and with increased in 2018 by 0.8%, the cumulative contraction in real GDP during the period 2014-2020 is 50%⁸⁶.

⁸⁵ "Productive Sectors" (Ministry of Oil and Minerals), accessed March 12, 2023, <https://rb.gy/qju5eh>.

⁸⁶ "YEMEN SOCIO-ECONOMIC 2020 UPDATE," 50th ed., vol. 1 (Sana'a, Yemen: Ministry of Planning & International Cooperation, OAD), 1.

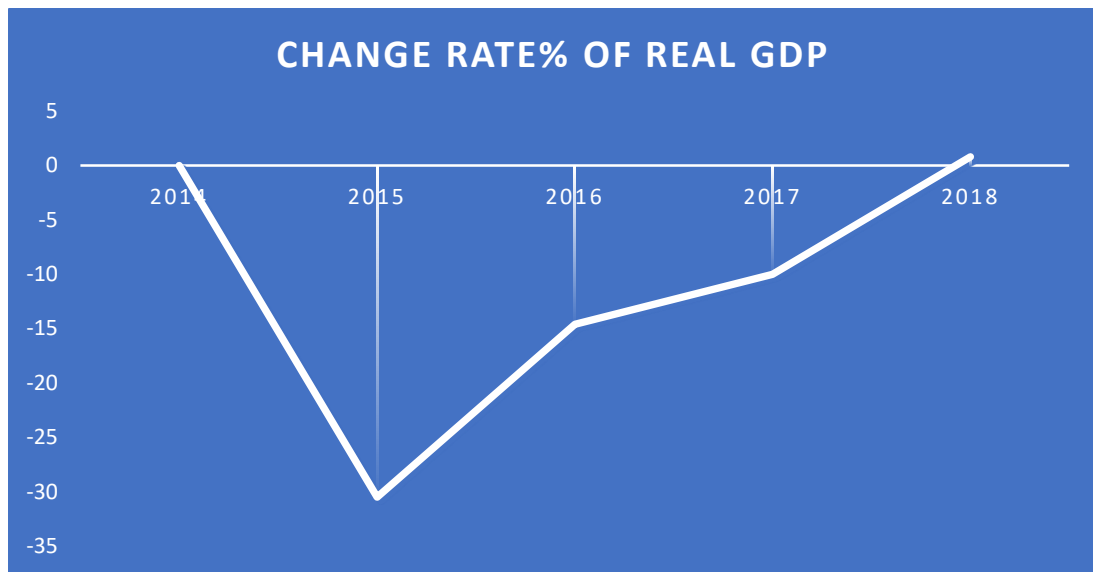


Figure 2.4: Change rate% of Real GDP

The rate of decline in real GDP in 2017 compared to 2014 was about 46.6%, in light of a population growth rate of 3%, which resulted in a decline in the average per capita share of real GDP by rates of 32.5%, 17.2%, and 12.7%, respectively within years 2015, 2016, 2017, and this is the result of the political conflict. Oil and gas production has stopped.⁸⁷

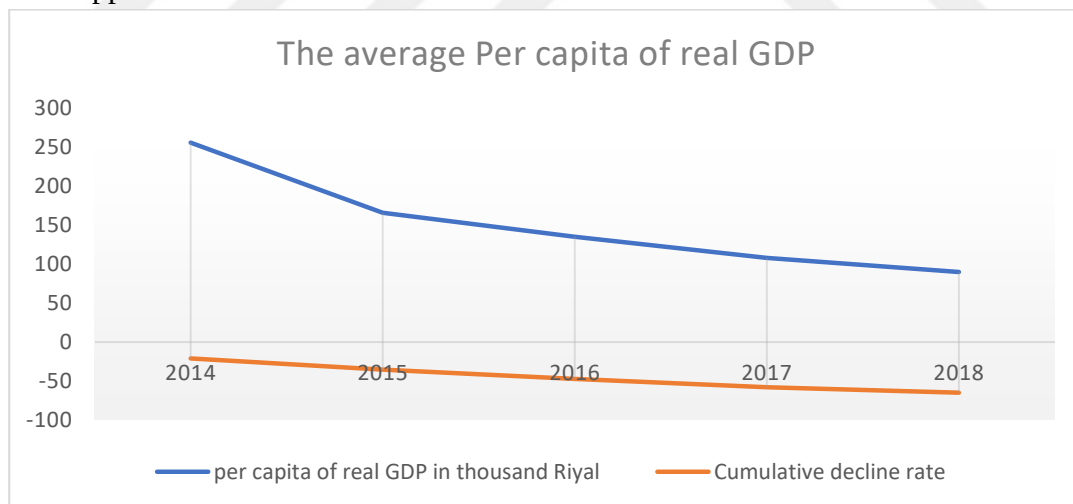


Figure 2.5: The average per capita of real GDP

⁸⁷ “The Performance of the National Economy during the Year 2018,” 18th ed., vol. 1 (Sana'a, Yemen: Ministry of Finance, 2018), 6.

Based on the Labor Force Indicators Survey in Yemen for the period 2013-2014, the overall unemployment rate was 13.3%, the unemployment rate in 2019 also increased, to around 24.8% while in 2021 decreased from 24.8 to 13.6%⁸⁸. The unemployment rate for females was 26.1%, which was 13.8% higher than the rate for males (12.3%). This indicates an increase in unemployment rate among females⁸⁹. As it can be seen from figure 2.6 the unemployment rate post university is zero in both sex male and female due to the few post-graduated students in the Yemeni labor force.

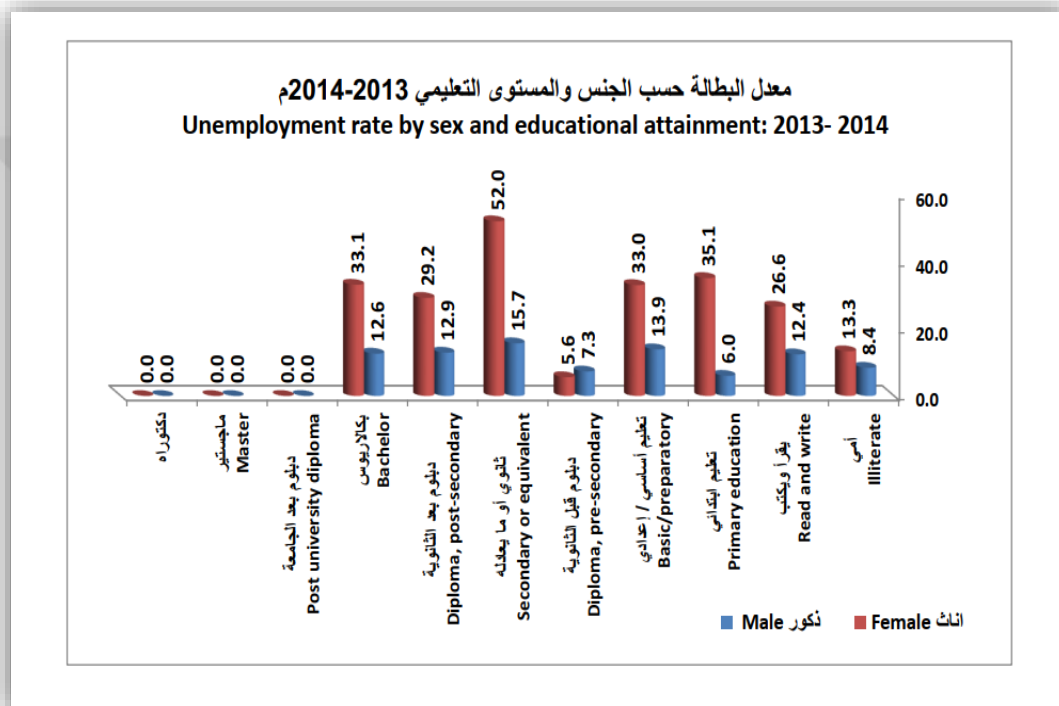


Figure 2.6: Unemployment rate by sex and educational attainment

Source: YCSO

⁸⁸ International Labour Organization, "Unemployment, Youth Total (% of Total Labor Force Ages 15-24) (Modeled ILO Estimate) - Yemen, Rep.," Data (The World bank, February 21, 2023), <https://rb.gy/m9v6ax>.

⁸⁹ Central Statistical Organization, "Statistical Yearbook 2019," 49th ed. (Sana'a, YEMEN: Central Statistical Organization, 2020), 110.

2.4 Economic Development in Yemen

According to data from the World Bank, Yemen's GDP per capita was \$701.7 in 2018, which is among the lowest in the world. The unemployment rate was also high, at around 24.8% in 2019. Inflation has been a significant issue in recent years, with accumulative rate of around 114.1% for the period 2015-2018, due to a decline in the availability of domestically produced or imported goods and services, as well as import restrictions imposed by coalition countries, particularly on oil products, the overall supply has been decreasing at an average annual rate of 21% p. This trend was exacerbated in 2018, when prices for oil products increased by 200% compared to 2014⁹⁰. The World Bank also reports that even before the crisis, poverty was on the rise in Yemen, impacting nearly half of the 29 million population. As of 2021, the situation has become worse, with an estimated 71-78% of Yemenis now living in poverty among the highest in the world, and women being particularly vulnerable⁹¹. The ongoing war has led to a disruption of basic services, with over a third of all health facilities out of service, and more than half of the total population in need of humanitarian assistance. The war also caused a significant disruption to the agricultural sector, which employs a significant portion of the population, and has resulted in the loss of crops and livestock. The International Monetary Fund (IMF) estimated that Yemen's economy contracted by around -8.5% in 2020 due to the ongoing civil war, and the IMF projects the economy will shrink by another -1% in 2021, with inflation reaching 45.7%⁹². It is important to note that the above figures are estimates and the real figures might vary as the situation in Yemen continues to be fluid and the data collection is difficult in the current situation.

⁹⁰ "The Performance of the National Economy during the Year 2018," 18th ed., vol. 1 (Sana'a, Yemen: Ministry of Finance, 2018), 8.

⁹¹ "The World Bank In Yemen-Overview" (World Bank, October 20, 2022), <https://rb.gy/ntzm7r>.

⁹² "Republic of Yemen and the IMF," IMF (IMF, October 2022), <https://www.imf.org/en/Countries/YEM>.

2.5 The Role of Energy Sector in Economic Development of Yemen

According to the Turkish Anadol News Agency, a source from the local government in the Hadramout governorate of eastern Yemen reported that a Houthi (Ansar Allah) group attack on the Al-Dhaba port in the governorate has disrupted the export of a shipment containing approximately 2 million barrels of crude oil this only amount support the government purchases and the foreign reserve, hence it stops the development efforts in country, while gas sector still feeds the domestic market with LPG but no exporting of LNG to the global market from 2015- 2023, however, the Yemeni government has tried many times to open the Balhaf facility but it could not reach to any agreement due to the control of the UAE on this vital facility⁹³. In terms of electricity production, a new conversion station has been established in September 2022 from the Marib gas station to feed the Marib city and some of its surrounding districts with power. This station which was built at a cost of \$18 million, has a conversion capacity of 176 MV and produces an excess of 56 MV beyond the domestic demand for electricity. This excess energy will be directed towards investment and the increasing growth of energy demand. The station saves a monthly revenue of 5 million dollars and 450 thousand liter/day of diesel for the state, totaling 60 million dollars per year, which makes the government dispense with energy purchased from foreign companies and locate this revenues to development Processes⁹⁴. The governorate of Marib is considered the most important developmental indicator of the importance of the energy sector in development, as the governorate, after meeting its energy needs, has undertaken development projects in the field of education and health for an amount exceeding one billion and 200 million riyals in 2023, as the governorate is witnessing a large development and investment movement in parallel with the improvement of services and the growth of

⁹³ “From Gas to Torture... a Yemeni Facility That the UAE Has Turned into a Prison (in Arabic)” (the Turkish Anadol News Agency, November 22, 2022), <https://rb.gy/p1xdnp>.

⁹⁴ “Marib | Re-Opening of the Gas Station after It Stopped during the Past Years in Arabic,” YouTube (Yemen Today satellite channel, October 3, 2022), <https://rb.gy/xl9dnr>.

infrastructure due to the new conversion station of electricity⁹⁵. The current energy situation in Yemen is characterized by a lack of access to reliable and affordable energy particularly in rural areas, as a result of the stopping of the Marib gas station and some national stations, and the exit of the national network from service, the electricity sector in the areas controlled by Ansar Allah al-Houthi turned into a private sector, and in the areas controlled by the internationally recognized government, the government stations that barely cover some hours of the day with 132 MW deficit in Aden city only. Recently Marib covers the demand for electricity by operating one turbine from the Marib gas station, and this resulted in an urban development movement in many sectors. Now Marib is considered a destination for Yemenis for stability and investment, as the number of residents in the city of Marib has reached 3.143106 millions of citizens.⁹⁶⁹⁷. The Yemeni government has divided the rural population into four categories based on their access to the national electricity grid. The first category includes those who have easy access to the grid, while the second category has slightly higher-cost access. The third category can only access the grid at a high cost, and the fourth category, which has the highest cost and least accessibility, faces difficulties in accessing the grid. Approximately 75% of the total population in Yemen reside in rural areas, however, only a mere 23% of these rural residents have access to electricity due to the fourth category (highest cost and difficult accessibility), whereas 85% of the urban residents have access to electricity because of the third category (can only access the grid at a high cost)⁹⁸. This shortage of a stable power supply greatly hinders industrial development and restricts

⁹⁵ “Undertaken Development Projects in the Field of Education and Health” (The official website of Ma'rib Governorate on the Internet, January 27, 2023), https://marib-gov.com/news_details.php?lng=arabic&sid=4403.

⁹⁶ - خاص مأرب, “Official Report: The Population of Marib Governorate Is More than 3.1 Million People in Arabic,” المهرية نت (Almahriah.net, August 26, 2022), <https://almahriah.net/local/22115>.

⁹⁷ وزارة الكهرباء والطاقة, “الاحمال اليوم- Daily Electricity Loads in Arabic,” (Ministry of Electricity and Energy), accessed March 11, 2023, <https://moe-ye.com/site-ar/loads/>.

⁹⁸ Al-Wesabi I;Zhijian F;Bosah CP;Dong H; “A Review of Yemen's Current Energy Situation, Challenges, Strategies, and Prospects for Using Renewable Energy Systems,” Environmental science and pollution research international (U.S. National Library of Medicine, February 6, 2023), <https://pubmed.ncbi.nlm.nih.gov/35729377/>.

electricity usage to primarily household purposes. The majority of the country's energy supply comes from fossil fuels, such as oil and natural gas, although the use of renewable energy sources such as solar and wind power is growing. One of the main challenges faced by the energy sector in Yemen is the instability caused by the ongoing conflict, which has disrupted energy production and distribution. The conflict has damaged infrastructure, including national grid with its power transmission lines, leading to frequent blackouts and reduced access to energy, another challenge is the limited investment in the energy sector, which has led to outdated and inefficient energy production and distribution systems. This has resulted in high energy costs and reduced competitiveness for businesses. There is also a lack of diversification in the energy mix, with a heavy reliance on fossil fuels, which are subject to price volatility and global geopolitical factors. This makes the energy sector vulnerable to shocks and contributes to high energy costs for consumers. In addition to these challenges, there are also challenges related to energy governance, including weak institutions, high corruption, and a lack of transparency, which hinder the development of the energy sector and its ability to drive economic growth.

