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Oil Discovery in America and the Birth of the Modern Petroleum Industry

Dissertation submitted as partial fulfilment of the requirements for the degree of *Master* in Literature and Civilization.

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Declaration of Originality

I hereby declare that this submission is my work and that, it contains no material previously published or written by another person nor material which has been accepted for the qualification of any other degree or diploma of a university or other institution.

Date: 6th July

Name: ABDICHE Asmaa

Signature:…….

Dedications

To my beloved parents,

To my husband,

To my friends and colleagues at Schlumberger and Weatherford companies, S. LAOUISSI and S.SENOUSSAOUI respectively,

To my relative A. ACHOUR at SonatrachCompany for his help and support.

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My thanks go to my supervisor Dr.R. RAOUTI for her guidance, patience and assistance in completing this research work.

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Last but not least, I would like to express my regards and blessings to all those who provided me with academic support during the completion of this humble work.

Abstract

Petroleum is an important substance consumed in modern society. It is a naturally occurred and non-renewable source of energy; it is a precious commodity, and the most commonly used source of energy in industry, for heating, transportation, and many other purposes. This research work aims to show how the first oil well discovered in 1859 precisely in Titusville, Pennsylvania the United States of America led to the birth of the modern petroleum industry. The first steps of the shaping of the modern industry are illustrated through analyzing the historical background of the industry and evolution of petroleum use basing on related documents, graphs, charts, and tables i.e. how ancient civilizations were and how they used oil seeped on the ground; Afterward, the first discovery of oil reservoirs in the US and their commercial exploitation and the evolution of the modern petroleum industry. From a historical standpoint, Oil was discovered before Christ's time, and used by older civilizations for construction, embalming mummies, and even in medicine. Following the discovery of the first commercial oil well in 1859 by Edwin Drake in the US, there was a move from using natural sources such as coal or whale oil for illumination to the use of Kerosene, transition to the automotive era, production of gasoline and other transportation fuels that led to the development of the petro-chemistry and the evolution of the modern industry. The US was the leading oil producer country, for the new oil field discoveries, advances in extraction technology, the rise of oil production, and was economically powerful by its monopoly of the oil market for several years. Many issues were not addressed in this study which needs further information. First, will the US keep being the leading oil producer country in the world for the next centuries? Second, will the world continue to rely on fossil fuels or it will shift to alternative energy sources?

Keywords: United State, petroleum, reservoirs, drilling, production, industry, energy, demand, petro-chemistry, monopoly, discovery, market

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List of Acronyms, Abbreviations

AD: Anno Domini

API: American Petroleum Institute

ARAMCO: Arabian American Oil Company

BC: Before Christ

BTEX: Benzene, Toluene, Ethyl Benzene, Xylene

BP: British Petroleum

C: Cubic

CH4: Methan gas

CH: Cetane

CN: Cetane Number

CFP: Compagnie Française des Pétroles

EOR: Enhanced Oil Recovery

ESP: Electrical Submersible Pump

IPC: Iraq Petroleum Company

LPG: Liquified petroleum gas

OAPEC: Organization of Arab Petroleum Exporting Countries

OPEC: Organization of Petroleum Exporting Countries

PAHs: polynuclear or polycyclic aromatic hydrocarbons

UAE: United Arab Emirates

USA: United States of America

USSR: Union of Soviet Socialist Republics

Measurments

B: barrel(s) (1b= 42 U.S.gallons)

Bpd: Barrels per day

Mmbpd: Millions of barrels per day

Bp: billion barrels

Mmboepd: Million Barrels of Oil Equivalent per Day

Bbl: Barrels

Tcf: Trillion Cubic Feet (of natural gas)

Bboe: Billions of barrels of oil equivalent

General Introduction

The modern petroleum industry plays a significant role in many different sectors; whether in the environmental, economic, political, or even in the other sectors. The 19th century was the age of oil discovery and the rise of the modern petroleum industry. Oil was first discovered by Edwin Drake in 1859 in Titusville, Pennsylvania, the United States. Since its first discovery, oil has become the world's most important source of energy. Its products support the modern society, mainly furnishing energy to power industry, heating homes, and provide fuel for aero-planes, vehicles to carry people and goods all over the world and even lead to gaining political authority.

The first discovery of oil in Pennsylvania in the United States of America was a motive that led to seeking oil in other surrounding regions and even in many other countries in the world. Later, discoveries occurred in several countries, such as Russia, Canada, Romania, Poland, Indonesia, Mexico, Venezuela, Iran, and Saudi Arabia. From 1861 to 2006, besides the US, these countries were all regarded as top oil producer countries. Although all these countries produced large quantities of oil, the US was regarded as the leading oil producer country in the world. And it controlled the petroleum industry and the world oil market.

In the light of the background provided, this research work studies the relation between the first discovery of oil in the United States and the birth of the modern petroleum industry through analyzing the historical background of the petroleum industry and evolution of petroleum use basing on related documents, charts, tables, and graphs.

Petroleum is indispensable in the production of many everyday essentials and is the primary source of energy that supports modern society; therefore, many inquiries have been asked about this black gold; its beginnings, use, price, and the evolution of modern petroleum industry. So, this research work aims to show the shaping of the modern petroleum industry after the discovery of the first oil well drilled by Edwin Drake in 1859 in Titusville, Pennsylvania the United States. It also focuses on the changes that America witnessed after the discovery of the first commercial oil well, the birth of the modern petroleum industry, and its impact on the US in becoming the leading producer of oil and monopolizing the world oil market for several years.

The main research questions for this research work are:

1. Was oil first discovered in America?

2. What changes oil discovery has brought to America?
3. What made America become the leading oil producer country in the world in the late 19th and during the 20th century?

Working on the preceding research questions, the following hypotheses are provided:

1. If oil was known by older civilizations, then it was not first discovered in America.
2. There are many changes that oil discovery has brought to America; for instance, the use of kerosene instead of other natural sources such as coal or whale oil for lighting homes, the production of new useful and cheap products, the oil demand to fuel motor cars, and the birth of the modern petroleum industry.
3. The exploration of giant oil reservoirs in the United States of America and the development of new technologies are what make the US become the leading oil producer country in the world in the late 19th and during the 20th century and economically powerful through monopolizing the world oil market.

This research work comprises three chapters; the first chapter presents an overview of the petroleum industry so that the reader grasps a general idea about the central stages of the industry, and for a better understanding of the next chapters. The following chapter provides a historical background of the petroleum industry focusing on the evolution of petroleum use, the first commercial oil well drilled by Edwin Drake in 1859, oil production, and oil shocks. Finally, the third chapter is devoted to the birth of the modern petroleum industry. Particularly how the discovery of the first oil well in the United State led to the evolution of the modern industry, also it focuses on the economic side of the industry.

During conducting this research work, many limitations came across. For instance, at the beginning of writing this work, there was limited access to data which led to spending time to find ways that facilitate access to all necessary data. Also, the topic selected presented a limitation as it was hard to read it from one perspective only. All sides the scientific, economic and political are related to each other. So it was hard somehow to keep limited to one side of the topic selected.

Chapter One

1.1. Introduction

Petroleum is an important substance consumed in modern society. It is the most commonly used source of energy, for it provides raw materials and other products such as fuel for energy, industry, heating, and transportation. The word petroleum is taken from the Latin word petra and oleum, which means rock oil and refers to hydrocarbons that occur widely in the sedimentary rocks in the form of gases, liquids, semisolids, or solids. This chapter aims to introduce to the reader the structure of the petroleum industry to have a general idea about the steps followed from the discovery of petroleum to its marketing, beginning with the formation of petroleum, its chemical composition, and petroleum types; conventional and unconventional crude oil. Next, it focuses on the important stages of the petroleum industry which are exploration, recovery, transportation, and refinery. Finally, refined petroleum products are listed at the end of this chapter followed by petroleum marketing.

1.2. Petroleum formation

Petroleum formation is a process that takes a long period underground. Petroleum is formed from the bodies of ancient organisms "primarily one" celled plants and animals. For this reason, it is called fossil fuel. The remains of the dead creatures accumulate at the bottoms of ancient lakes or seas along with sand and other sediments. Over time, pressure, heat, and bacterial action play a crucial role in transforming the deposits into sedimentary rock. Finally, the inserted organic matter transforms into chemicals, such as hydrocarbons, carbon dioxide, hydrogen sulfide, water, and others (Robinson & Hsu, 2007).