2.6 Oil and Gas Proportion Contribution to Yemeni GDP 2010-2014

Oil and Gas are the most important main energy supplies in Yemen, almost all of the output of oil and mining activities are half of the industrial output of Yemen in the 1990, or 13% of the output GDT during the period 1990-2000, as the percentage of oil supplies in 2000 reached 94.4%, while the percentage of oil supplies decreased to 76% of the total energy supplies, while natural gas entered the energy sector by 16% after the establishment of two units for gas processing and a facility in Belhaf for the export of liquefied gas⁹⁹. Despite a reduction in oil sector significance, the oil sector remains a crucial contributor to the nation's economy and its future growth. In 2005, the sector's contribution to the real GDP has decreased to 4.12%, compared to 17% in

⁹⁹ Al-Wesabi I;Zhijian F;Bosah CP;Dong H; “A Review of Yemen's Current Energy Situation, Challenges, Strategies, and Prospects for Using Renewable Energy Systems,” Environmental science and pollution research international (U.S. National Library of Medicine, February 6, 2023), <https://pubmed.ncbi.nlm.nih.gov/35729377/>.

2000, due to a decline in annual crude oil production by an average of 7.2% per year, even with efforts to maintain stability of the oil production. The value added by crude oil extraction has seen a slight decline of 2.2%, leading to a decrease in the sector's relative importance in the GDP. Several factors have helped to reduce the decline in production levels, most notably the ongoing development of producing fields and new explorations. On the other hand, global oil prices recorded a significant increase, exceeding expectations and ranging from \$27.4 to \$51.5 per barrel, which boosted revenue from oil exports¹⁰⁰. The oil and gas sector is a major source of resources for the state's general budget, as oil and gas revenues in 2014 contributed about 45.4% of total revenues and covered about 40% of public expenditures, so the discontinuation of this commodity since the end of March 2015 had a great impact on halting development efforts in the country¹⁰¹. Achieving rapid and sustainable economic growth (more than 5% annually) is essential in order to alleviate poverty in Yemen. This was realized in the second five-year plan drawn up by the government. However, this goal is considered a great challenge and requires making courageous changes to the fullest extent, in the general environment for business activities and in the structure of good governance alike, as well as removing tangible growth obstacles to growth in certain economic sectors such as the oil and gas sector, which are two of the most important sectors that accelerates development strongly¹⁰². The increase in public revenues from 22.4% of GDP in 2009 to 27.5% in 2010 was primarily due to the contribution of oil and gas revenues which have increased in 2010 to 17.6% compared to 12.5% in 2009, while in 2015, the contribution of Energy sector decreased to 4.1% from 14.6 in 2014 due to the in progress conflict¹⁰³.

¹⁰⁰“The Third Economic and Social Development Plan for Poverty Alleviation 2006-2010 in Arabic” (Ministry of Planning & International Cooperation and UNESCO, August 2006), <https://rb.gy/4ohal2>, 4.

¹⁰¹ “The Performance of the National Economy during the Year 2018,” 18th ed., vol. 1 (Sana'a, Yemen: Ministry of Finance, 2018), 20.

¹⁰² “Economic Growth in the Republic of Yemen: Sources, Obstacles, and Possibilities in Arabic” (Worldbank, May 2002), <https://rb.gy/xljobd>, 23.

¹⁰³ CBY, “Annual Report,” vol. 1 (Sana'a, Yemen: Central bank of Yemen, 2011), 12.

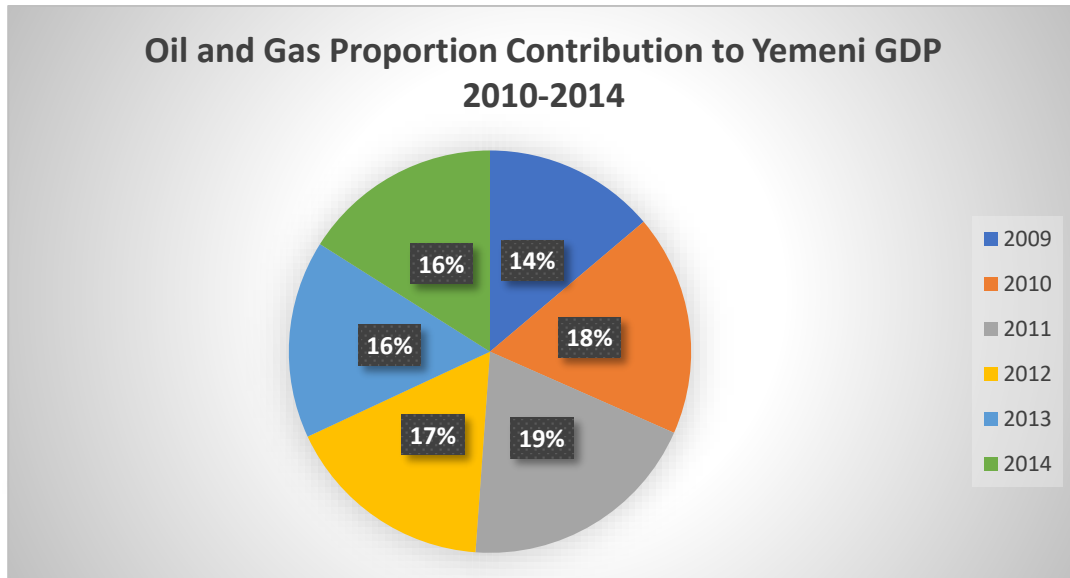


Figure 2.7: Oil & Gas Proportion Contribution to Yemeni GDP 2010-14 Source: CBY

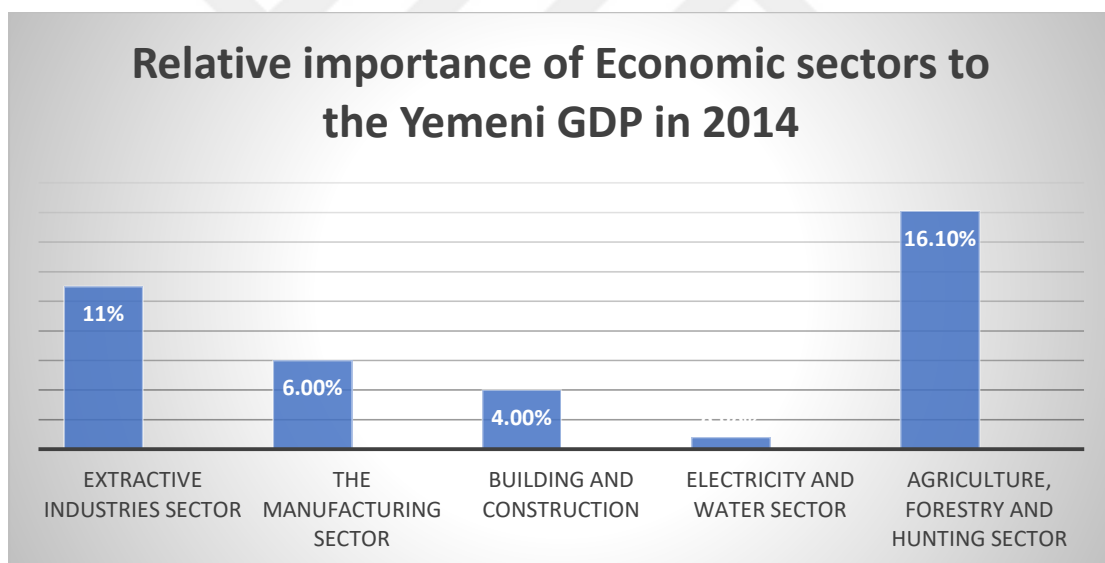


Figure 2.8: Relative important of Economic sectors to the Yemeni GDP in 2014
Source: CBY

2.7 Oil and Gas Sector in Trade Balance.

The trade balance is a term used to describe the difference between the value of a country's exports and imports of goods over a specific period of time, typically a year. If the value of exports exceeds that of imports, the trade balance is said to be positive or to have a surplus, while a negative trade balance or a deficit occurs when imports

are greater than exports. The trade balance is an important measure of a country's international trade performance and is often used to assess the strength of its economy. However, a trade deficit does not necessarily indicate an economic weakness, as it may result from factors such as high levels of domestic consumption, strong investment, or strategic decisions made by businesses¹⁰⁴. Oil and gas exports are the main influence in any change in the trade balance, as this effect lies in raising or lowering the deficit in the trade balance, raising the level of inflation, or reducing foreign exchange reserves, and all this influence comes through the amount of oil production or fluctuations in oil prices. The oil and gas sector is considered the main artery for feeding the Yemeni government with hard currency, with slight revenues for other sectors. The attacks of Ansar Allah (Houthis) on the oil fields, in addition to the drop in oil prices, continue to negatively effect on the Yemeni economy. Ansar Allah (Houthis), who controlled the capital of Yemen and several other cities in the north as well as state institutions, forced the Yemeni president to resign on January 2014. And then the Yemeni government submitted its resignation. Yemen's foreign exchange reserves fell to \$4.6 billion (equivalent to 6.4 months of imports) as oil exports declined due to the continuing insurgency coupled with low oil prices and Saudi Arabia's suspension of most of its aid. It was using foreign exchange reserves to support the currency as oil exports declined. Yemen's reserves include a \$1 billion deposit made by Saudi Arabia in 2012. Data from the central bank of Yemen shows that oil revenues fell by half, to \$4.0 billion in January-October 2014, from \$2.4 billion in 2013. Although no more recent data is available, the sharp drop in oil prices is expected to have added to the deterioration of fiscal revenues a month ago October. Oil and gas account for more than three-quarters of fiscal revenues¹⁰⁵. In the past years, Yemen's main source of income was crude oil, which accounted for 70% of the

¹⁰⁴ Glossary: Trade balance - Euro stat Statistics Explained (Euro stat Statistics Explained), accessed March 12, 2023, <https://rb.gy/uggvsg>.

¹⁰⁵“World Bank Document,” Quarterly economic summary for a region Middle East and North Africa in Arabic (World Bank, January 2015), <https://rb.gy/ydxc8e>, 24.

government's public budget resources, 63% of total exports, and 30% of the GDP¹⁰⁶. Oil and its products recorded an increase of 9% during 2010, compared with a fall of 15.5% last year, attributable basically to the rise of international oil prices and the increase of LNG quantities exports, while Imports during 2010 grow by 8 %, compared with a decline of 11% during 2009. This is mainly due to the increase in imports of oil and food stuffs. The decrease in the trade deficit is credited to the increase in oil and gas exports. In 2010, the trade balance showed a deficit of \$982.4 million, compared to a deficit of \$2012.8 million in the previous year. The deficit as a percentage of GDP dropped from 7.1% in 2009 to 3.4% in 2010¹⁰⁷. From Exchange Rate side, the Yemeni rial has been nearly pegged to the US dollar (at 214 riyals for US\$1) since 2011. However, the rial has been under great pressure to devalue since the outbreak of the political crisis in 2011, and the reserves of the Central Bank of Yemen, which cover currently about 4 months of imports, to be used to support the national currency. In light of the decline in oil prices and the subsequent decline in foreign exchange reserves, it is likely that the pace of pressures on the exchange rate will accelerate unless Yemen receives assistance from its partners¹⁰⁸.

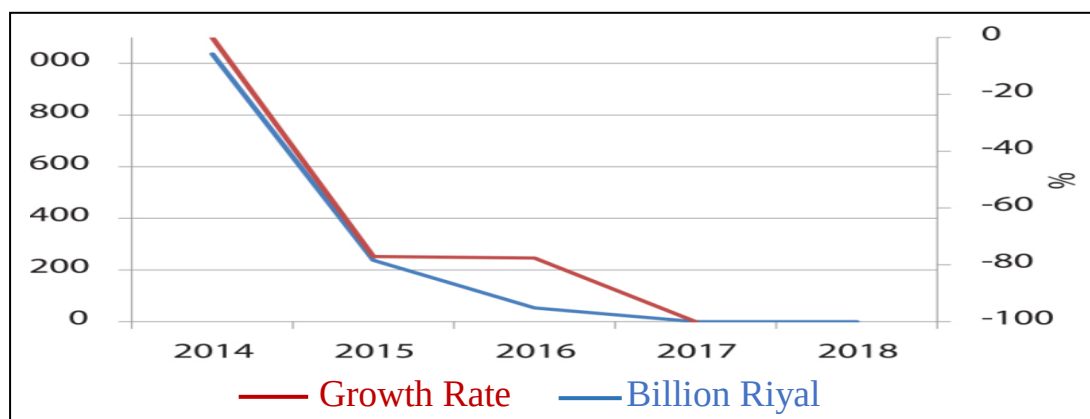


Figure 2.9: Oil and Gas Revenues Growth Rate¹⁰⁹

¹⁰⁶ "Productive Sectors," Ministry of Oil and Minerals (MOM), accessed March 10, 2023, <https://rb.gy/tghhx9>.

¹⁰⁷ "Annual Report," vol. 1 (Sana'a, Yemen: CBY, 2010), 57.

¹⁰⁸ "Improving Skills Development in the Informal Sector," Improving skills development in the informal sector (World Bank, 2015), <https://rb.gy/xbad3d>, 25.

¹⁰⁹ "The Performance of the National Economy during the Year 2018," 18th ed., vol. 1 (Sana'a, Yemen: Ministry of Finance, 2018), 16.

2.8 Oil and Gas Sector and Inflation Rate.

“Inflation rate measured by consumer price index (CPI) is defined as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households. Inflation is measured in terms of the annual growth rate and in index in base year”¹¹⁰. The oil and gas sector is considered as the main influence on the level of inflation and the purchasing power of the Yemeni consumer, as the increase in oil and gas exports increases foreign exchange reserves, and thus the value of the Yemeni rial rises against other currencies, which leads to an increase in the purchasing power of the Yemeni consumer and a decrease in commodity prices in the market.