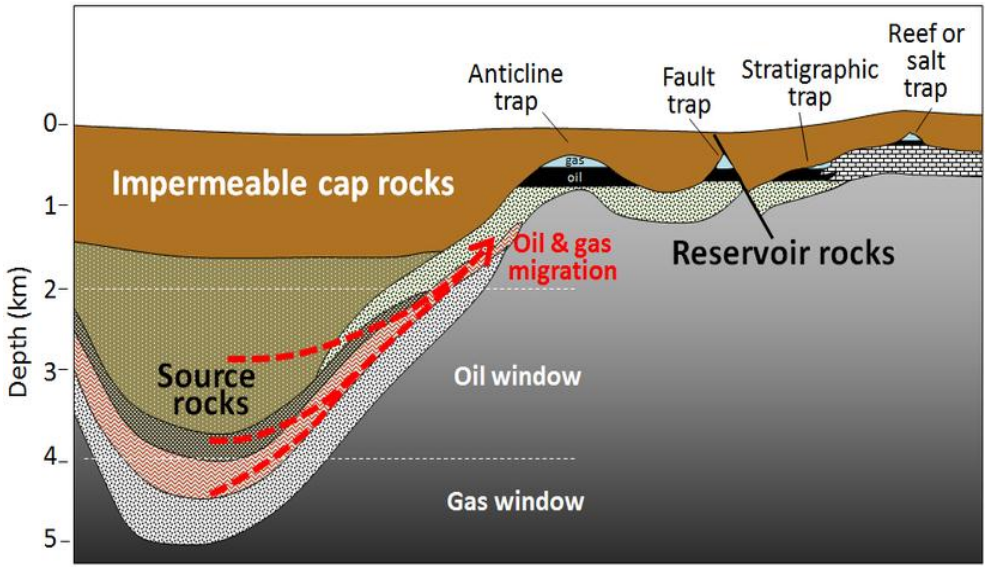
The chemicals formed always move, especially if the surrounding rock is porous. Thus, Liquids and gases could migrate from the source rock to the surface or into a reservoir that is sealed by impermeable rock see fig.1.1 (Robinson & Hsu, 2007).

Four elements are required for the formation and accumulation of petroleum in beneficial or economic quantities. The elements are Source rock, reservoir rock, trap, and seal. These components allow the crude oil to stick around underground and ready in large quantities. First, a source rock is usually sedimentary rock rich in organic matter. The crude oil generated by the decomposed matter migrates from the source rock to a reservoir rock. Second, the reservoir rock contains many tiny pores that store the oil. Third, a trap, either stratigraphic layers of impermeable rock or structural traps, prevents the oil from migrating from the reservoir rock to the surface of the ground. Finally, an impermeable

layer, or seal, prevents the oil from rising through or around the trap to the surface (American Petroleum Institute, 1984 as cited in Occupational Exposures in Petroleum Refining, 1988).

Figure 1.1

Source Rock



Note. From "Energy Education", by S.Sheardown and J. Donev, 2019, https://energyeducation.ca/encyclopedia/Source_rock. Copyright n.d. Permission not sought.

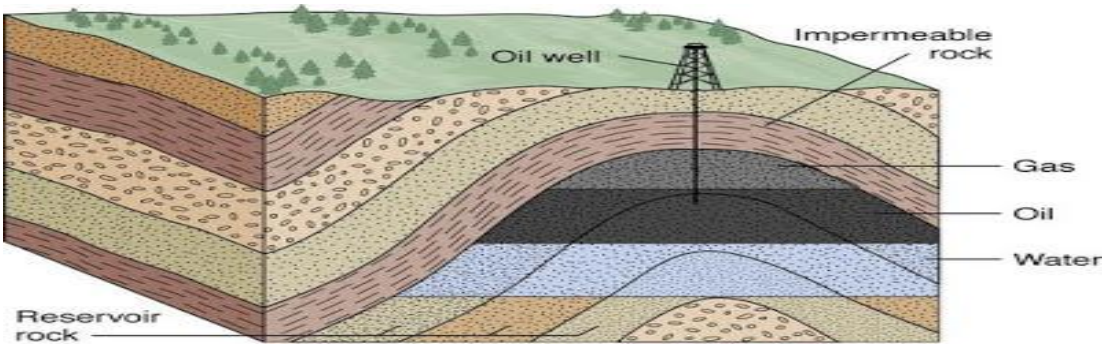
1.3. Types of petroleum

The term "Petroleum" is used by many people as a synonym for crude oil. Yet petroleum means any naturally occurring hydrocarbon mixture whether in a liquid, gaseous, or solid form. So, petroleum encloses many varieties of crude oil and natural gas (Vassiliou, 2009).

Commonly, the term "crude oil" refers to what is precisely called conventional crude oil. This crude is found in natural underground reservoirs as a liquid as is shown in figure 1.2 and remains the same at atmospheric pressures. The majority of crude oil produced to date has been conventional crude. Crude oil gravity ranges in density from 20 to 40° American Petroleum Institute (API) gravity and flows relatively easily (Vassiliou, 2009). On the other hand, unconventional crudes cover extra-heavy oil, oil shale, and oil sand. Energy and more money are needed to extract unconventional crudes in a useful form; however, it should be highlighted that even conventional crudes can also be expensive to produce. Extra-heavy oil is exploited in Venezuela's Orinoco Oil Belt, and oil sands are mined and processed in the Canadian province of Alberta (Vassiliou, 2009).

Figure 1.2

Oil and Gas Reservoir



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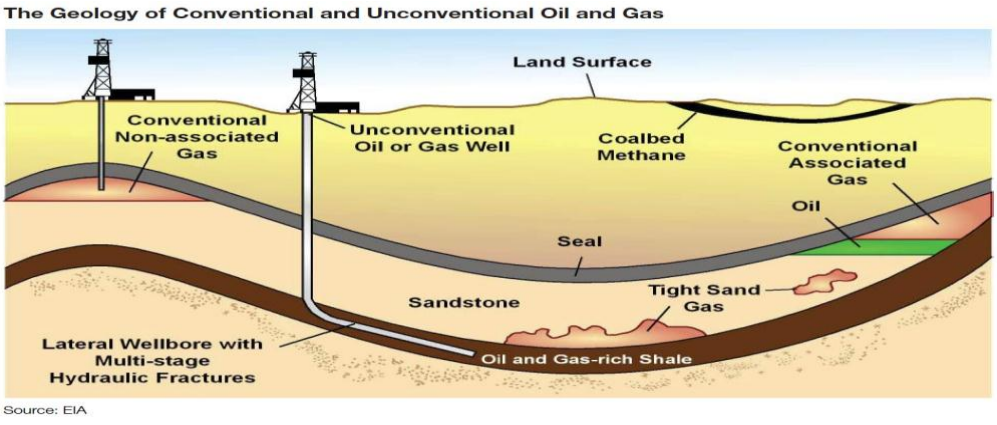
Natural gas, particularly methane, can be conventional natural gas and also can be unconventional. "Conventional" natural gas is found in pressurized reservoirs and easily recoverable. However, unconventional natural gas is hard to recover and is found in various forms. For instance, tight gas reservoirs in which gas cannot move easily because of the low permeability of formations where gas is held. In this case, natural gas must typically be recovered by hydraulic fracturing. In addition, Coalbed methane is found in coal deposits, and to be recovered, hydraulic fracturing is also required. Figure 1.3 shows the different conventional and unconventional petroleum (Vassiliou, 2009).

Figure 1.3

Conventional vs. Unconventional Resources



Note. From "Croft Productions", by Croft Productions, 2014, https://www.croftsystems.net/oil-gas-blog/conventional-energy-unconventional-energy-what-does-it-all-mean/. Copyright 2009-2021 Croft Production systems,Inc.

1.4. Chemical composition and physical properties

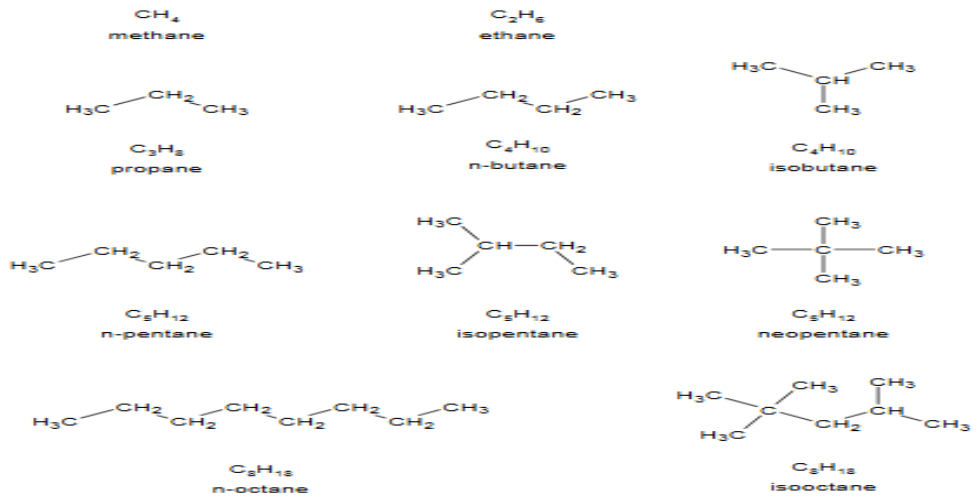
Crude oils are naturally occurring liquids, complex mixtures of varied and large numbers of hydrocarbon compounds, and containing also some compounds of oxygen, nitrogen, and sulfur. Each crude oil is a unique mixture, different in composition or properties from any other sample of crude oil (Occupational Exposures in Petroleum Refining, 1988). Carbon exists in nearly all of the chemical compounds in petroleum (Robinson & Hsu, 2007). Crude oils are usually classified into different groups, according to the nature of the hydrocarbons they contain. They are paraffin, naphthenes, and aromatics.