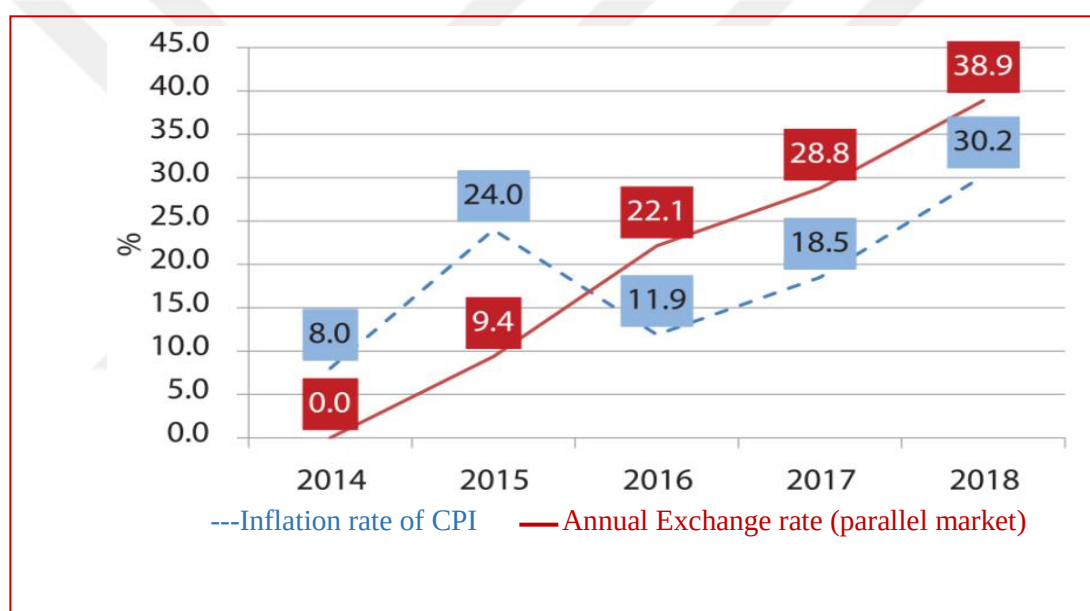


Figure 2.10: Inflation rate

As it can be seen from figure 2.9 and figure 2.10, when the oil and gas revenues decrease, the inflation rate and exchange rate increase which means there is a negative relationship between oil and gas revenues and inflation rate and exchange rate, this gives the indication that prices of oil and gas play a significant role in stabilizing of the Yemeni market and vice versa. As noticed from these figures, in 2014, 2015, 2016, 2017 and 2018 as oil and gas revenues decrease the inflation and exchange rate increase, the year of 2016, 2017 and 2018 improved that when there are no oil and gas revenues the inflation rate and exchange rate started to be rising rapidly from 9.4% in 2015 to 22.1% in 2016.

¹¹⁰ Prices - inflation (CPI) - OECD Data (OECD, 2023), <https://data.oecd.org/price/inflation-cpi.htm>.

2.9 Oil Products Subsidies & Its Effect in Foreign Currency Reserves.

“The IEA finds that after a noticeable dip in 2020 due to the Covid-pandemic, energy subsidies have been rising again since 2021. Preliminary estimates for 2022 point to global subsidies doubling from the previous year to an all-time high of USD 1 trillion¹¹¹”. Oil product subsidies refer to financial assistance provided by governments to reduce the cost of oil products, such as gasoline, diesel, and other petroleum-based fuels, to make them more affordable for consumers. Subsidies can take various forms, such as direct cash transfers, tax exemptions, or price controls. The aim of oil product subsidies is often to protect consumers, particularly the poor, from the volatility of global oil prices and to support economic development. However, oil product subsidies can have significant negative impacts on national economies, including fiscal deficits, distorted market signals, and inefficiencies in the use of energy. In addition, subsidies can encourage the smuggling phenomenon that smugglers benefit from, but the simple consumer who owns a car uses a few liters and who does not own a car does not benefit from this subsidy at all. Many countries have undertaken efforts to reform their oil product subsidies including reducing or eliminating them altogether. This has often been a challenging and politically sensitive process, particularly in countries where subsidies have become deeply ingrained in the economy and society like in Yemen whereas Yemeni government supports petroleum products and electricity, in 2008, Yemeni government spend 96.49 million US dollars in 2015 and electricity in 2010 with 23.15 million US dollars. The Yemen government's support for petroleum products reached its peak level in 2008 with \$3,800.28 billion US dollars and last electricity support was in 2010 with 23.15 million US dollars because the political conflict started in 2011¹¹². Subsidies for petroleum products and electricity are fed through oil and gas revenues through the trade balance. For these subsidies reaches low-income, some countries have

¹¹¹ Iea, “Energy Subsidies – Topics,” Energy subsidies – topics (IEA), accessed March 12, 2023, <https://www.iea.org/topics/energy-subsidies>.

¹¹² Ministry of financial, Annual report, 2015 p: 94 and CSO, Year book, 2017

implemented targeted subsidy programs aimed at supporting low-income households or promoting the adoption of cleaner energy sources. The exports of oil and gas have been the largest source of foreign currency contributing to the filling of the Central Bank's foreign currency reserves. This has enabled the bank to achieve its main objective as stipulated in Law No. 14 of 2000 by maintaining a reasonable degree of stability in the prices of basic commodities. In 2014, oil and gas export revenues amounted to nearly 6.4 billion US dollars, or 36% of the foreign currency inflows into the country, while the remittances of Yemeni expatriates into the country were estimated to be around 3.3 billion US dollars, or 18% of the sources of hard currency in Yemen, on the other hand, the supporting of oil products are reduce the foreign reserves due to import oil products for feeding the Yemeni market, At the end of January 2014, the foreign reserves of the Central Bank amounted to 1123.9 billion Yemeni Riyals, equivalent to 5230.3 million US dollars, covering 5.6 months of imports, compared to 1149.7 billion Yemeni Riyals, equivalent to 5350.3 million US dollars, at the end of December 2013. It is noteworthy that the level of foreign reserve coverage for imports is acceptable, despite the Central Bank's continued provision of significant amounts of foreign currency to import oil products and basic foodstuffs, which amounted to about 320.5 million US dollars during January 2014¹¹³.,,,

2.10 Using Gas Instead of Oil Products to Feed Domestic market.

Gas production in Yemen was directed to the local market until natural gas was discovered in Sector 18 in Marib-Al-Jawf in 2008, the government began constructing gas transport pipelines and then building a facility in Balhaf to liquefy natural gas (LNG) with an annual production capacity of 6.7 million metric tons and export it through its port located on the same location. The Belhaf facility started exporting liquefied natural gas in 2009. Unfortunately, the Balhaf project for the production of liquefied gas involved great corruption and waste of national wealth. Instead of exporting gas to the global market, the government should have fed the Yemeni

¹¹³ CBY, "Annual Report," vol. 1 (Sana'a, Yemen: Central bank of Yemen, 2014), ي.

domestic market with this national commodity, which suffers from a shortage of gas supplies for homes, cars, and national gas-fired power plants. The growth rate of demand is % 3 annually. Despite this, the government has allocated only one trillion cubic feet for domestic consumption, while 9 trillion cubic feet for export during the signing of the Yemeni gas sale agreement, the Yemeni domestic market consumed 5.019383 million metric tons of LPG from 2009-15 total 7 years whereas the government exports 6.7 million metric tons of natural annually, the rate of the exporting is fast then domestic demand which means that after few years, the gas quantities run out as a result, there will be no gas for either domestic consumption or export¹¹⁴¹¹⁵. Switching from oil products to gas for domestic consumption in Yemen could have several potential benefits. Here are some key points to consider, Cost Savings, Natural gas is often cheaper than oil products, which could lead to cost savings for consumers in Yemen. This could be especially important in a country where many people are struggling with poverty and food insecurity. Diversification of Energy Sources, Yemen currently relies heavily on oil products for electricity generating, cooking food in homes, cars and a few petrochemical industries, which makes the country vulnerable to price fluctuations and supply disruptions. Switching to natural gas could provide a more diverse and stable source of energy and less support for oil products and electricity which consume at least 4 billion dollars from the foreign reserves thus, it will be a burden on the public budget. In the session of the Yemeni Parliament on the corruption of the Ministry of Electricity on July 4, 2009, a member of the Yemeni parliament, Abdo Muhammad Bishr, spoke about the cost and electricity purchased from others. He stated that the Ministry of Electricity buys 286 MW of the electricity, with a loss of 86 Mw, at an amount of 7 million USD per month for 12 months = 84 million USD, with the payment of an amount of 40 million USD, as subsidies for the power station purchased in its purchases of petroleum

¹¹⁴ "Project Components," Upstream (Yemen LNG Company), accessed March 11, 2023, <https://rb.gy/5ah4h0>.

¹¹⁵ Planning and follow-up department, "The Annual Report on the Company's Activities and Achievements," vol. 1 (Sana'a, Yemen: Yemen Gas Company, 2015), 13.

products, and according to the representative, the cost of establishing gas stations to generate electricity with a capacity of 2000 Mw will cost 720 million USD for installing and , while the cost of purchasing 286 Mw from others will cost the state 574 million USD¹¹⁶, as can be seen from figure 2.10, the average construction cost of Kilowatt in 2020 for NG power plant is 1116 USD per Kw¹¹⁷ that means if the government wants to produce 2000 Mw by CCGT-NG, the total estimated cost will be 2.232 billion USD + 0.04454 \$/Kwh¹¹⁸, 32.5142 million USD for 2 million Kw the annually Average Power Plant Operating Expenses, the total is 2264.5142 million USD, with the lifetime of the CCGT plant is 30 years¹¹⁹. The 2014 budget projects included expenditures within the framework of the various social security programs, an amount of 331 billion riyals, equivalent to 1.540 billion USD to subsidize oil products, at a rate of 11.5% of total public expenditures, when the price of a barrel of crude oil is fixed at 75 USD. At the level of \$100 per barrel, the volume of subsidies will far exceed this amount and will constitute a heavy burden on public expenditures. The second gas stations of Marib were to supply the national grid with a capacity of 400 MW, with the addition of some electricity transmission towers, with co-financing from the Yemeni government by 69%, and the Arab Fund for Economic and Social Development by 31%, at a cost of 337 million USD, but unfortunately, work on it was stopped because of the outbreak of the conflict politics in 2011¹²⁰. Although the electricity sector has experienced a significant growth rate of 86%, which is essential for attracting and securing investments, and has a positive impact on the overall economic growth and improvement of the average per capita income, leading to strengthened anti-poverty policies and improved living standards for citizens, it is

¹¹⁶ Yemeni Parliament, session of July 4, 2009

¹¹⁷ "Electricity," Electricity - Construction cost data for electric generators installed in 2020 (EIA, 2020), <https://www.eia.gov/electricity/generatorcosts/>.

¹¹⁸ Average Power Plant Operating Expenses for Major U.S. Investor-Owned Electric Utilities, 2011 through 2021 (Mills per Kilowatthour) (EIA, 2021), <https://rb.gy/rar16n>.

¹¹⁹ IEA and NEA, Projected-Costs-of-Generating-Electricity-2020,P:36

¹²⁰ Construction of a Second Maarib Gas-Turbine Power Generating Station and the Expansion of the Transmission Grid (The Arab Fund for Economic and Social Development, March 27, 2007), <https://rb.gy/jdlvza>.

evident that corruption within the msector consumes foreign reserves, increases the trade balance deficit and the public budget without providing any improvement in service provision or sustainable development. In 2010, the Yemeni government approved a budget of 403,513 million riyals, equivalent to \$1.8 billion, for the electricity sector, but the sector's current state highlights the need for reforms to address the issues of corruption and lack of sustainable development¹²¹. The Liquefied petroleum gas is a national commodity that touches the life of the Yemeni citizen, one metric ton contains 86 domestic gas cylinders, and each cylinder of 20 liters is approximately 11.5 kilograms. The total consumption of the Yemeni domestic market in 2016 amounted to 552 thousand metric tons, which equals 47.472 million cylinders, -16% less than 2015, and due to the lack of gas supplies from Marib city as a result of the political conflict. Gas cylinders for domestic gas were sold until 2015 at a price of 1200 riyals, equivalent to 5 USD, at an exchange rate of 220 riyals per USD, although with the beginning of 2016, its price increased to 6000 riyals, equivalent to 12.8 USD, at an exchange rate of 550 riyals per USD¹²². The public transportation is appropriate for transferring the low income of the Yemeni individual which prefer to use it instead to owning his own car which needs money and time to provide it with gasoline or NG and maintenance. Public transportation is a private sector and cheap and saves time for the citizen instead of going in his own car to fill it up and wait in long lines for a period that may exceed a day or two due to lack of oil products, Cars use natural gas, which is cheaper and cleaner than gasoline and diesel for public transportation consumption. The total quantities draw out from Marib and Aden refineries in 2015 amounted to 700 thousand metric tons only 52 thousand of the total quantities drawled were allocated to fill cars at a price of 411 riyals per liter, as this quantity is not sufficient as a result of the continuous increase in cars that convert from gasoline to cheaper gas in the same year, the private sector imported 5,000 metric tons in order to meet the demand of 16 companies in the private sector. The

¹²¹ Ministry of Finance, Yemen, The financial report of the fiscal year 2010, p:20,21,23

¹²² Planning and follow-up department, "The Annual Report on the Company's Activities and Achievements," vol. 1 (Sana'a, Yemen: Yemen Gas Company, 2015), 8,13.

importance of shifting the domestic market from oil products to natural gas has an economic feasibility in terms of reducing pressure on foreign exchange reserves, which consume the largest part of them in subsidizing and covering the bill of a importing oil products, and on the other hand, reducing the cost of transportation for citizens.

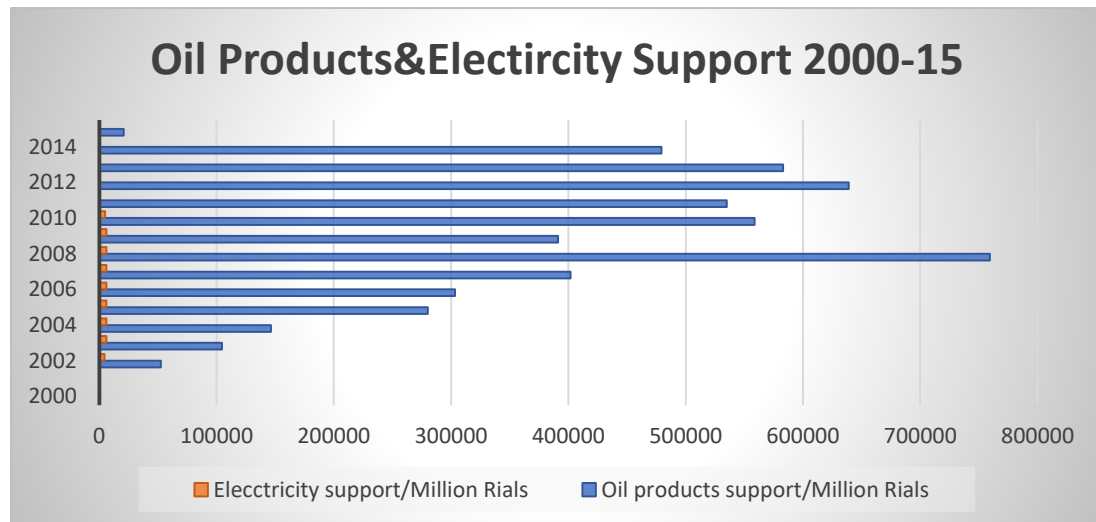


Figure 2.11: Oil Products and Electricity support (2000-15)¹²³

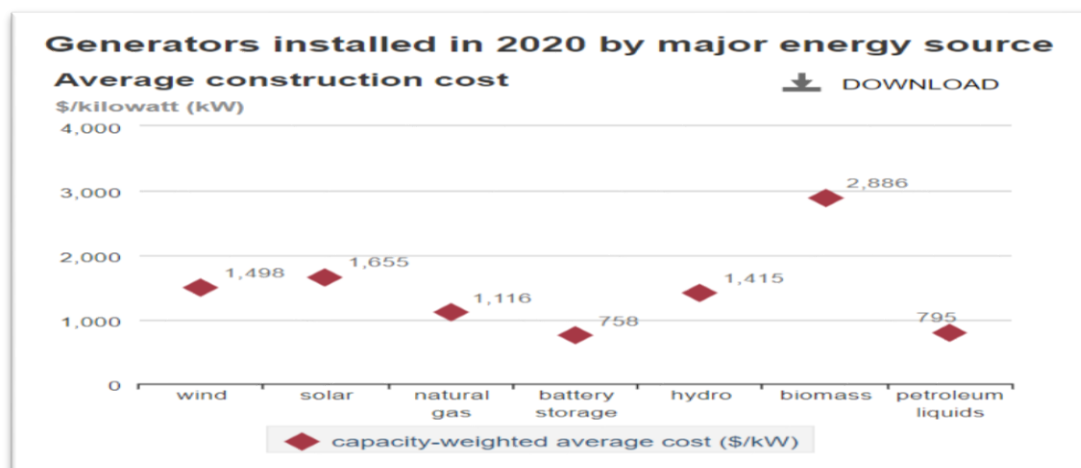


Figure 2.12: Average Construction Cost of NG Power Plant \$/KW 2020¹²⁴

¹²³ Ministry of financial, annual report, 2000 -2015 p: Expenditures and Net Lending according to the Standard Classification for 1800 - 1806 (%)

¹²⁴ "Electricity," Electricity - Construction cost data for electric generators installed in 2020 (EIA, 2020), <https://www.eia.gov/electricity/generatorcosts/>.