1.4.1. Paraffins

As clarified in figure 1.4, Paraffins or as are also known as Alkanes; they have the general molecular formula CnH2n+2, where "n" is the number of carbon atoms. The simplest alkane is methane CH4. Normal paraffins are unbranched straight-chain molecules; whereas, isoparaffins are branched-type hydrocarbons. Paraffins have the same chemical and physical properties which change gradually as carbon atoms are added to the chain (Fahim et al., 2009).

Figure 1.4

Isomers of selected light paraffins



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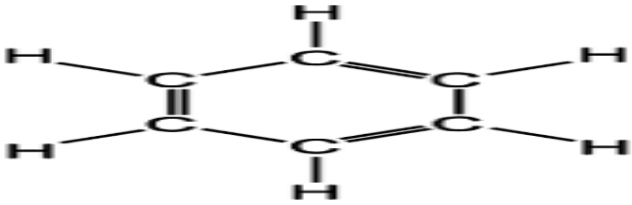
1.4.2. Aromatics

Aromatics as shown in figure 1.5 are also found in petroleum, they are unsaturated cyclic compounds that are quick in reaction because they have carbon atoms that are lacking in hydrogen. In addition, at least one benzene ring is included as a part of all aromatics molecular structures. (BTEX) Benzene, Toluene, Ethyl Benzene, Xylene are one-ring compounds that are numerous, and naphthalenes are fused double-ring aromatic compounds; whereas, (PAHs) polynuclear or polycyclic aromatic hydrocarbons are found in heavier fractions of crude oil. They are very complex aromatics (Kolmetz, 2016).

Figure 1.5

Example of aromatics; Benzene



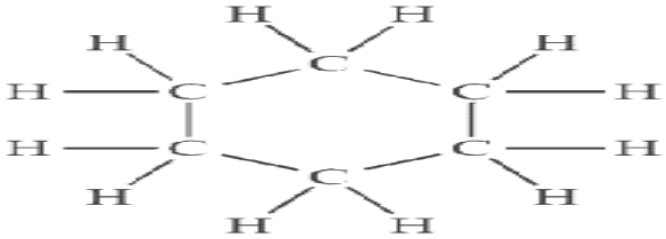
Note. From "Crude oil Properties" p. 11, K.Kolmetz, & R. M.Sari, 2016, KLM Technology Group. Copyright n.d. Permission not sought

1.4.3. Naphthenes

Naphthenes have the general formula CnH2n, they are saturated hydrocarbon series, and grouped in the form of closed rings (cyclic) as illustrated in figure 1.6, and available in all crude oil fractions excluding the very lightest ones. Single-ring naphthenes (mono-cycloparaffins) with five and six carbon atoms dominant, with two-ring naphthenes (dicycloparaffins) found in the heavier ends of naphtha (Kolmetz, 2016).

Figure 1.6.

Example of Naphthenes; Cyclohexane



Note. From "Crude oil Properties" p.12, K.Kolmetz, & R. M.Sari, 2016, KLM Technology Group. Copyright n.d. Permission not sought

1.4.4. Other compounds

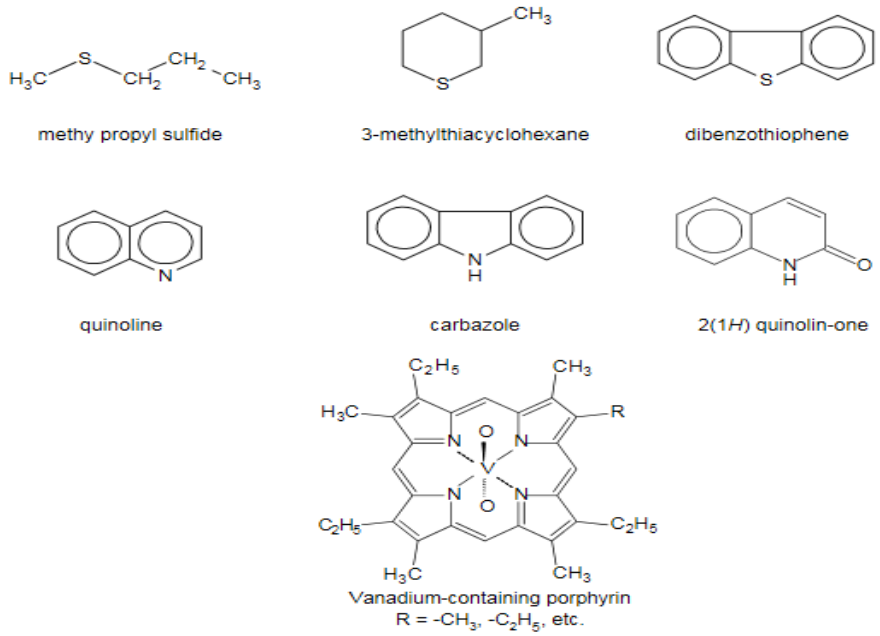
Hetero-atom Compounds and Olefins are other hydrocarbon compounds. These compounds may also be found in crude oils.

1.4.4. 1. Hetero-atom Compounds

Atoms other than carbon and hydrogen are found in crude oils and called hetero-atoms. Such atoms are sulfur, nitrogen, oxygen, and metals which represent secondary components of crude oil. Figure 1.7 shows some of the sulfur and nitrogen compounds that are seen as dangerous because of the problems that present to oil refiners. For example, high-sulfur fuels, when burned in vehicles cause acid rain. For this reason, Sulfur is considered a stimulating poison, and nitrogen and metals as well. Hence, oil refiners dedicate much time and money to remove hetero-atoms from intermediate streams and finished products (Robinson & Hsu, 2007).

Figure 1.7

Hetero-atom compounds found in crude oil



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Note. From "*Practical advances in petroleum processing"* by C. S. Hsu and P. R.Robinson,2007, Springer Science & Business Media, Vol. 1,p.10. Copyright 2006 Springer Science+Business Media, Inc. Permission not sought.

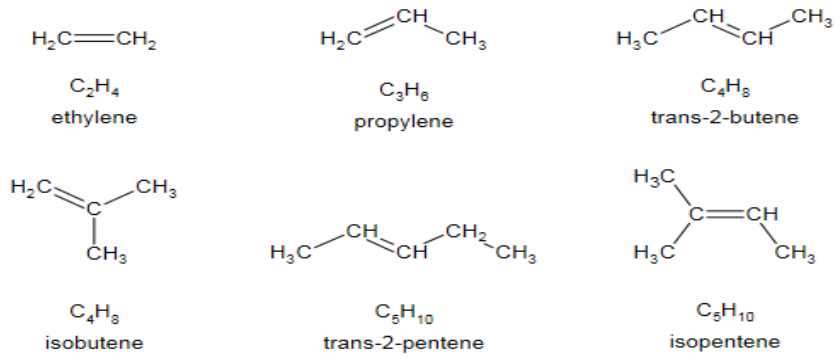
1. 4.4.2. Olefins

Olefins are another class of molecules. They are characterized by their high reactivity. Olefins are not widespread in natural crude oil. Yet, they are generated by

several“cracking“processes in refineries. Figure 1.8 shows structures for some common light olefins (Robinson & Hsu, 2007).

Figure 1.8

Selected light olefins



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Note. From “*Practical advances in petroleum processing”* by C. S. Hsu and P. R.Robinson,2007, Springer Science & Business Media, Vol. 1,p.10. Copyright 2006 Springer Science+Business Media, Inc. Permission not sought.

1.5. Crude Oil Classification

Crude oil classification can be usually relevant to the geological source. Crude oils from the same producing sand may have the same fractional and chemical compositions, although they are drained from completely distant pools. However, some oilfields that are close together may produce very different crude oils from the same stratum or from different oil-bearing sands. For instance, in East Texas, USA, Woodbine sand produces almost identical crude oils in different, and crude oils from other Woodbine oilfields close to the East Texas field differ only slightly from the East Texas crude oil. In contrast, crude oils produced from the New and Old Grozny fields in the Union of Soviet Socialist Republics (USSR) are very different, despite being only ten miles (16 km) from each other (Occupational Exposures in Petroleum Refining, 1988).

The chemical composition of crude oils has no relation to their geological age or origin. For instance, in the US crude oils that are geologically old are paraffin- and mixed-based, while those that are geologically new are naphthenic or asphaltic. However, Oilfields in other countries are different: in Poland, crude oils that are geologically new are asphaltic, naphthenic, and paraffinic (Occupational Exposures in Petroleum Refining, 1988).

Hydrocarbons have three different phases. They may be gaseous, liquid, or solid, under normal conditions of temperature and pressure, and this is controlled by the number

of carbon atoms and their positioning in the molecules. For instance Compounds with molecules containing up to 4 carbon atoms are gaseous. Whereas, those with 5-20 carbon atoms are liquid, and those with more than 20 carbon atoms are solid (World Health Organization, 1982).

Some Crude oils may contain mostly paraffin, whereas other ones may contain mostly naphthenes. In addition, crude oil may be light containing a large quantity of lower hydrocarbons and be mobile or containing a lot of dissolved gas, another may be viscous consisting mainly of higher hydrocarbons, with little or no dissolved gas (World Health Organization,1982).

Crude oils are also classified as light, medium or heavy, depending on their density. A light crude oil generally has an API greater than 40, a medium crude oil between 15, and 40 and a heavy crude oil less than 15 (Occupational Exposures in Petroleum Refining,1988).

Also, crude oil's color may vary from dark, for instance, green, brown, or black in some oil wells to a clear color in other wells. Besides, as stated by Vassilio, some crude oils are as sour with high sulfur content or smell like rotten eggs, and others are sweet with low sulfur content (2009). In addition, some crude oils flow as easily as water; whereas, others flow with difficulty if they are not heated. And some are so solid they have to be mined (Robinson & Hsu, 2007).

1.6. Petroleum Reservoirs Classification

As Islam et al stated, petroleum reservoirs classification is depending on the state of the fluid compound. Petroleum reservoirs are divided into two wide categories; oil and gas reservoirs. These latter may be subdivided into different groups according to the hydrocarbon compounds, the initial temperature and pressure of the reservoir and so on (2011).

1.7. Exploration, Recovery, and Transportation

1.7.1. Exporation

The beginning of the exploration of petroleum goes back to the 19th century. Geologists were the first who started to map land features to find favorable places for drilling (Landes, 1959; Hobson and Tiratsoo, 1975 as cited in Speight, 1999). They were interested in rock formations that provided evidence of alternating layers of porous and impermeable rocks. The porous rock form a reservoir for petroleum, and impermeable rock acts as a trap and prevents the migration of petroleum from the reservoir (Speight, 1999).

Most areas where surface structural characteristics showed evidence for oil had been investigated by the twentieth century, and the era of subsurface exploration for oil began in the early 1920s (Forbes, 1958 as cited in Speight, 1999). The strata were not adequately exposed to permit surface mapping of the subsurface characteristics. For this reason, new geological and geophysical techniques were developed. In the 1960s, geophysics developed methods for exploration underground. For instance, gravity methods, magnetic methods, seismic methods, electrical methods, electromagnetic methods, radioactivity methods, borehole logging (Speight, 1999). Thus, exploration for oil started first by geologists then geophysics to locate appropriate places for drilling.

1.7.2. Drilling

Drilling a well into the underground reservoir is the first step in the extraction of crude oil. While drilling, many ways might be followed for the rate of extraction can be economically beneficial. For instance, many wells will be drilled into the same reservoir to raise the extraction rate, or some wells may be used to pump acids, water, steam, or various gas mixtures into the reservoir in order to raise the reservoir pressure, and maintain an economic extraction rate (Speight, 1999).

As Speight declared, drilling for oil is a complex operation. It involves raising and dropping a heavy drilling bit and drill stem attached by cable at the surface. Through the application of a heavyweight, the bit smashes the rock and earth gradually forming the hole (1999).

1.7.2.1. Preparing to drill

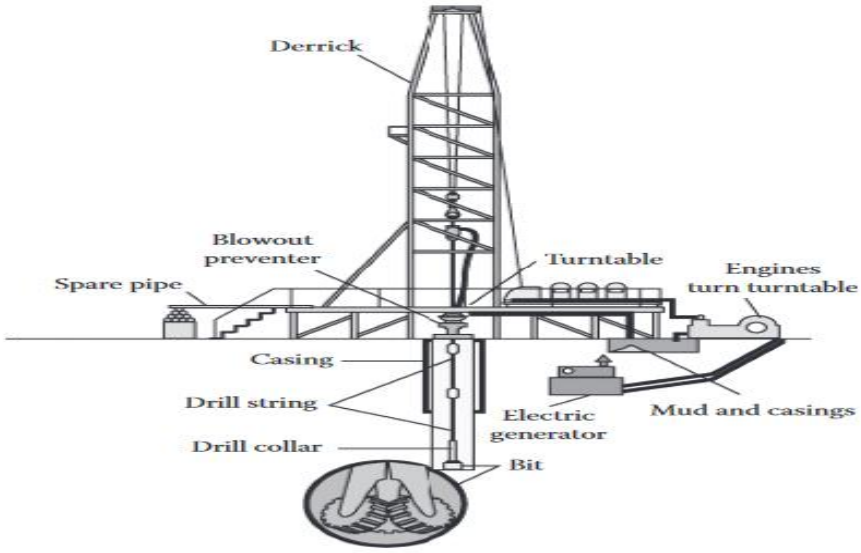
Driling a well underground to extract oil is preceded by some preparations. First, the site that has been selected must be surveyed to determine its boundaries. Then obtaining the right to access land must be legally evaluated. Once the legal issues have been settled, the crew prepares the land following these steps: cleaning the land, building access roads, provide a source of water that is used in drilling, and create a reserve pite, for it is needed during the drilling process in order to dispose of rock cuttings. After preparing the land, the drilling rig is welcomed into the site. The crew then begins drilling the main hole (Speight, 1999).

1.7.2.2. Drilling equipment

Drilling equipment should be available on the site before the drilling operation begins. The equipment may be transported to the site by helicopter, barge, or truck. Once the equipment is at the site, the rig is installed as illustrated in figure 1.9 However, some rigs are built on ships or barges for work on water as in seas, marshes, or lakes where there is no foundation to support a rig. Although the drilling rig is simple in the schematic representation, yet in reality, it is completely complex and consists of the following systems: Power system, Mechanical system, Rotating equipment, Circulation system, and the Blowout preventer, in addition, Casing, and Derrick (Speight, 1999).

Figure 1.9

Schematic of a drilling rig



Note. From "*The chemistry and technology of petroleum"* by J. G. Speight, 1999, CRC press, p.123. Copyright 2014 by Taylor & Francis Group, LLC.Permission not sought.

Drilling an oil well is a monotonous process. Once the rig is set up, drilling operations commence and a surface hole is drilled to a predetermined depth, which is somewhere above where the oil trap is located.

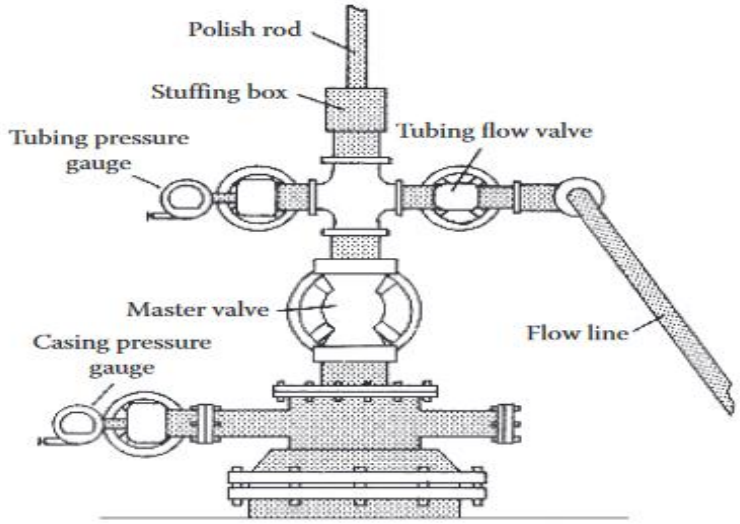
1.7.3. Well completion

Well completion process is the next step that comes after drilling an oil well. After reaching the final depth, the well completion begins for oil flow into the casing in a surveilled manner. Then, tubing is run into the hole as a conduit for oil and gas to flow up the well and a packer is run down the outside of the tubing. The packer forms a seal around the outside of the tubing. In the end, equipment; "the Christmas tree" as illustrated in

Figure 1.10 is set up at the top of the tubing and cemented to the top of the casing. The Christmas tree controls the flow of oil from the well (Speight, 1999).

Figure 1.10

The Christmas tree—a collection of control valves at the wellhead



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In some cases, reservoir stimulation techniques are needed to encourage reservoir fluids that are able to flow into the wellbore. For instance, tight formations are sometimes encountered and it becomes compulsory to use one of the stimulation techniques which are acidizing and fracturation (Speight, 1999).

Hydraulic fracturing is the process of using a fluid, such as water charged with nitrogen used on formations composed of sandstone. The fluid is pumped under high pressure at high rates into the well to create deep-penetrating fractures in the reservoir. Charging the water with nitrogen facilitates the flow of water back out of the well (Giuliano, 1981; Baker et al., 1986a cited in Occupational Exposures in Petroleum Refining, 1988).

Acidizing is the process of treating the formation of limestone or dolomite with specific types of acids for instance, hydrochloric, acetic, or hydrofluoric acid. Precise products or additives, for example, corrosion inhibitors, surface-active agents, sequestering agents, and anti sludge agents are mixed with the acids to prevent an acid attack on tubing and casing, to help disperse the acid in the formation, to prevent precipitation of ferric iron during acidizing and to prevent the formation of insoluble sludge (Giuliano, 1981; Baker et al., 1986a cited in Occupational Exposures in Petroleum Refining, 1988).

Well completion process is the next step that follows drilling operation, and it allows the reservoir to flow the liquids up to well in a controlled manner.