2.11 The Relationship between GDP/capita (PCGDP) & Energy Consumption /capita (PCEC) Growth.

The relationship between energy consumption and economic growth in Yemen is complex and multifaceted. Energy consumption is a critical driver of economic growth, as it fuels industrial production, transportation, and other essential economic activities which cover 45.4% of the public revenues¹²⁵. At the same time, economic growth can lead to increased energy consumption, as more energy is needed to power factories, homes, and transportation networks. In Yemen, the energy sector is dominated by the production and export of oil and natural gas. The country has significant reserves of both resources, and they are a critical source of revenue for the government. However, Yemen also faces significant challenges in developing its energy sector, including corruption, political instability, infrastructure deficiencies, and a lack of investment, despite these challenges, Yemen has experienced significant economic growth in recent years, with GDP increasing by an average of 1.9% between 2000 and 2014¹²⁶. This growth has been driven by a range of factors, including an increasing in oil and gas revenues, population, trade and investment, and a little improvements in the business environment. At the same time, energy consumption in Yemen has also been on the rise, driven in part by the increased in demand for transportation and manufacturing. According to the Central Bank of Yemen, Yemen's electricity sector contracted by 24.9% in 2011 after having achieved a positive growth of 6.7% in 2010¹²⁷. In 2013, Kalyoncu, Gürsoy, and Göcen conducted a study to investigate the relationship between GDP and Energy Consumption in three countries: Georgia, Azerbaijan, and Armenia. The study findings indicated that there was no cointegration between GDP and Energy Consumption in Georgia and Azerbaijan. However, in the case of Armenia, these two variables were found to be cointegrated. Consequently, the researchers conducted a causality analysis for Armenia, which

¹²⁵ Ministry of Finance, Yemen, The financial report of the fiscal year 2014, p:22

¹²⁶ Ministry of Finance, Government Finance Statistics, Quarterly Bulletin Issues 2000-2014, p: Economic Indicators+ the average collected by Author.

¹²⁷ CBY, "Annual Report," vol. 1 (Sana'a, Yemen: Central bank of Yemen, 2011), 9.

revealed that there was a unidirectional causality from per capita GDP to per capita energy consumption in this country¹²⁸. Whereas In 2019, Hamis Simba conducted a study that investigated the causal relationship between energy consumption and economic growth in Tanzania during the period of 1990 to 2018, the study reveal a bidirectional causal relationship between energy consumption and economic growth in Tanzania. This means that both energy consumption and economic growth have a causal relationship with each other, with each factor influencing the other in both the short-run and long-run. The research findings suggest that an increase in energy consumption positively impacts economic growth in the short-run and the long-run. As well, the study concludes that Tanzanian policymakers should consider increasing energy consumption as a mean to promote economic growth in the country. These findings provide policymakers in Tanzania with new insights into how to approach economic growth¹²⁹. Another study has made by Banu Çevirgen (2008) analyzed causality relationship between energy consumption and economic growth in 21 low-income, 35 middle-income, and 26 high-income countries over the period 1990-2004. The main finding of this dissertation is that Granger causality from energy consumption to economic growth is more prevalent in high-income countries compared to low-income and middle-income countries. Conversely, the Granger causality from economic growth to energy consumption is more common in low-income and middle-income countries than in high-income countries¹³⁰. Overall, the relationship between energy consumption and economic growth in Yemen is complex and multifaceted, with both factors influencing each other in various ways. While energy consumption is critical to driving economic growth, it is also essential that Yemen develops its energy sector in a sustainable manner that supports long-term

¹²⁸ International Journal of Energy Economics and Policy, Causality Relationship between GDP and Energy Consumption in Georgia, Azerbaijan, and Armenia, Kalyoncu, Gürsoy and Göcen, 2013, p111, 112 <https://dergipark.org.tr/tr/download/article-file/361211>

¹²⁹ Ankara Yıldırım Beyazıt Üniversitesi, “Energy consumption and economic growth in Tanzania”, 2019, p: XVI

¹³⁰ Middle East Technical University, “The relationship between energy consumption and economic growth” Banu Çevirgen, 2008, P: IV, file:///C:/Users/zaidh/Downloads/index%20(1).pdf

economic growth and development. This will require significant investments in infrastructure, technology, and human capital, as well as fighting corruption in oil and gas agreements and improve policies that encourage renewable energy and energy efficiency.

2.12 The effect of population growth in Average Energy Consumption P/C KWH Growth.

The demand and its corresponding generation are estimated for the population by the end of 2019 with a 5% increase in this demand¹³¹. Population growth can have a significant effect on average energy consumption. As the population grows, there is an increase in the number of people who require energy for their daily activities, such as heating, cooling, lighting, and transportation. This leads to an increase in overall energy demand, which can put pressure on the energy supply and contribute to higher energy prices. The relationship between population growth and average energy consumption is complex, as other factors can also impact energy consumption, such as technological advancements and changes in lifestyle. However, it is generally observed that a larger population leads to higher energy consumption, as more people require energy to maintain their standard of living. In developing countries, where populations are growing rapidly, there is often a lack of access to modern energy sources, such as electricity and natural gas. As a result, many people in these countries rely on traditional energy sources, such as wood and charcoal, which are inefficient and contribute to environmental problems, such as deforestation and air pollution. On the other hand, in developed countries, where populations are typically stable or growing slowly, there is often a greater focus on energy efficiency and reducing energy consumption. This can be achieved through policies and initiatives that encourage the use of renewable energy sources, promote energy conservation, and incentivize the adoption of energy-efficient technologies. Overall, population growth can have a significant impact on average energy consumption, and it is important to

¹³¹ Ahmed Abdullah, “Opportunities and Challenges for Restructuring Yemen’s Post-Conflict Electricity Infrastructure Using CCGT with CCS for EOR” (dissertation, 2019), 70.

address this issue by promoting sustainable energy use and investing in renewable energy sources. This can help to ensure that energy remains accessible and affordable for all, while also reducing the negative environmental impacts associated with energy production and consumption.

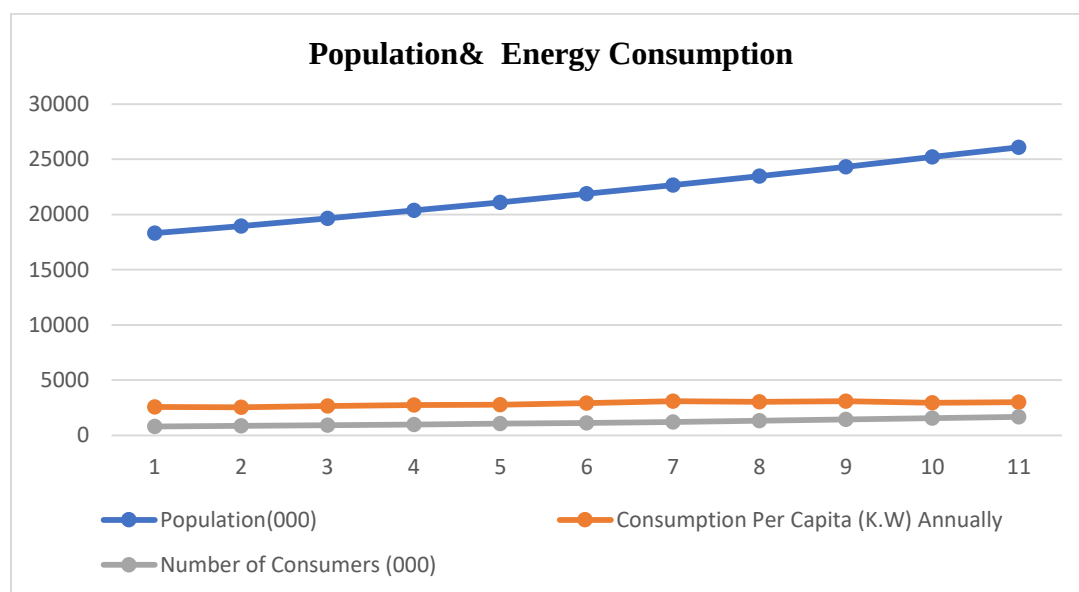


Figure 2.13: Population and Energy Consumption¹³²

As we can see from the Figure 2.13. the trend of all variables upward which indicate that they move together in same direction, as the population of Yemen has been increasing, the number of consumers has also been on the rise, leading to a corresponding increase in the demand for energy. In 2014, Yemen's population had surged to 28,170 thousand individuals, while the number of Yemeni consumers had reached 2014.9 thousand subscribers, which translates to 7.16% of the total resident population having access to electricity¹³³. Thus, they may face challenges in meeting their basic energy needs. This impacts their overall living standard, economic growth, and other aspects of development.

¹³² Ministry of financial, CSO, Year book, 2017, P: (Population and energy)

¹³³ Ministry of financial, CSO, Year book, 2017, P: (Energy)

CHAPTER THREE

METHODOLOGY& DATA

3.1 Introduction

The present investigation employs research methodology to analyze how fluctuations in oil prices affect economic growth in Yemen. The methodology is developed based on the examination of relevant theoretical and empirical contexts. This includes a model, variable definitions, estimation procedures, and data sources. The study utilizes annual time series data spanning from 1991 to 2021 from Energy International agency (EIA) for Oil Price, World Bank for Exchange Rate, GDP Growth and Foreign direct Investment (FDI) and IMF for Inflation Rate to evaluate the impact of oil price instability on Yemeni economic growth.

3.2 Model Specification

The model of this research is developed based on an examination of relevant theoretical and empirical contexts. To analyze the correlation between instability in oil prices and economic growth in Yemen, the study utilized a Vector Auto-regression (VAR) model. This method enables the evaluation of the relative significance of a specific variable in the fluctuations of other variables. Sims (1980) developed the VAR technique, which treats a set of variables equally as long as there is true simultaneity between them, avoiding the complexities associated with the description and assessment of simultaneous structural equations. The model considers all variables as endogenous. The unrestricted VAR model for this study is as follows:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \dots + \beta_p Y_{t-p} + \varepsilon_t \dots \dots \dots (1)$$

Y = (OILP, EXR, INFR, GDP, FDI)

Where:

OILP =Oil Prices,

EXR = Exchange Rate,

INFR =Inflation Rate,

GDP =Gross Domestic Product,

FDI = Foreign Direct Investment,

While Y_t represents the endogenous variables, α is the constant vector, β is the coefficient matrix, p is the lag length, and ε_t represents the vector of white noise process.

The general econometrics model expressing the correlation between the independent variable (OILP) and dependent variables can be formulated as follows:

$$OILP_t = \alpha + \beta_1 EXR_t + \beta_2 INFR_t + \beta_3 GDP_t + \beta_4 FDI_T + \varepsilon_t \dots \dots (2)$$

The model contains a constant term represented by α , coefficients β_1 through β_4 , and an error term denoted by ε_t .

The non- percentage ratio variables in the equation shown previously can be rewritten using logarithmic transformation to show its elasticity as follows:

$$LOILP_t = \alpha + \beta_1 LEXR_t + \beta_2 INFR_t + \beta_3 GDP_t + \beta_4 FDI_T + \varepsilon_t \dots \dots (3)$$

3.3 Variables Definition

This research considers the following variables: Oil price (OP), Exchange Rate (EXR), Real Gross Domestic Product (RGDP), Inflation Rate (CPI), and Foreign Direct Investment (FDI). The percentage ratio is used to express RGDP, INFR, and FDI, while local currency (Yemeni rial) is used for Exchange Rate (EXR) data. On the other hand, international market currency (US dollar) is used to measure the Oil price variable.

3.3.1 Oil Prices (OPs)

Oil price refers to the global market value of oil, which can fluctuate and cause instability in the Marib Light oil price - a type of Yemeni crude oil sold on the international market. The oil price level can indicate how oil price instability impacts the economy, and how changes in the economy can be analyzed. When oil prices rise or fall, it affects the demand for goods and services, leading to measures like increased production, exchange rates, and gross domestic product. For this study, the annual average price of oil per barrel in US dollars was used as a variable¹³⁴.

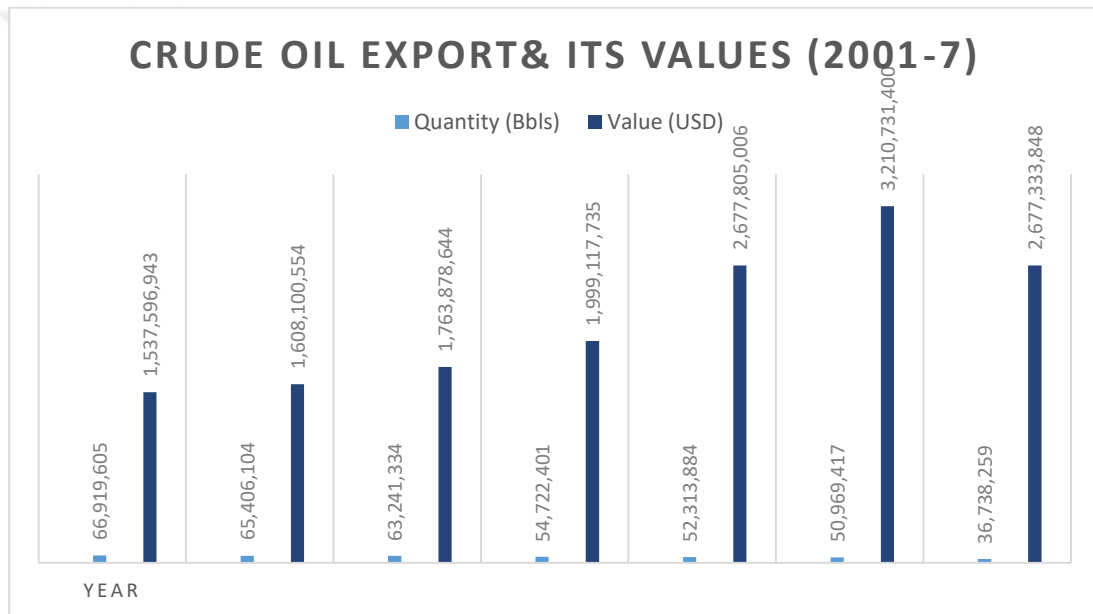


Figure 2.14: Crude Oil Export& its Values (2001-7)

3.3.2 Exchange Rate (EXR)

The trade-weighted exchange rate, also known as EXR, is an indicator of a country's currency value in relation to the currencies of its trading partners. The weight of a country's currency in determining the EXR is based on the volume of its trade with

¹³⁴ ABDULLAHI NUHU, "The Impact of Oil Price Instability on Economic Growth (a Case of Nigeria)" (Near East University), accessed May 2, 2023, <https://rb.gy/w81g7>, 40.

other countries. The EXR of a country reflects the purchasing power of its currency and the strength of its trade relationships¹³⁵.