1.7.4. Recovery

In the petroleum industry, recovery is the production of oil from a reservoir. There is recovery due to reservoir pressure called primary recovery i.e., the oil flows from the well naturally and without assistance. Next, there is also the second recovery method which is followed when the pressure of the well falls and becomes insufficient underground to force the oil to the surface. Secondary oil recovery methods involve adding pumps on the surface or submerged; Electrical Submersible Pump (ESP) to bring the oil to the surface or other techniques such as, water injection and gas injection which injects air or some other gas into the reservoir. Finally, enhanced oil recovery (EOR) or tertiary oil recovery is the supplementary ultimate oil recovery that can be recovered over the oil that can be obtained from primary and secondary recovery methods (speight, 1999).

1.7.5. Transportation

The oil field's location is usually in distance or far away from refineries where crude oil is converted into usable products. For this reason, crude oil must be transported in pipelines, tankers, railroad cars, and motor vehicles, or barges which are used to transport oil on inland waterways. However, most crude oils need some form of treatment near the reservoir, for they are not pure. Oil often contains quantities of gas, saltwater, or even sand. For this reason, Separation must be done before transportation (speight, 1999).

1.8. Refinery

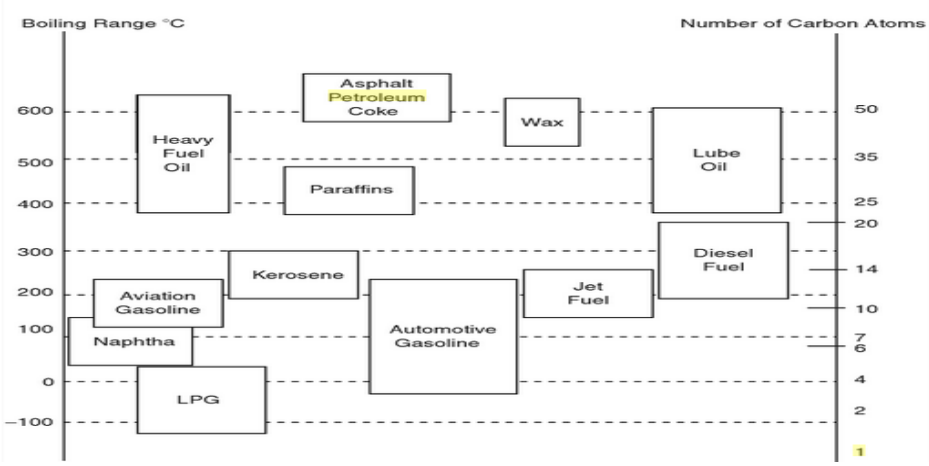
Crude oil has no value to consumers once pumped from the ground. So, it must be transformed into products that can be used in the marketplace. In refining processes, various physical and chemical methods are applied. Heat, pressure, catalysts, and chemicals are applied to convert crude oil and other hydrocarbons into petroleum products. Refining begins with the distillation of crude oil through boiling to separate it into fractions. After crude oil is separated into its fractions, each stream is further converted by changing the size and structure of the molecules through cracking, reforming, and other conversion processes. The converted products are then subjected to various treatments and separation processes to remove undesirable constituents and improve product quality (Gary et al., 2007).

1.9. Petroleum products composition

There are descriptions for more than 2000 single refinery products. Raw materials can be dispatched to several units to produce different blend products relying on market demand. Figure 1.11 shows refinery products with carbon atoms they contain and their boiling scopes (Fahim et al., 2009).

Figure 1.11

Principal petroleum products with carbon number and boiling ranges



Note. From "*Fundamentals of petroleum refining"by* M. A.Fahim, T. A. Al-Sahhaf and A. Elkilani, 2009, Elsevier, P.21. Copyright 2010 Elsevier B.V. Permission not sought.

1.9.1. Liquified petroleum gas

Liquified petroleum gas (LPG) is derived from natural gas fractionation or crude oil refining, and it is a group of gases hydrocarbon-based. LPG contains ethane, ethylene, propane, propylene, normal butane, butylenes, isobutene, and isobutylene. These gases are liquefied through pressurization, for the suitability of transportation (Fahim et al., 2009).

1.9.2. Gasoline

Gasoline is classified into three grades: regular, midgrade, and premium. This classification is formed by octane ranking (conventional, oxygenated, and reformulated)

Regular Gasoline: Gasoline having an octane rating over 85 or equal and less than 88.

Mid-grade Gasoline: Gasoline having an octane rating ranging from 88 to 90.

Reformulated Gasoline: Gasoline having an octane rating of over 90.

Aviation gasoline which is a complex mixture of volatile hydrocarbons is mixed with additives to form a convenient fuel for aviation engines. Also, the use of premium and regular-grade motor gasoline is according to octane ranking (Fahim et al., 2009).

1.9.3. Kerosene

Kerosene is a light petroleum product that is the result of petroleum distillation. Kerosene is used in space heaters, water heaters, cookstoves, and also is used for lighting. It is utilized as a light source. It is used in space heaters, water heaters, cookstoves (Fahim et al., 2009).

1.9.4. Jet fuel

Jet fuel is a variety of petroleum products that include both kerosene and gasoline and is suitable for use in aviation turbine power units (Fahim et al., 2009).

1.9.5. Diesel fuel

Diesel fuel quality may be expressed as cetane number or cetane index. Diesel fuel includes No.1 diesel which is super, and has a cetane number of 45 and is used in trucks, buses, and high-speed engines. The other one, No.2 diesel has a 40 cetane number. For railroad diesel fuels, are similar to automotive diesel fuels, yet have lower cetane numbers (CN=30) (Fahim et al., 2009).

1.9.6. Fuel oil

Fuel oils are mostly used in space heaters, and accordingly fuel oil market is completely high particularly in cold climates. Kerosene is identical to No.1 fuel oil, and No.2 is analogous to No.2 diesel fuel. No.3 and 4 are also available as heavier grades (Fahim et al., 2009).

1.9.7. Residual fuel oil

Residual fuel oil is composed of vacuum residue. Viscosity and sulfur content are two critical parameters. Low sulfur residues are more demanded in the market (Fahim et al., 2009).

1.9.8. Lube oil

Paraffinic and naphthenic are two different lubricants based on viscosity index. Lubricants have a finished viscosity index of over 75 (Fahim et al., 2009).

1.9.9. Asphalt

Asphalt is another precious product, particularly in the construction industry. It consists of up to 20% of products. Asphalt is produced only from crude comprising asphaltenic material (Fahim et al., 2009).

1.9.10. Petroleum coke

Petroleum coke is a carbon compound formed from the thermal conversion of petroleum-containing resins and asphaltenes. Fuel grade coke contains about 85% of carbon and 4% hydrogen (Fahim et al., 2009).

1.10. Oil Marketing

Oil marketing is the final stage and the most complex sector in the oil and gas industry. Marketing may be in wholesale markets, where large sales are made to small sellers, or in retail markets, which is sell to final consumers. There are crude oil markets and oil product markets (Abdel-Aal & Alsahlawi, 2013).

Historically, in the early 1970s, crude oil marketing was through integrated company systems. Crude oil was sold by producers to refiners via spot markets. However, this system is now changed as a result of nationalization of the assets of most major oil producers. Recently, oil exchange markets changed physical crude oil markets to paper markets which consist of futures options. As a result, market speculation was increased and price volatility too rather than the fundamentals of the supply and demand forces (Abdel-Aal & Alsahlawi, 2013).

Oil products marketing were simple in the past. There were mainly three products: motor gasoline, heating oil, and heavy oil. Among the world's oil products, motor gasoline markets were, and remain, the most fragmented (Abdel-Aal & Alsahlawi, 2013).

1.11. Conclusion

This chapter has tended to present to the reader a general idea about the petroleum industry structure from the discovery of petroleum to marketing focusing on the stages of the industry "exploration, recovery, transportation, refinery and marketing". Petroleum is any naturally occurring hydrocarbon mixture whether in a liquid, gaseous, or solid form. So, it encloses many varieties of crude oil and natural gas**.** It can be light, medium, or heavy and its color may vary from dark such as black, or brown to clear color, for instance, yellow. It may also be sour with high sulfur content or sweet with low sulfur content. From a chemical standpoint, it is an extremely complex mixture of hydrocarbon compounds, and containing also some compounds of oxygen, nitrogen, and sulfur. There are two types of petroleum, conventional and unconventional. Conventional petroleum is easily recovered from underground and unconventional is hard to recover and requires more money and energy. From the discovery of petroleum to its marketing and use, three basic stages are followed. The first stage is exploration which is the search to find favorable places for drilling and the drilling operation that confirm the presence of petroleum reserves. Second, a recovery which is the production of oil from a reservoir, and finally transportation of petroleum from the field to the refineries to extract the different products from it. The following chapter will deal with the historical background of the petroleum industry precisely the evolution use of petroleum and the development of the modern industry.

Chapter Two

2.1. Introduction:

The use of petroleum and its derivatives was experienced before Christ and is known broadly through historical use in many of the older civilizations. However, the petroleum industry is essentially a twentieth-century industry, but to understand the evolution of the modern industry, it is essential to have a brief understanding of the first uses of petroleum. So this chapter tends to represent the evolution of petroleum use from pre-Christian times to its discovery in the 19th century and the development of the modern petroleum industry in the 20th century. This chapter starts with the early years of the evolution of petroleum use. Next, it focuses on the first well drilled by Drake that sparked the first true modern oil boom then the development of the modern industry including global historical oil and gas production and prices.

2.2. Evolution of Petroleum Use: Early Years (Before 1861)

In ancient times, crude oil seeped on the surface of the ground was being used by human beings for different purposes. For example, as stated by Sozanski et.al. (2005), asphalt was used in construction as a binding material because of its sticky property for connecting stone blocks of erected structures, for paving of roads in Mesopotamia, sealing of ships and water tanks, preservation of wood, and embalming of corpses. Also, crude oil was used as water repellant, which means ancient man used crude oil as a substance or material to prevent water from entering unwelcome places. The same thing for Bitumen, this later had already been known by people of the ancient world.

So how has crude oil seeped on the surface of the ground? As reported by Sozanski et.al., Crude oil that has been used by humankind for so many years migrated from reservoirs underground to the surface of the ground by the planes of faults and fissures (2005). This Self migration of hydrocarbons led to marking the beginning of discoveries of many oil deposits. Natural oil seeps, leaks of gas, asphalt, and native paraffin have long been known in many sites around the globe on the surface of the Earth.

Before 1861, crude oil was discovered in different places of the world and was used for various objectives and in different ways. For instance, Mesopotamians, Sumerians, and Egyptians made use of crude oil for several intents; such as sealing boats, building roads, embalming mummies, and used asphalt to fix pictures and designs on walls and floors, to grease chariots, and so on around 3000 BC. While many people around the world had been using crude oil that seeped through cracks and fault lines to the surface of the ground, there have been other discoveries and extractions of crude oil in many other different parts of the

world. For example, the Chinese were the first to discover and extract crude oil by chance while digging salt wells using pipelines made of bamboo poles around 600 BC. The Chinese used petroleum for lamps and heating homes. Besides, Arab and Persian chemists used to mix petroleum with quicklime to generate Greek fire, the napalm of its day from 600 BC to 500 BC (Robinson & Hsu, 2007).

Furthermore, from 1200 AD to 1600 AD Oil from Carpathians Mountains was used to polish roads, and during the same period, the Chinese drilled many other oil wells of more than 2000 feet "600 meters" deep. Moreover, in 1735 AD, oil was extracted from oil sands in Alsace, France, and in early 1800, oil was produced from brine wells in Pennsylvania, United States. In 1847 specifically, James Oakes established a rock oil refinery in England. The rock oil refinery was used to process around 300 gallons per day to produce paraffin oil for lighting lamps. Whereas, in 1849 precisely, a Canadian geologist named Abraham Gesner was the first to distill crude oil to get kerosene. After that, Michael Dietz invented a flat-wick kerosene lamp in 1857, and in the following year, Ignacy Luckasiewiez built a distillery in Katowice, Poland (Robinson & Hsu, 2007).

Next, Robinson & Hsu confirmed that 1859 was marked by the Pennsylvania oil boom aroused by Colonel Edwin Drake who was the first to drill a well of 69-feet deep near Titusville, Pennsylvania. The well that was drilled, produced 35 barrels per day, and in the same year, an oil refinery was built in Baku, now in Azerbaijan. After that, in the year 1860-1861, many oil refineries were established near Oil Creek, Pennsylvania, Petrolia, Ontario, Canada, and Union County, Arkansas (2007).

According to some Greek and Roman scholars and writers, petroleum was also used in medicine ''petroleum is an oil coming from rock and is used in the treatment of various human and animal diseases" (Sozanski et.al. 2005, p.812). Petroleum was used as a cure against the different diseases that were spread in ancient times, for instance, scabies, angina, rheumatism, and even leprosy.

Besides, Sozanski et.al. (2005) state, "crude oil was used for lighting and signaling for the protection needs of the city" **(**p.812). Crude oil was used as a material for light signaling to start a fire on land, and during marine battles, such us, The Roman warriors used blazing objects containing crude petroleum as weapons of war.

Since the dawn of history, natural gas also has been known through its self-seepages. Fires and fumes were worshiped in some places in the world. Sozanski et.al. (2005) state**,** "Everlasting fires and fumes of hydrocarbons were the subjects of religious worship in Mesopotamia, Persia, Greece, and the coasts of the Caspian Sea" (p.812). For

people of those places, burning gas was regarded as a holy fire. Also, gas was used as a type of lighthouse. Gas seepage was not observed easily as oil seepages. For this reason, gas was less mentioned by ancient chroniclers.

According to the historical background of petroleum before 1861, it is viewed that before 1859 specifically, oil seeped up out of the earth was used for several aims. For instance, it was used as an adhesive in construction, to water-proof ships, for flaming projectiles, and was used in medicine and a large variety of lotions and so on; whereas, after 1859 oil was extracted from drilled wells. These wells were later produced in beneficial quantities and even refined into other products to meet some specific needs.

2.3. The Seek for Source of Illumination

Many sources were used for illumination. Black explained that animal and vegetable fats were the only familiar sources of burning oil in the early 1700s, yet through burning such oils, a lot of smoke, unpleasant odor, and unbalanced flame and light was produced. Whale oil was very reliable and was burned in a variety of lamps, unlike the other oils which were not pure enough to burn very well (2000). Whale oil came to whet the human appetite for cheap, clean, and efficient illumination.

The American whaling fleet determined the process of the hunt and refinery technology, and then it dominated over the fishery. Consequently, this dominance established trade markets for distributing whale oil illumination internationally. Whale oil illumination proved to be successful to the point that Americans purchased whale oil even though it was very expensive. However, through time, and during the 1800s especially, the whale population regularly decreased as the efficiency of the hunting process grew. As a result, the Americans had to look for a lasting alternative for illumination (Black, 2000).

2.4. The emergence of Drake and Discovery of the First Oil Well

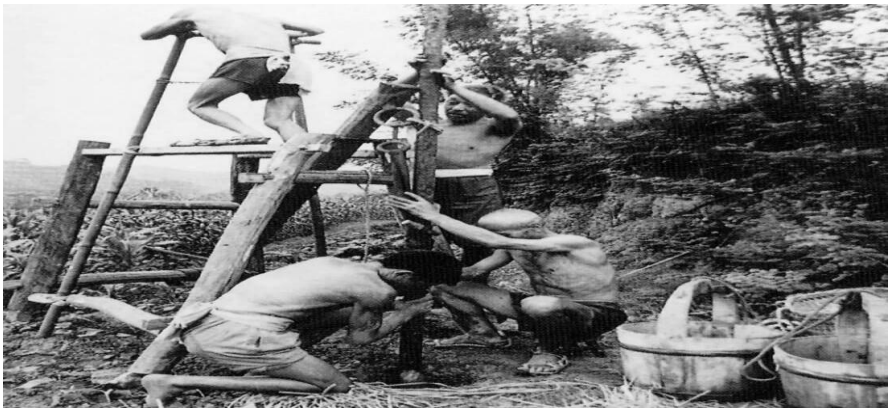
Edwin Drake and the first oil well discovered in Pennsylvania issue had attracted many historians to write about. As historians describe him, Edwin Drake was a bearded man who often wore a black top hat, like the era's other men of stature. He worked as a conductor for the railroad in Connecticut. After the death of his wife, his health worsened because of stress and age. For this reason, he was motivated by his doctor to move to a rural area. Drake traveled to western Pennsylvania in 1858, where he occupied a new position which is a pass for free travel on the rail lines. The following year, he became a famous man for his first drilled well in Pennsylvania (Black, 2000).

An oil well of 69 ½ feet deep was drilled at Oil Creek near Titusville, Pennsylvania, in August of 1859. This well was dug to look for oil and produce it. However, according to

Bluemle, previous to Drake's well other oil wells were drilled in different parts of the world. For instance, James Williams while drilling a well for drinking water, he came across free oil in a depth of 66 feet (20.1168 meters). Moreover, the earliest well in North America was at Oil springs, Southern Ontario (2001). As mentioned previously, there were oil wells drilled in China and other parts of the world. However, the drilling and production operations were only through the use of bamboo rod strings. To illustrate, gas discovered by these wells was routed to the surface of the ground through bamboo pipes as shown in figure 2.1.

Figure 2.1

Ancient Chinese Drilling



Note. From "Cseg Recorder", by O. Kuhn, 2004, https://csegrecorder.com/articles/view/ancient-chinese-drilling. Copyright Canadian Society of Exploration Geophysicists. Reprinted with permission.

2.5. The Modern Petroleum Industry

The modern petroleum industry got its start, after the first oil well was drilled in Titusville, Pennsylvania.

2.5.1. The Start

According to Essley (1976), the modern petroleum industry generally started on August 27, 1859, when Drake extracted oil from a well of 69 feet of depth on Oil Creek near Titusville, Pennsylvania. Essley Declared that Drake's well was neither the first oil well nor the first commercial exploitation of oil. For, oil had been exploited next to natural seeps for thousands of years through drilling holes for oil seeps into them (1976). And as stated previously, oil had been used to treat diseases, to make things stick together, to calk boats, to lubricate pieces of equipment, and specifically to burn in lamps, and so on. Oil was occasionally discovered while drilling salt wells.