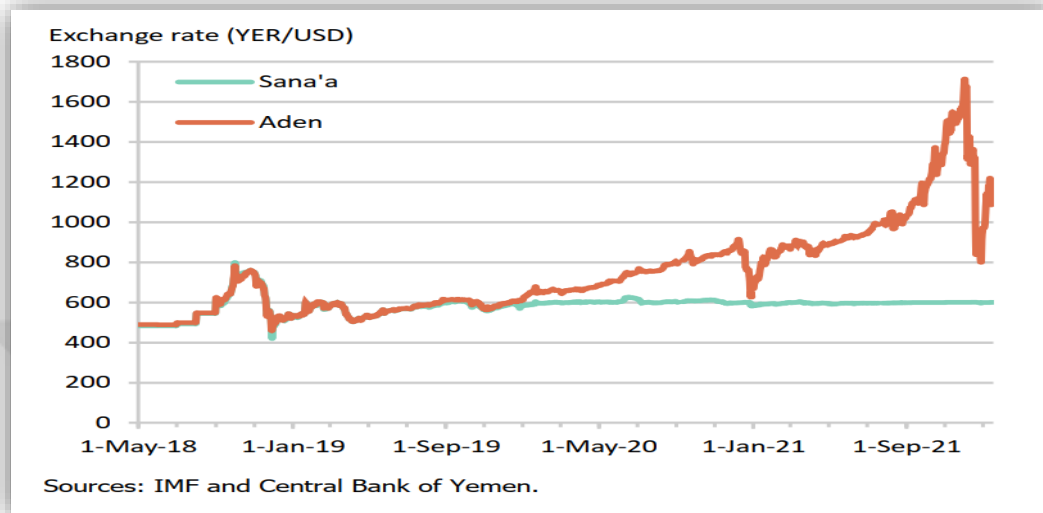


Figure 2.15: Exchange rate trend: Yemen (Sana'a and Aden bank)

3.3.3 Inflation Rate (INFR)

Inflation is a measure of the rate of change in the price level of goods and services over a specific period of time. It is calculated using the consumer price index (CPI), which reflects the percentage change in the prices of goods and services that are typically purchased by the average consumer. The CPI may be fixed or adjusted at regular intervals, such as monthly, and is used to estimate inflation for a population¹³⁶.

¹³⁵ Ibid. s. 41.

¹³⁶ Ibid. s. 41.

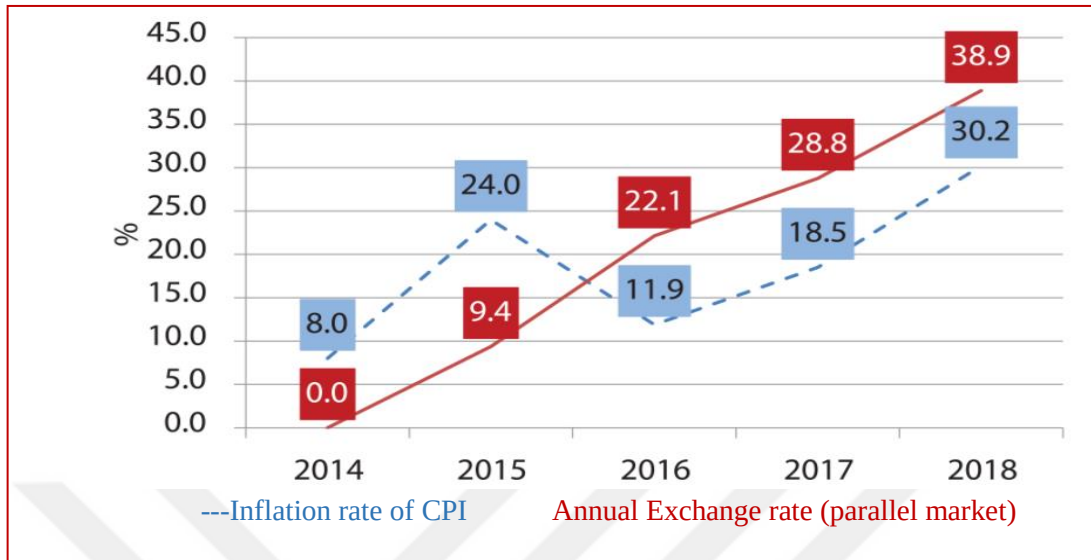


Figure 2.16: Inflation rate

3.3.4 Real GDP (RGDP)

Gross Domestic Investment (GDP) is a measure of an economy's growth. It represents the total value of income generated by a country's residents from all final goods and services, regardless of their source - domestic or international. Additionally, GDP includes the total value added by each resident producer, as well as taxes that are not included in the assessment of productivity, and disposable income from primary foreign sources. Primary income includes worker compensation and property wages from foreign sources. In this research, GDP data is presented in percentage ratios¹³⁷.

¹³⁷ Ibid. s. 41.

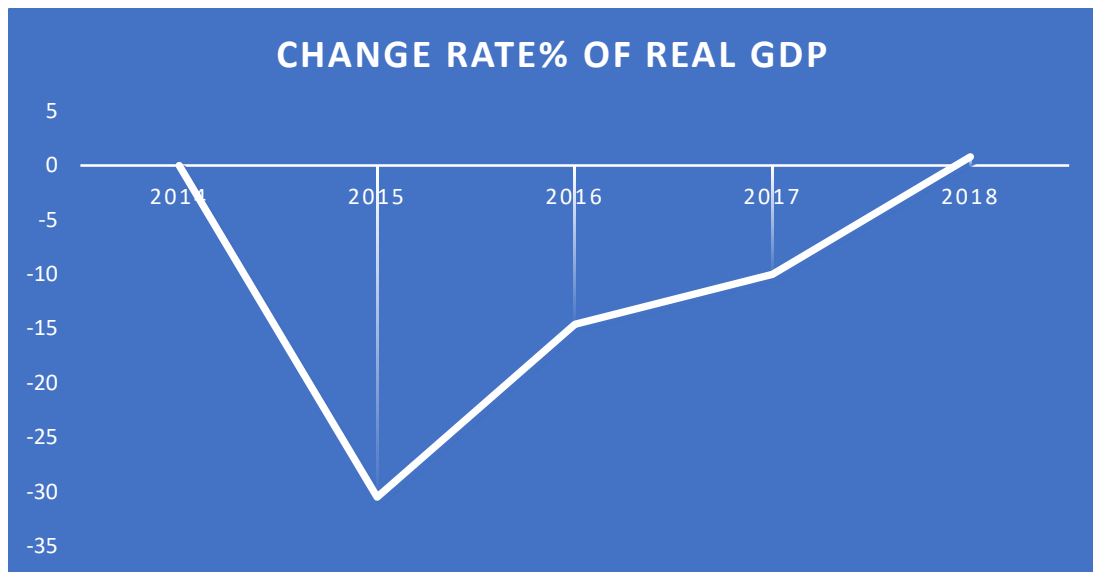


Figure 2.17: Change rate% of Real GDP

3.3.5 Foreign Direct Investment (FDI)

Foreign Direct Investment (FDI) has the potential to significantly contribute to economic growth. This type of investment involves a foreign entity investing in a domestic company or establishing a new business in a foreign country. FDI can bring in additional capital to the economy, which can be used to fund new projects and expand existing businesses. Additionally, FDI can create new job opportunities in the host country, which can help reduce unemployment rates and boost the economy. Furthermore, FDI can bring new technologies, management skills, and business practices to the host country, which can improve productivity and competitiveness. Moreover, FDI can enhance trade by increasing exports and imports and providing domestic firms with access to new markets. However, the effectiveness of FDI in promoting economic growth depends on several factors, including the host country's policies, the nature of the investment, and the quality of institutions in the host country.

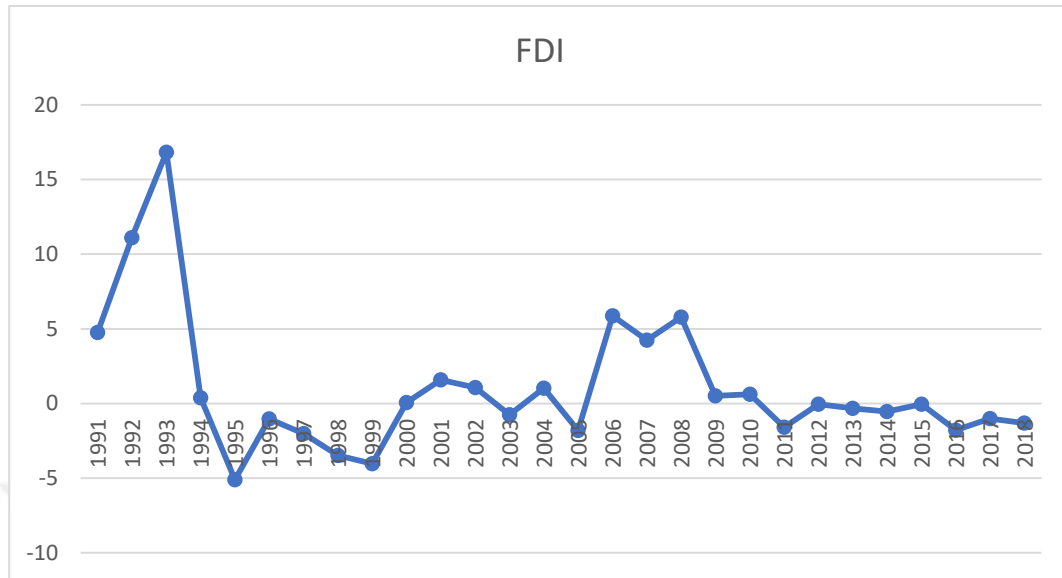


Figure 2.18: Foreign Direct Investment

3.4 Analysis of the Results

3.4.1 Introduction

This part presents the analysis and discussion of the results obtained using the methodology mentioned above. The analysis includes the assessment of unit root, co-integration, vector error correction model, Granger causality test, and variance decomposition test. The results obtained from each of these tests are analyzed and discussed in detail. Furthermore, the implications of the results on policy-making are also discussed.

3.4.2 Unit Root Test

The process of testing for stationarity (unit root) is carried out on the variables prior to the estimation of the VAR model, in order to determine their stationarity. If the data is non-stationary, it can produce inaccurate or false results when estimating the model. The VAR model estimation requires a test for stationarity (unit root) to be conducted on the variables beforehand to determine their stationarity. The Augmented

Dickey-Fuller (ADF) test is the most commonly used test for stationarity. Several econometric problems may impact the estimation of parameters in time series data, which is why the unit root test for stationarity is necessary for each time series data before model estimation. Additionally, the unit root test is recommended since most macroeconomic data are expected to be a deterministic and stochastic trend. A time series data is considered stationary if its mean and variance remain constant over time, while it is considered non-stationary if its mean varies over time¹³⁸.

Table 1.10: ADF Unit Root Test Result (1991-2021)

Unit Root Test at Level				
Variable	ADF Statistics	5% Critical Level	Prob.	Result
LOILP	-1.278270	-2.963972	0.6263	Non-Stationary
LEXR	-1.117291	-2.963972	0.6957	Non-Stationary
INFR	-2.248813	-2.967767	0.1945	Non-Stationary
FDI	-3.247907	-3.580623	0.0959	Non-Stationary
LRGDP	-3.653523	-2.963972	0.0104	Stationary
Unit Root Test at First Difference				
LOILP	-5.135985	-2.967767	0.0002	Stationary
LEXR	-3.571993	-2.967767	0.0129	Stationary
INFR	-4.819606	-2.971853	0.0006	Stationary
FDI	-5.134514	-3.587527	0.0016	Stationary

Source: Obtained from E-views (10) estimation result

The Augmented Dickey-Fuller (ADF) test was used to test for stationarity, and the results showed that all variables were non-stationary at the level except RGDGP hence it will be exclude from the next application section. However, after differencing the variables once, they were found to be stationary. The results of the unit root test can be found in Table: 1.10 above.

3.4.3 Lag Selection Criteria

The criterion for selecting lags provides techniques for determining the number of lags required in performing the Johansen co-integration test. According to the E-views

¹³⁸ Ibid. s. 42.

10 User's Guide, it is important to note that the model with the lowest value is deemed the most desirable when utilizing information criteria for model selection. Based on the table 1.11 below, the Schwarz Information Criterion (SC) Method propose one lag while Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQ) which suggests two lags. Thus, this research will use one lag to avoid confusion and ensure consistency.

Table 1.11: Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-230.0545	NA	214.1754	16.71818	16.90850	16.77636
1	-154.4803	124.1577	3.085923	12.46288	13.41445*	12.75378
2	-132.6376	29.64368*	2.200137*	12.04554*	13.75838	12.56917*
3	-118.2321	15.43444	3.051791	12.15944	14.63353	12.91579
*specifies the lag order selection by the criterion. LR: Modified LR Test Statistic (each test at 5% level). FPE: Final Prediction Error. AIC: Akaike Information Criterion. SC: Schwarz Information Criterion. HQ: Hannan-Quinn Information Criterion.						

Source: E-views 10 test result

3.4.4 Co-integration Test

A co-integration test is used to check for the presence of a long-term relationship between non-stationary variables. The Johansen approach is commonly used to determine the number of co-integrating vectors for variables of the same order, which are stationary at first difference but not at level. The aim of the test is to determine if a group of non-stationary variables is co-integrated or not. Co-integration means that a linear combination of individual variables can be stationary, even if the variables themselves are non-stationary (Gujarati, 2004). This linear combination is known as

the co-integration equation. The standard VAR model is used when the variables are not co-integrated. However, if co-integration is present among the variables, the VAR should incorporate them through the vector error correction model. Therefore, testing for co-integration is a crucial step in VAR analysis since its existence may impact the final result. A co-integration test should, therefore, be conducted as a trial to avoid spurious results¹³⁹. To determine if there is a long-term relationship among the variables that are non-stationary at level, the Johansen test for co-integration is conducted. The purpose of the co-integration tests is to establish whether there is a co-integrated relationship among the variables, namely Oil price, Exchange rate, Inflation rate and FDI. The Johansen co-integration result below indicates that both the Trace statistic and maximum Eigenvalue statistic indicate the presence of one co-integrating equation among the variables. Therefore, it can be concluded that there is at least one co-integrated or long-term relationship among the variables. It should be noted that the lag order selection criteria presented in table 1.11 above, the Schwarz Information Criterion (SC) Method propose one lag while Akaike Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQ) which suggests two lags.

Table 1.12: Johansen Cointegration Test Result (Trace)

Sample (adjusted): 1991-2021				
Lags intervals (in first differences): 1 to 2				
Hypothesized No. of CE	Eigen Value	Trace Statistic	5% Critical Value	Prob.
None*	0.832369	77.99442	47.85613	0.0000
Trace test indicates 1 co-integrating eqn(s) at the 0.05 level.				
* denotes rejection of the hypothesis at the 0.05 level				

Source: Extracted from E-views 10 estimation result.

¹³⁹ Ibid. s. 42-43.

Table 1.13: Johansen Co-integration Test Result (Maximum Eigenvalue)

Sample (adjusted): 1991-2021				
Lags intervals (in first differences): 1 to 2				
Hypothesized No. of CE	Eigen Value	Max Eigen Statistic	5% Critical Value	Prob.
None*	0.832369	50.07765	27.58434	0.0000
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level.				
* denotes rejection of the hypothesis at the 0.05 level				

Source: Extracted from E-views 10 estimation result

3.4.5 Vector Error Correction Model

The purpose of this model is to analyze the short-term dynamic relationships between variables. However, this is only possible when the variables are stationary at first difference and are co-integrated. Therefore, if the variables are non-stationary at level and are found to be co-integrated, the Vector Error Correction Model (VECM) is used for adjustment. The VECM considers the long-term behavior of endogenous variables by incorporating their co-integrating relationship, while also taking into account short-term dynamic adjustments¹⁴⁰. The VECM is employed after the co-integration test confirms the presence of a long-run relationship for analyze short-run dynamic adjustment relationship. The VECM divide the long-run relationship into short-run components. This is applicable when the variables are co-integrated and become stationary at first difference. The error term coefficient of the co-integrating equation explains the dynamics of the speed of adjustment and the negative and significant. The result in the table below shows that the error term coefficient of D(LOP) based on the co-integrating equation is 0.473805, which means that the speed of adjustment is approximately 47% per year as the variables move toward re-establishing long-term equilibrium in the event of any deviation. Therefore, the burden of the long-term equilibrium within a year when there is a deviation is

¹⁴⁰ Ibid. s. 43.

significant because the speed of adjustment is high, while D(LEXR), its co-integrating equation is 0.092996, which means that the speed of adjustment is approximately 9% per year as the variable moves towards the long-term equilibrium in the event of any deviation. Therefore, the burden of the long-term equilibrium within a year when there is a deviation is not significant because the speed of adjustment is low.

Table 1.14: Vector Error Correction Model Result

Sample (adjusted): 1991-2021				
Standard Errors in () & T-Statistic in []				
Variable	D(LOP)	D(LEXR)	D(INFR)	D(FDI)
CointEq1	-0.473805 (0.11520) [-4.11303]	-0.092996 (0.13135) [-0.70803]	-2.808305 (3.39371) [-0.82750]	5.058144 (1.93551) [2.61334]
D(LOP(-1))	0.091786 (0.17011) [0.53955]	-0.080380 (0.19396) [-0.41441]	2.978227 (5.01165) [0.59426]	1.172456 (2.85825) [0.41020]
D(LEXR(-1))	-1.429364 (0.38046) [-3.75693]	0.281078 (0.43380) [0.64794]	-38.51419 (11.2085) [-3.43615]	8.911315 (6.39245) [1.39404]
D(INFR(-1))	-0.017613 (0.00842) [-2.09063]	0.009182 (0.00961) [0.95591]	-0.816417 (0.24819) [-3.28943]	0.020425 (0.14155) [0.14429]
D(FDI(-1))	-0.057843 (0.01951) [-3.70786]	-0.047114 (0.01893) [-2.48850]	0.847467 (0.48918) [1.73241]	0.383655 (0.27899) [1.37515]
C	0.218466 (0.06976) [3.13189]	0.059281 (0.07953) [0.74535]	5.229953 (2.05501) [2.54497]	-0.976452 (1.17202) [-0.83314]

Source: Extracted from E-views 10 estimation result

The coefficients of the variables, D(LEXR), D(INFR) and D(FDI) have a positive related to D(LOP). However, theoretically, D(INFR) should have a positive relationship with D(LOP), but in this case of Yemen as a rentier state, D(INFR) has a negative relationship to oil prices in contrary to theoretical illogic, due to the effect of Yemeni government oil product subsidies that supported from the foreign exchange reserves, which leads to decrease inflation in goods and services .

3.4.6 Granger Causality Test

After conducting the co-integration test, it was determined that there is a long-term relationship among the tested variables. However, this test does not reveal which variable is the cause and which is the effect. To determine the interdependence between the variables, a Granger causality test is conducted, which is a statistical tool used in building estimation models to determine whether one variable is significant in estimating another variable. Finally, the causality test is a method of determining the relationship between variables. The research employs the Granger causality test to establish the relationship between the variables. This test is a statistical tool used in modeling and estimation. It determines the significance of one variable in explaining the behavior of another variable. By examining whether the previous values of one variable can forecast changes in another variable, the causality test helps in identifying the interdependence between the variables. The use of causality tests in economics was formalized by Granger (1969) and Sims (1972), and it is a valuable tool in investigating the causal relationship between economic variables. The Granger causality test measures the value that a variable adds in explaining the latest value of another variable¹⁴¹.

This table of the pairwise Granger causality tests conducted on data from Yemen, with a sample period from 1991 to 2021 and a lag of 2. The tests examine whether one variable (the "cause") Granger-causes another variable (the "effect"), meaning that changes in the cause variable can be used to predict changes in the effect variable. The null hypothesis is that there is no Granger causality between the two variables. If the p-value is less than the significance level (typically 0.05), then we reject the null hypothesis and conclude that there is evidence of Granger causality. Looking at the results, we can see that there is an evidence between LEXR (the logarithm of the exchange rate) and LOP (the logarithm of the oil price) in unidirectional. This means

¹⁴¹ Ibid. s. 43.

that changes in LEXR can be used to predict changes in LOP. There is no evidence of Granger causality between INFR (the inflation rate) and LOP in bidirectional, nor between FDI (foreign direct investment) and LOP in bidirectional. However, there is evidence of Granger causality between INFR and LEXR in the unidirectional of INFR causing LEXR (changes in INFR can be used to predict changes in LEXR), but not in the other direction. Similarly, there is evidence of Granger causality between FDI and LEXR in the unidirectional of LEXR causing FDI (changes in LEXR can be used to predict changes in FDI), but not in the other direction. Finally, there is evidence of Granger causality between FDI and INFR in the unidirectional of FDI causing INFR, but not in the other direction.

Table 1.15: Pairwise Granger Causality Test Result

Null hypothesis	Obs	F-Statistic	Prob
LEXR does not Granger Cause LOP	29	4.27974	0.0257
LOP does not Granger Cause LEXR		0.10983	0.8964
INFR does not Granger Cause LOP	29	1.96124	0.1626
LOP does not Granger Cause INFR		1.96077	0.1627
FDI does not Granger Cause LOP	29	0.64919	0.5314
LOP does not Granger Cause FDI		0.17723	0.8387
INFR does not Granger Cause LEXR	29	6.64687	0.0050
LEXR does not Granger Cause INFR		0.38006	0.6879
FDI does not Granger Cause LEXR	29	4.02947	0.0310
LEXR does not Granger Cause FDI		1.10758	0.3467
FDI does not Granger Cause INFR	29	5.19282	0.0134
INFR does not Granger Cause FDI		0.03241	0.9682

Source: Extracted from E-views 10 estimation result

These results suggest that changes in the exchange rate can be used to predict changes in the oil price not the opposite. Additionally, changes in inflation can be used to predict changes in the exchange rate, and changes in the exchange rate can be

used to predict changes in foreign direct investment. However, there is no evidence of a causal relationship between inflation or foreign direct investment and the oil price.

3.4.7 Impulse Response

The impulse response function is a tool used to understand how a dependent variable responds to shocks in other variables. This function examines the responsiveness of the dependent variable to shocks in the error terms. The impulse response function is a tool used to analyze the impact of shocks to each of the variables on the dependent variables. It was created to address the challenges of interpreting the coefficients of the VAR model. By examining the response of the dependent variable to shocks in the error terms, the impulse response function can provide insight into how the dependent variables react to shocks in each of the variables. In other words, it can help us understand how sensitive the dependent variables are to changes in each of the variables¹⁴². The analysis is divided into three terms, each with three periods (short, middle, and long-term). The last period of each term is used in the analysis, with the short term representing (1 to 3) periods, the middle term for (4 to 6) periods, and the long-term for (7 to 9) periods. The graphs of impulse response can be seen in Appendix VI¹⁴³. The table below shows the impulse response of LOP indicates that the shock in INFR causes LOP to increase by 0.040228 % in the first period, while a shock in LEXR causes a smaller increase of 0.004569 % in the first period. A shock in FDI has a negligible effect on LOP in the short term, with an increase of only 0.004891 % in the first period, moving to the middle term, it can be seen that a shock in LEXR has the largest effect on LOP, with an increase of 0.054838 % in the sixth period. A shock in INFR also has a positive effect on LOP, with an increase of 0.038635 % in the seventh period. However, a shock in FDI has a negative effect on

¹⁴² Ibid. s. 44.

¹⁴³ Ibid. s. 52.

LOP, with a decrease of 0.026013 % in the eighth period. Finally, for the long term, it can be seen that a shock in INFR has the largest positive effect on LOP, with an increase of 0.126149 % in the eleventh period. A shock in LEXR also has a positive effect on LOP, with an increase of 0.045116 % in the tenth period. However, a shock in FDI has a negative effect on LOP, with a decrease of 0.009447 % in the twelfth period.

Table 1.16: Impulse Response of LOP

Response of LOP				
Period	LOP	LEXR	INFR	FDI
Short Term	0.136395	0.004569	0.040228	0.004891
Middle Term	0.010362	0.054838	0.038635	-0.026013
Long Term	-0.069627	0.045116	0.126149	-0.009447

Source: Extracted from E-views 10 result

The results suggest that the LEXR and INFR variables have a positive impact on LOP in both the short term and long term, while FDI has a negligible positive effect on LOP in the short term and a negative effect in the middle and long term.

Table 1.17: Impulse Response of LEXR

Response of LEXR				
Period	LOP	LEXR	INFR	FDI
Short Term	-0.052765	0.135058	0.074426	-0.174784
Middle Term	-0.175491	0.051519	0.290403	0.030989
Long Term	-0.185577	0.002966	0.385709	0.120059

Source: Extracted from E-views 10 estimation result

The Table 1.17 shows the response of LEXR to shocks in the four variables, LOP (Oil Prices), INFR and FDI. The response is shown for three different time term: short-term, middle-term, and long-term. In the table above suggest that a shock to LOP has a consistently negative effect across all periods while LEXR and INFR have a consistently positive effect across all periods. In the short term, a positive shock to

LOP causes in a negative response in LEXR while a positive shock to FDI results in a negative response in LEXR as well. A positive shock to INFR results in a positive response in LEXR while the response of LEXR to its own shock is positive. In the middle term, a positive shock to LOP results in a negative response in LEXR while a positive shock to INFR results in a positive response in LEXR. The response of LEXR to its own shock is positive while the response to FDI shock becomes positive. In the long term, a positive shock to LOP results in a negative response in LEXR while positive shocks to INFR and FDI result in positive responses in LEXR. The response of LEXR to its own shock is positive.

Table 1.18: Impulse Response of INFR

Response of INFR				
Period	LOP	LEXR	INFR	FDI
Short Term	-1.350258	-2.368990	4.428902	7.076506
Middle Term	0.872923	-0.921494	-0.620341	0.830336
Long Term	1.004516	0.163723	-1.661094	-0.540950

Source: Extracted from E-views 10 estimation result

As shown in Table 1.18, the impulse response of INFR reveals that there are significant short-term effects in response to a shock. In the short term, there is a substantial increase in INFR, with a positive response of 4.428902%. However, in the middle term, there is a decline in the response of INFR, with a negative response of -0.620341%. In the long term, there is a slight decrease in the response of INFR, with a negative response of -1.661094%. Overall, it appears that a shock to INFR has a significant short-term effect on the Yemeni economy, but this effect dissipates over time.

Table 1.19: Impulse Response of FDI

Response of FDI				
Period	LOP	LEXR	INFR	FDI
Short Term	0.684851	-0.398559	-0.242726	-0.070264
Middle Term	0.308387	0.169767	-0.685854	-0.197488
Long Term	0.166149	0.088488	-0.476484	-0.292496

Source: Extracted from E-views 10 estimation result

As shown in Table 1.19, the impulse response of response table shows the effects of a shock in the four variables on FDI in the short, middle, and long terms. In the short term, a shock to LOP has a positive effect on FDI, while shocks to LEXR and INFR have a negative effect on FDI. In the middle term, a shock to LOP and LEXR have a positive effect on FDI, while shocks to INFR has a negative effect on FDI. In the long term, LOP and LEXR have a positive impact on FDI while a shock to INFR has a negative effect on FDI. Overall, these results suggest that fluctuations in LEXR and INFR have a more significant impact on FDI than fluctuations in LOP.

3.4.8 Variance Decomposition

The variance decomposition test is utilized to examine how much the shocks associated with one variable affect the assessment of another variable. This test measures the average squared forecast error of the model due to unexpected movements related to each of the variables and helps in understanding the relative importance of each variable in the model. The forces error test is used to describe the Vector Auto-regression (VAR) model. The equation for the moving average representation of the VAR system is employed to estimate the variance decomposition. The test was performed on LOP, LEXR, INFR, and FDI over a nine-year period. These periods are divided into short, middle, and long terms, with each term consisting of three periods. The analysis uses the last period of each term. The short term covers 1 to 3 periods, the middle term covers 4 to 6 periods, and the long-term covers 7 to 9 periods.

Table 1.20: Variance Decomposition of LOP

Variance Decomposition of LOP				
Period	LOP	LEXR	INFR	FDI
Short Term	96.58175	1.315039	1.262942	0.840268
Middle Term	87.48137	5.648789	2.863856	4.005984
Long Term	71.77923	8.302081	15.22895	4.689743

Source: Extracted from E-views 10 estimation result

The variance decomposition result of LOP in the table 1.20 above indicates that in short term, LOP is responsible for approximately 96.5818% of the variations (in its self-shock). Whereas in middle and long terms, LOP is responsible for approximately 87.4814% and 71.7793% of the self-variations respectively. Also, the variations in LOP are accountable by LEXR in short, middle and long terms approximately 1.3151%, 5.6488% and 8.3021% respectively, as noted from result of the LEXR the variations in the periods increase with time especially from middle term to long term which means the responsiveness level from middle to long-term is more stronger than in short-term in contrast to LOP its self which the responsiveness level decrease over time. Moreover, INFR is responsible for approximately 1.2621%, 2.8639% and 15.2289% variations for LOP in short, middle and long terms respectively, as INFR responsiveness level increased in the middle term 2.8639%- 15.2289% in the long run, the only interpretation in case of Yemen any increase or decrease in exchange rate and Inflation rate due to the oil price changes than the level of the government subsidies. Finally, approximately 0.84027%, 4.0051% and 4.6898% variations in LOP are accountable by FDI in short, middle and long terms respectively, indicated that the responsiveness level to LOP increase after three periods in short term.