Thirty years before Drake drilled his oil well, a well which produced salt in Kentucky on the banks of the Cumberland River spurted oil 30 feet into the air. This well flowed at a rate of 1,000 barrels per day, caught fire, and created a solid sheet of flames for 40 miles. However, at that time, there was a boundless supply of cheap whale oil for America's lamps, and factories were less demanding for fuel to lubricate their machinery. Seemingly, oil was unwanted at that period. Although a few men, for instance, Kier Samuel Pittsburg the salt-works owner who had used this by-product of some salt wells profitably, sold the oil produced with brine as "Kier's petroleum or rock oil celebrated for its wonderful curative powers" (Essley, 1976).

By the late 1850s, Whale oil provision began to diminish, and prices also rose suddenly and rapidly. So, the world urgently sought a considerable new source of fuel to illuminate lamps. Benjamin Silliman a Yale University Chemistry professor has displayed a sample of oil taken off from a spring near Titusville. Through Silliman's analysis, the experiment showed that the oil could be refined into kerosene. For this reason, in 1858, Colonel Drake working with the enterprise in Titusville started his famous well which is the first to be drilled in the United States specifically looking for oil (Essley, 1976).

One year later, after Drake's disappointment and on the point of quitting, the oil began flowing into the hole. At this time, Drake rigged up a pump and commenced producing 35 barrels of oil a day, selling each barrel for $40. After that, the rush for oil was on; wells on Oil Creek were soon producing several thousands of oil per day. Unfortunately, large quantities of oil were produced that swamped the market. And in two years, oil was sold for 10 cubic (c) per barrel. As a result, fortunes made in 1860 were lost in 1862. The industry almost struggled at its beginning (Essley, 1976).

2.5.2. The Start of the Scientific Period

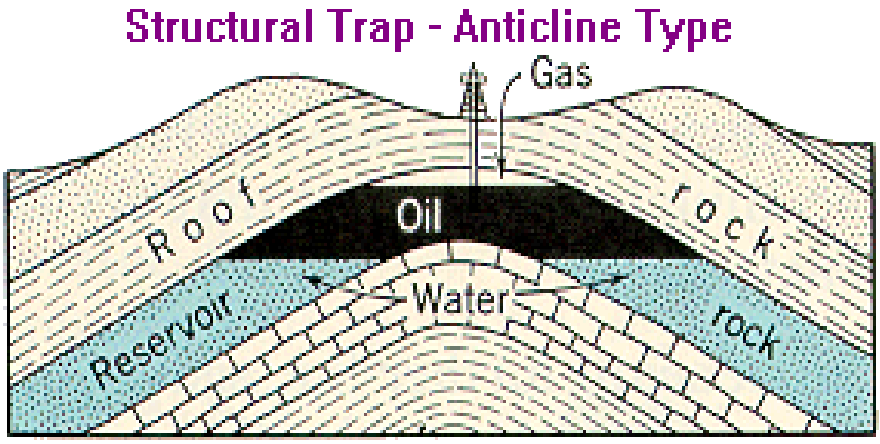
The Drake Well was drilled near known oil seeps, which means in an area where the presence of oil underground is confirmed. At that time, once an area became productive, oil researchers would try with trends, creekology, witching sticks, and other different methods for further oil wells exploration. However, few gave more importance to science that it might help them discover oil wells from several areas, or produce more oil from the same area or field (Essley, 1976).

Geologists had discovered that most oil fields have some geological features in common. As an example, all oil fields in Oklahoma set under anticlinal folds as shown in figure 2.2 few oilmen knew what is meant by anticline; whereas, others didn't know and even mocked it. In 1914, Henry L. Doherty's cities service oil company, and based on

geological studies, discovered the Augusta field in Kansas. Yet, this achievement was noted only by a few. However, in 1915, city services at Augusta rented 30,000 acres before drilling, based on geological mapping, and found 275 million barrels of oil in the El Dorado field in Kansas (Essley, 1976).

Figure 2.2

Hydrocarbon Traps



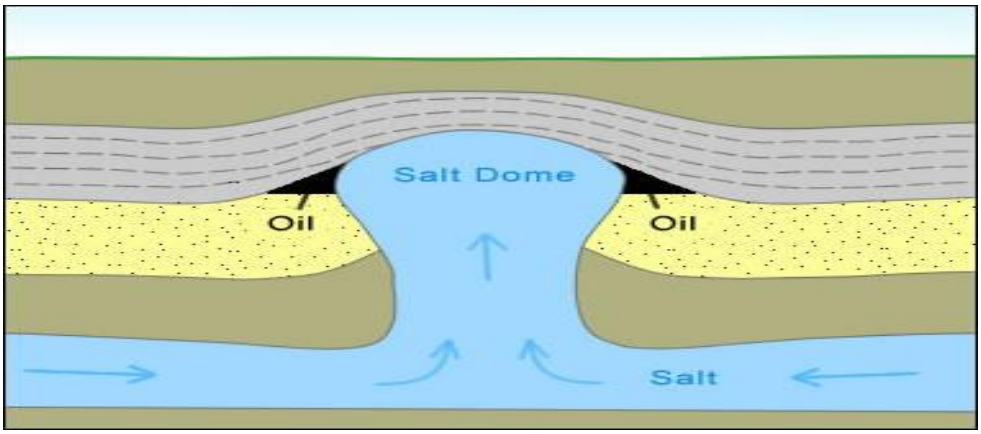
Note. From "Anticlinal (fold) and dome traps", by Geology in, n.d, http://www.geologyin.com/2014/12/hydrocarbon-traps.html. Copyright 2021 Geology in. Permission not sought.

Science had proven its worth. As Essley confirmed, science helped oilmen to locate oil, productive areas, and even to avoid drilling inessential wells or produce at unrestrained rates. The scientific man Doherty not only proved the scientific method for oil discovery, yet he later created the first petroleum engineering department to produce oil scientifically, develop of oil field orderly and effective conservation (1976).

In addition to Doherty's success in geological exploration, Everette Lee Degolyer added on another success through the implementation of a new scientific method which is geophysical exploration. In 1927, Degolyer's geophysical research corporation set a stunning record of discovering eleven new salt dome oil fields as shown in figure 2.3 in nine months in the Gulf Coast marches. Dogolyer, via the use of his new perfect tool, the reflection seismograph, could locate buried anticlines besides dome salt fields and other geological structures which are not clear from surface geology. In February 1930, the first hidden anticline was discovered, and the industry had the scientific tool that would detect every single secret underground than geologists could ever decipher through studying surface rocks (Essley, 1976).

Figure 2.3

Salt Dome



Note. From "What is Salt Dome?", by Geology.com, n.d, https://geology.com/stories/13/salt-domes/ . Copyright 2005-2021 Geology.com. Permission not sought.

To sum up, the modern petroleum industry had its first start after the drilling of the first oil well in Pennsylvania and particularly after detecting that oil could be refined into kerosene, as kerosene was the first thing that people were seeking at that time to illumination. Additionally, science played a crucial role in the rise of the modern petroleum industry.

2.5.3. Oversupply and Market Demand Prorationing

Market demand prorationing came to control oil fields development and production rates. As stated by Essley (1976), the period following world war one was marked by a rush in demand for oil which generated its tentative reduction in 1920, with a price of $3.29 per barrel. As a result, geologists and geophysicists were pushed into a rush search for oil. Thus, the 1920s became a period of oversupply as the exploration of several oil fields prospered one after another. During this period, oil prices shifted between $1.20 to $2.30 per barrel. Then in 1920, the great depression began and demand declined. Yet, in the following year or less than a year, the giant East Texas field was discovered. The field was discovered in October 1930, it produced considerable quantities of oil that were sold at $1.10 per barrel. However, after following intense drilling, the field was producing 360,000 barrels per day while the price of oil had dropped to 10 c per barrel. In August 1931, the action took by martial law to shut down 29 Oklahoma fields. In contrast, the Texas ruler sent the National Guard to the east Texas field, by then oil production was 800,000 barrels per day; yet, much of it was stored at tank farms and refineries. The nation had more than a year's supply of crude oil in storage. Then market demand prorationing

was born and new fields were developed under new orderly controlled conditions. Each well would be authorized to produce only a limited amount of oil each day.

2.5.4. Change in the Character of the Industry: Impact of the new laws

In the 1930s, the oil industry changed in character as a result of the market demand prorationing. As indicated by Essley, producing rates were controlled; damaging competition and high costs to develop discoveries were also eliminated. At that period, there was an emphasis on discovery rather than development; the discovery of new fields and their development to produce at low rates sufficient to save production (1976). According to Essley, the 1930s were the golden years for the exploration of new fields, and U.S oil reserves increased vastly (1976). The new laws of market demand prorationing could balance between discovery and production, regulate producing rates.