Table 1.21: Variance Decomposition of LEXR

Variance Decomposition of LEXR				
Period	LOP	LEXR	INFR	FDI
Short Term	3.355818	69.53902	4.221097	22.88406
Middle Term	17.75667	27.74565	38.84970	15.64797
Long Term	18.41719	12.60563	58.94003	10.03715

Source: Extracted from E-views 10 estimation result

The variance decomposition result of LEXR in the table1.21 above indicates that in short term, LEXR is responsible for approximately 69.5391% of the variations (in its self-shock). Whereas in middle and long terms, LEXR is responsible for approximately 27.7457% and 12.6057% of the self-variations respectively which indicated that the responsiveness level of LEXR decrease over-time. Also, the variations in LEXR are accountable by LOP in short, middle and long terms approximately 3.3559%, 17.7567% and 18.4172% respectively, as noted from result of the LOP the variations in the periods, the responsiveness level of LOP decrease over-time as same as LEXR. Moreover, INFR is responsible for approximately 4.2211%, 38.8498% and 58.9401% variations for LEXR in in short, middle and long terms respectively, as INFR responsiveness level increased in the middle term 38.8498%- 58.9401% in the long run, the only interpretation in case of Yemen any increase or decrease in exchange rate and Inflation rate due to the oil price changes than the level of the government subsidies as happened above with responsiveness of INFR to LOP. Finally, approximately 22.8841%, 15.6471% and 10.0372% variations in INFR are accountable by FDI in short, middle and long terms respectively, indicated that the responsiveness level to INFR decreases after three periods (short term).

Table 1.22: Variance Decomposition of INFR

Variance Decomposition of INFR				
Period	LOP	LEXR	INFR	FDI
Short Term	5.922752	21.95349	44.36488	27.75887
Middle Term	5.289942	20.66695	36.15381	37.88930
Long Term	6.123401	19.98241	37.12433	36.76986

Source: Extracted from E-views 10 estimation result

The variance decomposition result of INFR in the table1.22 above indicates that in short term, INFR is responsible for approximately 44.3649% of the variations (in its self-shock). Whereas in middle and long terms, INFR is responsible for approximately 36.1539% and 37.1244% of the self-variations respectively. Also, the variations in INFR are accountable by LOP in short, middle and long terms approximately 5.9228%, 5.2899% and 6.1235% respectively. Moreover, LEXR is responsible approximately 21.9535%, 20.6669% and 19.9824% variations for INFR in in short, middle and long terms respectively which increases slightly. Finally, approximately 27.7589%, 37.8893% and 36.7699% variations in INFR are accountable by FDI in short, middle and long terms respectively, which indicated that the responsiveness level to INFR increase from short term to middle term, otherwise long term decreased.

Table 1.23: Variance Decomposition of FDI

Variance Decomposition of FDI				
Period	LOP	LEXR	INFR	FDI
Short Term	5.331303	3.892586	5.811096	84.96502
Middle Term	6.228928	4.060165	11.56488	78.14602
Long Term	6.487571	3.915643	14.73285	74.86393

Source: Extracted from E-views 10 estimation result

The variance decomposition result of FDI in the table1.23 above indicates that in short term, FDI is responsible for approximately 84.9650% of the variations (in its self-shock). Whereas in middle and long terms, FDI is responsible for approximately

78.1460% and 74.8639% of the self-variations respectively. Also, the variations in FDI are accountable by LOP in short, middle and long terms approximately 5.3313%, 6.2289% and 6.4875% respectively, which indicated that the responsiveness level to FDI increase from short term to long term slightly. Moreover, LEXR is responsible for approximately 3.8926%, 4.0601% and 3.9157% variations for FDI in in short, middle and long terms respectively, as INFR responsiveness level increased in the middle term, it is come back to the same level of the responsiveness in the long run. Finally, approximately 5.8110%, 11.5648% and 14.7328% variations in FDI are accountable by INFR in short, middle and long terms respectively, indicated that the responsiveness level to INFR increase throughout short term to long term.

CONCLUSION

In this dissertation, we have undertaken a study with the aim of gaining deeper insights into the role of the energy sector on economic development, we have achieved some important results in terms of this aim.

On the grounds of the oil sub-sector, our study highlights the critical role of the oil sub-sector in supporting the revenues of the Yemeni government. We have observed that government revenues are closely linked to international oil prices, with increases or decreases in prices impacting revenue accordingly. However, it is concerning that oil production has been on a declining trend since 2003. This decline has been accompanied by a growing demand for refined petroleum, surpassing the capacities of existing refineries in Aden and Marib is not enough. In summary, the potential and contributions of the oil sub-sector are crucial for supporting the Yemeni government's revenues. However, it is essential to address challenges such as declining oil production and the underutilization of natural gas to ensure sustainable economic development in the country. By implementing measures to optimize oil production and improve gas infrastructure, Yemen can maximize its resource potential and leverage oil and gas revenues to foster growth in vital sectors of its economy.

On the gas sub-sector, the gas commodity holds significant potential as an alternative crude oil source and revenue contributor for the Yemeni government, according to the findings of this thesis. The estimated revenues for the government from the gas sector over a 20-25 year period range from \$30-50 billion. Despite challenges in contract negotiations and corruption, there has been a notable increase in domestic consumption of liquefied petroleum gas (LPG), with a growing number of LPG filling stations. However, the consumption of LPG remains a small fraction of the country's total gas reserves. The steady growth in LPG sales revenues highlights the economic benefit of the LPG market. To fully capitalize on the potential of the

gas sector, it is essential to address these challenges and create a favorable environment for its sustainable development.

On the electricity sub-sector, Yemen has great potential to utilize alternative renewable energy sources and reduce its reliance on fossil fuels. Solar energy, with its abundant resource in the country, can be harnessed to meet the growing energy demand sustainably. The average solar insolation in Yemen falls within a favorable range, making it an important resource for the country's energy future. Additionally, wind energy presents a viable option, with technically attractive sites capable of generating significant power. Yemen has the potential to harness thousands of megawatts of wind energy, especially in the Al-Khoukh region. However, political conflicts have hindered the implementation of wind farm projects, delaying progress in this area. Despite the focus on renewable energy development, Yemen still faces challenges such as frequent power outages, which impact daily life and the economy. Embracing renewable energy sources and addressing technical and political issues will be crucial for Yemen to achieve energy security and sustainable economic growth.

On the economic growth part, the energy sector plays a crucial role in shaping the macroeconomic landscape and driving economic growth in Yemen. The findings of this study indicate that the sector's performance has a direct impact on the overall economy. For instance, the study reveals that the unemployment, exchange and inflation rate and foreign direct investment in Yemen is influenced by the energy sector. In 2019, when the energy sector faced challenges, the unemployment rate increased to around 24.8%. However, there has been a positive development as the unemployment rate decreased to 13.6% in 2021, indicating the importance of a robust and stable energy sector for job creation and economic stability.

At the application part, it provides valuable insights into the dynamics of key macroeconomic variables in Yemen. The unit root tests revealed that all variables, except for real GDP (RGDP), were non-stationary at the level. However, after differencing, all variables became stationary. The Johansen cointegration test

confirmed the presence of one co-integrating equation among the variables, indicating a long-term relationship. The Vector Error Correction Model (VECM) was employed to analyze short-term dynamic relationships, considering the variables' co-integration. The Granger causality tests revealed that the exchange rate (LEXR) exhibited unidirectional Granger causality with the logarithm of oil price (LOP), suggesting that changes in exchange rate can predict changes in oil prices, changes in inflation rate can predict changes exchange rate, changes in foreign direct investment can predict changes in exchange rate and foreign direct investment can predict changes in inflation rate. These findings contribute to a better understanding of the interrelationships between macroeconomic variables in Yemen and have implications for policymakers seeking to manage and stabilize the economy.

Recommendation

Based on the findings of this study regarding the impact of oil price instability on Yemen economic growth, the following recommendations are proposed:

- **Diversification of the Economy:** To reduce the vulnerability of the Yemen economy to oil price fluctuations, there is a need to prioritize the diversification of revenue sources. This can be achieved by promoting non-oil sectors such as agriculture, manufacturing, services, and tourism. Diversification will help create a more resilient and sustainable economic growth path.
- **Strengthening Economic Stability Measures:** Given the significant influence of oil price instability on economic growth, it is crucial to implement robust economic stability measures. This includes maintaining a stable exchange rate, prudent fiscal management, and effective monetary policies to mitigate the adverse effects of oil price shocks on the economy.
- **Investment in Infrastructure after war:** Enhancing infrastructure development, particularly in sectors beyond oil, can boost productivity and attract both domestic and foreign investments. This includes improving transportation networks, power

supply, telecommunications, and other critical infrastructure to facilitate economic activities across various sectors.

- **Promoting Non-Oil Exports:** Encouraging and supporting non-oil exports can reduce the country's dependence on oil revenue. This involves providing incentives, improving export infrastructure, and implementing policies that promote competitiveness and market access for Yemen non-oil products in the global market.
- **Establishing a renewable energy fund** to support sustainable activities of energy by allocating 15% of the oil and gas revenues.
- **Giving priority in exploration and excavation** to local joint-stock companies in cooperation with foreign companies, and the participation rate of foreign companies should not exceed 40% of the project capital.
- **Enhancing Data and Research Capabilities:** Continuously improving data collection, analysis, and research capabilities is essential for better understanding the dynamics between oil price instability and economic growth. This will provide policymakers with accurate and timely information to make informed decisions and design effective policies.

Overall, implementing these recommendations can help mitigate the adverse effects of oil price instability on Yemen economic growth and foster a more diversified and resilient economy.

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APPENDIX

Appendix I: Lag Order Selection Criteria

VAR Lag Order Selection Criteria

Endogenous variables: LOP LEXR INFR FDI

Exogenous variables: C

Date: 05/08/23 Time: 06:23

Sample: 1991 2021

Included observations: 28

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-230.0545	NA	214.1754	16.71818	16.90850	16.77636
1	-154.4803	124.1577	3.085923	12.46288	13.41445*	12.75378
2	-132.6376	29.64368*	2.200137*	12.04554*	13.75838	12.56917*
3	-118.2321	15.43444	3.051791	12.15944	14.63353	12.91579

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Appendix II: Johansen Cointegration Test

Date: 05/08/23 Time: 06:37
Sample (adjusted): 1994 2021
Included observations: 28 after adjustments
Trend assumption: Linear deterministic trend
Series: LOP LEXR INFR FDI
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.832369	77.99442	47.85613	0.0000
At most 1	0.396299	27.98676	29.79707	0.0797
At most 2	0.347533	13.85580	15.49471	0.0870
At most 3	0.065605	1.899970	3.841466	0.1681

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.832369	50.00765	27.58434	0.0000
At most 1	0.396299	14.13096	21.13162	0.3544
At most 2	0.347533	11.95583	14.26460	0.1123
At most 3	0.065605	1.899970	3.841466	0.1681

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by $b'S_{11}b=I$):

LOP	LEXR	INFR	FDI
-0.383142	0.388021	0.045157	0.262070
0.510237	-0.190886	0.099315	-0.454540
2.579686	-2.797234	-0.086746	-0.143021
-1.070854	-1.159658	-0.060969	-0.148540

Unrestricted Adjustment Coefficients (alpha):

D(LOP)	-0.014879	-0.054747	-0.109143	0.037660
D(LEXR)	0.070442	0.114184	-0.043595	-0.004788
D(INFR)	-1.715998	-3.158341	-0.887193	-1.123781
D(FDI)	-2.748415	0.296503	-0.714440	-0.022351

1 Cointegrating Equation(s): Log likelihood -132.2255

Normalized cointegrating coefficients (standard error in parentheses)

LOP	LEXR	INFR	FDI
1.000000	-1.012734	-0.117859	-0.684002
	(0.59486)	(0.04023)	(0.14660)

Adjustment coefficients (standard error in parentheses)

D(LOP)	0.005701
	(0.02276)
D(LEXR)	-0.026989
	(0.01800)
D(INFR)	0.657471
	(0.62095)
D(FDI)	1.053033
	(0.16204)

2 Cointegrating Equation(s):		Log likelihood	-125.1600
Normalized cointegrating coefficients (standard error in parentheses)			
LOP	LEXR	INFR	FDI
1.000000	0.000000	0.377716	-1.012011
		(0.09671)	(0.46439)
0.000000	1.000000	0.489343	-0.323885
		(0.10444)	(0.50152)
Adjustment coefficients (standard error in parentheses)			
D(LOP)	-0.022233	0.004677	
	(0.03699)	(0.02507)	
D(LEXR)	0.031272	0.005537	
	(0.02457)	(0.01665)	
D(INFR)	-0.954030	-0.062959	
	(0.91856)	(0.62252)	
D(FDI)	1.204320	-1.123041	
	(0.26614)	(0.18037)	
3 Cointegrating Equation(s):		Log likelihood	-119.1821
Normalized cointegrating coefficients (standard error in parentheses)			
LOP	LEXR	INFR	FDI
1.000000	0.000000	0.000000	-2.929194
			(0.42097)
0.000000	1.000000	0.000000	-2.807658
			(0.42726)
0.000000	0.000000	1.000000	5.075733
			(1.04266)
Adjustment coefficients (standard error in parentheses)			
D(LOP)	-0.303788	0.309976	0.003359
	(0.13807)	(0.14707)	(0.00724)
D(LEXR)	-0.081189	0.127481	0.018303
	(0.09860)	(0.10502)	(0.00517)
D(INFR)	-3.242709	2.418726	-0.314201
	(3.78501)	(4.03147)	(0.19852)
D(FDI)	-0.638712	0.875416	-0.032687
	(1.01407)	(1.08009)	(0.05319)

Appendix III: Vector Error Correction Estimates

Vector Error Correction Estimates
Date: 05/02/23 Time: 16:08
Sample (adjusted): 1994 2019
Included observations: 26 after adjustments
Standard errors in () & t-statistics in []

Cointegrating Eq:	CointEq1			
LOILPRICES(-1)	1.000000			
LEXCHANGE_RATE(-1)	-0.613132 (0.11880) [-5.16092]			
INFLATION_RATE(-1)	-0.010795 (0.01019) [-1.05916]			
FDI(-1)	-0.161719 (0.02321) [-6.96699]			
C	-0.285853			
Error Correction:	D(LOILPRIC	D(LEXCHAN	D(INFLATIO	D(FDI)
CointEq1	-0.473805 (0.11520) [-4.11303]	-0.092996 (0.13135) [-0.70803]	-2.80830513 (3.39371) [-0.82750]	5.058144 (1.93551) [2.61334]
D(LOILPRICES(-1))	0.091786 (0.17011) [0.53955]	-0.080380 (0.19396) [-0.41441]	2.978227 (5.01165) [0.59426]	1.172456 (2.85825) [0.41020]
D(LOILPRICES(-2))	-0.295701 (0.17237) [-1.71547]	0.249036 (0.19654) [1.26711]	-8.851826 (5.07816) [-1.74312]	1.364123 (2.89618) [0.47101]
D(LEXCHANGE_RATE(-1))	-1.429364 (0.38046) [-3.75693]	0.281078 (0.43380) [0.64794]	-38.51419 (11.2085) [-3.43615]	8.911315 (6.39245) [1.39404]
D(LEXCHANGE_RATE(-2))	-0.180856 (0.28859) [-0.62668]	0.369316 (0.32905) [1.12236]	-6.581433 (8.50206) [-0.77410]	-4.874409 (4.84890) [-1.00526]
D(INFLATION_RATE(-1))	-0.017613 (0.00842) [-2.09063]	0.009182 (0.00961) [0.95591]	-0.816417 (0.24819) [-3.28943]	0.020425 (0.14155) [0.14429]
D(INFLATION_RATE(-2))	-0.016299 (0.00840) [-1.93965]	0.013867 (0.00958) [1.44728]	-0.583164 (0.24756) [-2.35563]	-0.089299 (0.14119) [-0.63248]
D(FDI(-1))	-0.057843 (0.01660) [-3.48353]	-0.047114 (0.01893) [-2.48850]	0.847467 (0.48918) [1.73241]	0.383655 (0.27899) [1.37515]
D(FDI(-2))	-0.072355 (0.01951) [-3.70786]	-0.018674 (0.02225) [-0.83932]	-0.182771 (0.57488) [-0.31793]	0.493535 (0.32787) [1.50528]
C	0.218466 (0.06976) [3.13189]	0.059281 (0.07953) [0.74535]	5.229953 (2.05501) [2.54497]	-0.976452 (1.17202) [-0.83314]

Appendix IV: Pairwise Granger Causality Tests

Pairwise Granger Causality Tests

Date: 05/07/23 Time: 21:36

Sample: 1991 2021

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LEXR does not Granger Cause LOP LOP does not Granger Cause LEXR	29	4.27974 0.10983	0.0257 0.8964
INFR does not Granger Cause LOP LOP does not Granger Cause INFR	29	1.96124 1.96077	0.1626 0.1627
FDI does not Granger Cause LOP LOP does not Granger Cause FDI	29	0.64919 0.17723	0.5314 0.8387
INFR does not Granger Cause LEXR LEXR does not Granger Cause INFR	29	6.64687 0.38006	0.0050 0.6879
FDI does not Granger Cause LEXR LEXR does not Granger Cause FDI	29	4.02947 1.10758	0.0310 0.3467
FDI does not Granger Cause INFR INFR does not Granger Cause FDI	29	5.19282 0.03241	0.0134 0.9682

Appendix V: Impulse Response (Table)

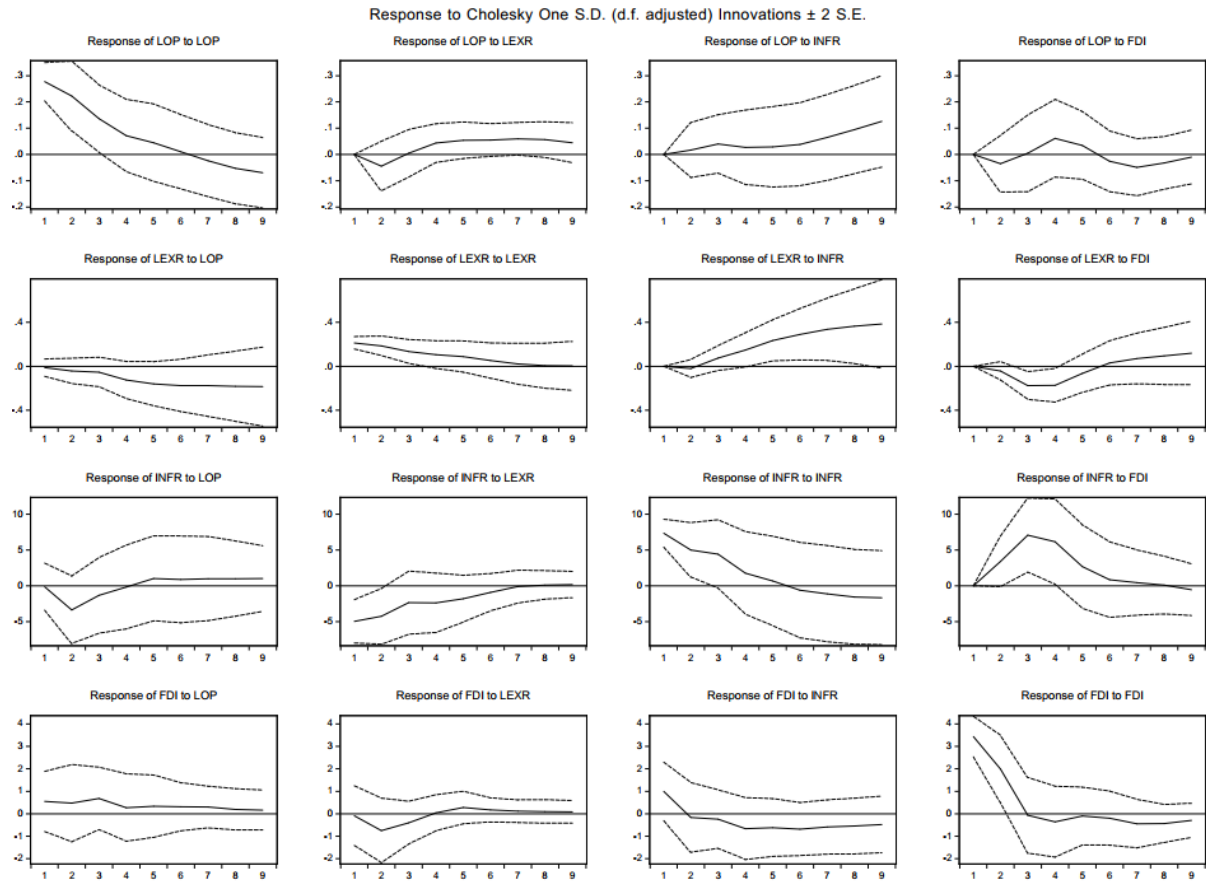
Response of LOP:				
Period	LOP	LEXR	INFR	FDI
1	0.277145 (0.03639)	0.000000 (0.00000)	0.000000 (0.00000)	0.000000 (0.00000)
2	0.222671 (0.06603)	-0.044197 (0.04746)	0.016665 (0.05243)	-0.035179 (0.05387)
3	0.136395 (0.06416)	0.004569 (0.04519)	0.040228 (0.05576)	0.004891 (0.07298)
4	0.071772 (0.06877)	0.043738 (0.03686)	0.027324 (0.07104)	0.061873 (0.07408)
5	0.044803 (0.07350)	0.054197 (0.03464)	0.029143 (0.07639)	0.034728 (0.06425)
6	0.010362 (0.07065)	0.054838 (0.03089)	0.038635 (0.07906)	-0.026013 (0.05758)
7	-0.023921 (0.06842)	0.059207 (0.03103)	0.064751 (0.08176)	-0.048825 (0.05432)
8	-0.052236 (0.06760)	0.056397 (0.03400)	0.094564 (0.08386)	-0.032171 (0.05024)
9	-0.069627 (0.06674)	0.045116 (0.03798)	0.126149 (0.08679)	-0.009447 (0.05118)

Response of LEXR:				
Period	LOP	LEXR	INFR	FDI
1	-0.012563 (0.03958)	0.212985 (0.02797)	0.000000 (0.00000)	0.000000 (0.00000)
2	-0.042361 (0.05748)	0.185861 (0.04421)	-0.020455 (0.04084)	-0.041825 (0.04168)
3	-0.052765 (0.06658)	0.135058 (0.05416)	0.074426 (0.05635)	-0.174784 (0.06316)
4	-0.125320 (0.08462)	0.105623 (0.06282)	0.148323 (0.07833)	-0.173679 (0.07638)
5	-0.159309 (0.10036)	0.088099 (0.07073)	0.235247 (0.09336)	-0.064000 (0.08687)
6	-0.175491 (0.11916)	0.051519 (0.08082)	0.290403 (0.11708)	0.030989 (0.10075)
7	-0.176417 (0.14030)	0.020740 (0.09312)	0.336074 (0.14201)	0.070342 (0.11491)
8	-0.182816 (0.15936)	0.005642 (0.10250)	0.364175 (0.16980)	0.093912 (0.12992)
9	-0.185577 (0.17949)	0.002966 (0.11112)	0.385709 (0.20176)	0.120059 (0.14470)

Response of INFR:				
Period	LOP	LEXR	INFR	FDI
1	-0.131915 (1.64688)	-4.981740 (1.51129)	7.336717 (0.96336)	0.000000 (0.00000)
2	-3.362353 (2.35680)	-4.277575 (1.94822)	5.002873 (1.89616)	3.396477 (1.77463)
3	-1.350258 (2.64561)	-2.368990 (2.20637)	4.428902 (2.38751)	7.076506 (2.58956)
4	-0.180672 (2.93269)	-2.384820 (2.07275)	1.769000 (2.88806)	6.157485 (2.97850)
5	1.021891 (2.97210)	-1.810969 (1.62597)	0.654233 (3.12386)	2.666948 (2.92263)
6	0.872923 (3.03353)	-0.921494 (1.29805)	-0.620341 (3.32838)	0.830336 (2.63678)
7	0.991204 (2.94003)	-0.121207 (1.14403)	-1.115757 (3.36127)	0.438756 (2.27688)
8	0.989712 (2.62543)	0.101885 (0.99581)	-1.563330 (3.31089)	0.086128 (2.01639)
9	1.004516 (2.28914)	0.163723 (0.91869)	-1.661094 (3.28252)	-0.540950 (1.80503)

Response of FDI:				
Period	LOP	LEXR	INFR	FDI
1	0.548833 (0.66925)	-0.084688 (0.66527)	0.998413 (0.65213)	3.440135 (0.45171)
2	0.472043 (0.86068)	-0.747698 (0.72024)	-0.163373 (0.77459)	1.996749 (0.74938)
3	0.684851 (0.69435)	-0.398559 (0.47405)	-0.242726 (0.65225)	-0.070264 (0.84226)
4	0.272394 (0.75229)	0.045092 (0.40167)	-0.659939 (0.68956)	-0.357347 (0.79017)
5	0.336596 (0.69562)	0.274916 (0.35824)	-0.616518 (0.64325)	-0.104153 (0.64270)
6	0.308387 (0.53491)	0.169767 (0.26825)	-0.685854 (0.59381)	-0.197488 (0.60349)
7	0.296642 (0.46578)	0.112233 (0.25487)	-0.590303 (0.60403)	-0.445039 (0.53919)
8	0.192062 (0.46068)	0.100213 (0.26440)	-0.547081 (0.62045)	-0.438918 (0.42219)
9	0.166149 (0.44399)	0.088488 (0.25045)	-0.476484 (0.62991)	-0.292496 (0.37926)
Cholesky Ordering: LOP LEXR INFR FDI				
Standard Errors: Analytic				

Appendix VI: Impulse Response (Graphs)



Appendix VII: Variance Decomposition Test

Variance Decomposition of LOP:

Period	S.E.	LOP	LEXR	INFR	FDI
1	0.277145	100.0000	0.000000	0.000000	0.000000
2	0.360362	97.32895	1.504195	0.213874	0.952986
3	0.387463	96.58175	1.315039	1.262942	0.840268
4	0.402202	92.81707	2.402986	1.633588	3.146359
5	0.410812	90.15668	4.043782	2.069086	3.730457
6	0.417193	87.48137	5.648789	2.863856	4.005984
7	0.429773	82.74503	7.220821	4.968601	5.065550
8	0.447874	77.55199	8.234567	9.033117	5.180323
9	0.472734	71.77923	8.302081	15.22895	4.689743

Variance Decomposition of LEXR:

Period	S.E.	LOP	LEXR	INFR	FDI
1	0.213356	0.346711	99.65329	0.000000	0.000000
2	0.289874	2.323411	95.09681	0.497927	2.081853
3	0.375687	3.355818	69.53902	4.221097	22.88406
4	0.469218	9.284594	49.64622	12.69829	28.37090
5	0.559235	14.65125	37.43171	26.63476	21.28228
6	0.656878	17.75667	27.74565	38.84970	15.64797
7	0.762192	18.54614	20.68208	48.29754	12.47423
8	0.869386	18.67647	15.90055	54.66837	10.75460
9	0.976456	18.41719	12.60563	58.94003	10.03715

Variance Decomposition of INFR:					
Period	S.E.	LOP	LEXR	INFR	FDI
1	8.869191	0.022122	31.54962	68.42826	0.000000
2	12.03455	7.817983	29.76957	54.44724	7.965216
3	14.89825	5.922752	21.95349	44.36488	27.75887
4	16.39274	4.904200	20.24951	37.80887	37.03742
5	16.75071	5.068999	20.56211	36.36268	38.00621
6	16.83068	5.289942	20.66695	36.15381	37.88930
7	16.90285	5.588744	20.49598	36.28146	37.63381
8	17.00434	5.860994	20.25563	36.69490	37.18847
9	17.12412	6.123401	19.98241	37.12433	36.76986

Variance Decomposition of FDI:					
Period	S.E.	LOP	LEXR	INFR	FDI
1	3.624878	2.292416	0.054583	7.586361	90.06664
2	4.235011	2.921847	3.157034	5.706724	88.21439
3	4.315906	5.331303	3.892586	5.811096	84.96502
4	4.389361	5.539475	3.773946	7.878732	82.80785
5	4.454920	5.948507	4.044510	9.563740	80.44324
6	4.525443	6.228928	4.060165	11.56488	78.14602
7	4.596383	6.454653	3.995425	12.86002	76.68990
8	4.654634	6.464369	3.942401	13.92160	75.67163
9	4.691870	6.487571	3.915643	14.73285	74.86393

Cholesky Ordering: LOP LEXR INFR FDI

Appendix VIII: Data

YEAR	OP	EXR	RGDP	INFR	FDI
1991	22.26	12.01006	6.3	44.9	4.763615
1992	18.44	12.01	8.2	51.2	11.10827
1993	16.33	12.01	4	61.7	16.82106
1994	15.53	12.01	6.7	71.3	0.379137
1995	16.86	12.01	5.7	63.9	-5.11178
1996	20.29	40.83917	4.6	38.8	-1.03877
1997	18.86	94.15667	5.2	4.6	-2.02528
1998	12.28	129.2808	6	11.5	-3.4687
1999	17.44	135.8817	3.8	7.9	-4.0256
2000	27.6	155.7183	6.2	11	0.066299
2001	23.12	161.7183	3.8	11.9	1.573189
2002	24.36	168.6717	3.9	12.2	1.06878
2003	28.1	175.625	3.7	10.8	-0.75656
2004	36.05	183.4483	4	12.5	1.034961
2005	50.59	191.5092	5.6	9.9	-1.80372
2006	61	197.0492	3.2	10.8	5.880659
2007	69.04	198.9533	3.3	7.9	4.236847
2008	94.1	199.7642	3.6	19	5.776963
2009	60.86	202.8467	3.9	3.7	0.514121
2010	77.38	219.59	7.7	11.2	0.610358
2011	107.46	213.8	-12.7	19.5	-1.58234
2012	109.45	214.3492	2.4	9.9	-0.04022
2013	105.87	214.89	4.8	11	-0.3305
2014	96.29	214.89	-0.2	8.2	-0.53924
2015	49.49	230.8333	-28	22	-0.03639
2016	40.76	283.8958	-9.4	21.3	-1.79131
2017	52.51	282.195	-5.1	30.4	-1.00532
2018	69.78	214.89	0.8	33.6	-1.30564
2019	64.04	486.7309	1.4	15.4	NA
2020	41.47	743.006	-8.5	19.6	NA
2021	69.89	1035.467	-1	26	NA