Most large oil companies had petroleum engineering departments and engineers were increasing in number. Some engineers attempted to improve drilling and production equipment and even testing wells; whereas other engineers devoted their time to learn more about oil reservoirs. As an example, the two French engineers, the Schlumberger brothers, learned how to make electrical resistance measurements in a well to record or "log" the different formations underground. They are currently forming one of the largest oil service companies in the world "Schlumberger" which works in many countries in the world such as, Algeria, the United States, the United Arab Emirates, and so on. In addition, others developed instruments to measure the porosity of rocks that contain oil and also their permeability through recovering samples of rocks from productive formations. The information collected from logs and samples of rocks, allowed engineers to determine how much oil a reservoir contained (Essley, 1976). The increase in the engineer's number had a positive impact on the oil and gas industry. In addition, other instruments were developed to measure reservoir pressure and temperature besides devices that permitted gathering subsurface fluid samples. Also, engineers discovered that oil reservoir under pressure contained gas in solution, and this gas provided the energy to produce oil in high quantities. And it was discovered that in some fields water was moving at low rates displacing oil and partially maintaining reservoir pressure. In others, gravity affects the oil to continue to flow into wellbores, sometimes at very high rates. In these cases, engineers learned how to calculate water influx and gravity drainage (Essley, 1976). Briefly, engineers improved existed equipment, created new instruments and learned a lot about the petroleum industry for the aim of its development.

Subsequently, there were many debatable questions on how to increase recovery from fields, and maintain reservoir pressure and provide supplementary energy to displace oil. Injecting water and gas into the reservoir was proved to be a good way to maintain its pressure. The industry rushed to prove the engineer's theory on how to produce oil from depleted reservoirs and to improve the production of already producing reservoirs. And the process required injecting water or gas from one wellbore to displace oil in another well. Consequently, producing rates usually increased when secondary recovery methods were applied (Essley, 1976).

Seemingly, during the first eighty years of the industry, there was more focus on oil discovery and production, and in the following 30 years producers, or engineers spent their efforts collaborating to improve recovery.

2.6. Production in Post World War II

The end of World War II marked a sharp transition to the automotive era. Demand for products increased 12% between 1945 and 1947 (Williamson et al., 1963, p. 805 as cited in Essley, 1976) as the Americans pursued their love for automobiles and factories began to produce civilian goods. For this reason, the industry moved to meet the new demand through developing the fields discovered in the 1930s and to discover new fields in other new areas. The scientific knowledge was applied by the industry to explore and develop the new rented areas. As a result, the production exceeded demand and the development pace slowed (Essley, 1976).

The invention and diffusion of the automobile led the industry to shift to producing gasoline and other transportation fuels. During the 20th century, the United States led the world in adopting automobiles. The United States had about 8,000 passenger cars in circulation in 1900. Whereas, in 1930 it had over 23 million, out of a world total of about 29 million. Then, the industry struggled to produce sufficient quantities of gasoline, yet advances in refining technology helped the industry meet demand. A thermal cracking created by William Burton of the Standard Oil Company of Indiana in 1913, led to increasing gasoline production from crude oil. In addition, Eugene Houdry's Catalytic cracking process increased not only the yield of gasoline but also its quality (Vassiliou, 2009).

Gasoline production also empowered the development of petrochemistry. By the 1930s, petrochemical products such as synthetic fibers, synthetic rubber, and explosives were already being introduced and played a crucial role in World War II. For example, the use of synthetic rubber for tires. Moreover, in the 1950s the petrochemical revolution was

in a rush where synthetic materials as plastics were inexpensive and spread throughout society.

In the 1970s Shah Mohamed Reza Pahlavi of Iran stated that oil is a too valuable source of petrochemicals and should not be burned (Vassiliou, 2009).

2.7. History of Global Oil Production

From 1860 to 2016, there were many different countries in the world that were regarded as top oil producers and production was increasing through the years. In 1860, at the dawn of the modern industry, world oil production was less than 400 barrels per day (bpd); whereas, in 1866 it surpassed 10,000 (bpd) and 100,000 bpd in 1885. By 1900, production was about 410,000 bpd. And in the late 19th century, the United States especially Pennsylvania, and Russia especially the Baku region of Azerbaijan were the dominant producers, where the United States was the top producer during all the 19th century, and Russia was at the second place. Moreover, these two countries were in first and second place in total production from 1900 to 1940 (Vassiliou, 2018).

In 1913 world production exceeded 1 millions of barrels per day (Mmbpd) and 2 Mmbpd in 1921; whereas, by 1941, it surpassed 6 Mmbpd. During the first third of the 20th century, Venezuela, Romania, Iran Indonesia, and Mexico became new important producer countries. From 1901 to 1920, Mexico was the third top producer country following the United States and Russia and followed by Indonesia. From 1921 to 1940, Venezuela was the third country followed by Mexico. In the 1930s, the Persian Gulf region specifically Saudi Arabia began to discover giant oil reserves. During World War II progress of discovering new oil reserves interrupted, yet after 1950, the Persian Gulf became an important producer region, and from 1941 to 1960, Saudi Arabia was the fourth-largest total producer, next to the United States, Venezuela, and the Soviet Union and followed by Iran. Iran was the fifth (Vassiliou, 2018).

In the following 20 years, Saudi Arabia ranked third after the United States and the Soviet Union. Iran and Venezuela were fourth and fifth. From 1981 to 2000 the United States was first and Saudi Arabia second followed by the Soviet Union, or Russia after 1991, Mexico, and Iran. By the same time, Norway and the United Kingdom had also become important producers. From 2000 to 2016, Saudi Arabia was the first oil producer country in the world, followed by Russia, the United States, Iran, and China (Vassiliou, 2018).

It is not necessarily that the countries that have the largest total reserves are the top producers in a given interval of time. For the United States ranked 10^{th} in the world in

reserves of oil and liquids in 2016, with less than 3 percent of the world's total. Yet, it dominated global oil production for a century. From 1860 to 1874, in the early years of the modern industry, it had for over 90 percent of the world's annual production. Also from 1903 to 1952, it accounted for over half the world's annual production and was even the world's largest producer during the whole year 2016 (Vassiliou, 2018).

By the end of 2016, the world had produced about 1,315 billion barrels (Bb) of crude oil and all of it was a conventional one. This produced quantity is considered as close to the amount of remaining global reserves, indicating that the world has already produced half of its oil. However, this is deceptive since the total remaining recourses transcend remaining reserves. Global production in 2016 was about 78.3 million barrels per day mmbpd or 28.6 Bp for the year. From the start of the modern industry in 1860 to 2016, the United States and Russia were two top oil producer countries specifically at the beginning years with a significant quantity of the oil that increased through years. After a specific period, the US and Russia were followed by other countries such as Venezuela, Iran, and Saudi Arabia, and so on (Vassiliou, 2018).

2.8. History of Global Gas Production

Natural gas global production was too late compared to oil production. This was either because oil was the target and gas was not important, or because gas markets had no infrastructure built for storage and or distribution. For gas is too difficult to capture, store and transport. In 1950, about 3.2 million barrels of oil equivalent per day (Mmboepd) that the world produced worth of natural gas, compared to 10.4 Mmbpd of oil (Vassiliou, 2009). Natural gas production was about 30 percent of the oil in terms of energy equivalent. However, in 1980, gas production was 24.6 Mmboepd, or approximately 41 percent of oil production which was around 59.4 Mmbpd (Vassiliou, 2009). Overall, this indicates that the proportion rose in the following 30 years. Whereas in the 1980s, oil production didn't regain its high until 1995-1996, and during the same period gas production continued to grow fairly steadily (Vassiliou, 2009). Oil production fell down at the beginning of the 1980s, yet it rose simultaneously with natural gas production at the end of this period. Global natural gas production 37.5 Mmboepd, was about 59 percent of oil production. In 2006, the world produced 47.9 Mmboepd of natural gas approximately, to 65 percent of oil production in energy-equivalent terms (Vassiliou, 2009). Seemingly, natural gas had gained more importance and for this reason, its production had been in increase through the years.

For a long part of the 20th century, the United States was the world's dominant producer of natural gas. In 1950, 90 percent of the world's natural gas was produced by the United States. Moreover, it continued to produce more than half the world's gas until 1972. Concurrently, the Soviet Union became a major producer. As it was accounted, the United States and the Soviet Union reached 73 percent of global gas production (Vassiliou, 2009). Although production grew rapidly in the rest of the world, the United States and the Soviet Union were regarded as the top gas producers. As stated by Vassiliou (2009), taken together, the US and the Soviet Union accounted for more than half the world's annual gas production until 2002.

In 2006, in decreasing order, the world's top producing countries were Russia, the United States, Canada, Iran, Norway, Algeria, the United Kingdom, the Netherlands, Indonesia, Saudi Arabia, Turkmenistan, and Malaysia. As illustrated by Vassiliou, Jointly, they counted for roughly three-quarters of world production. Furthermore, in the same year, the United States produced approximately 18 percent of the world's gas and Russia alone produced 22 percent (2009). Among all these countries cited above, the United States and Russia remain at the first and second places as top gas producers in 2006.

Over the years, natural gas production was in growth, yet it doesn't have developed a global market, likewise oil, and this goes back to its dependence on a fixed distribution network and for other reasons.

2.9. Historical Oil Shocks

The 1970s was marked as a decade of oil shocks that is to say; large increases in oil prices. The first oil shock was from 1973 to 1974 where the prices rose four times especially between October and December 1973. The immediate stimulus was the Arab reaction to the Yom Kippur War; the Arab-Israeli War where OPEC increased prices to 76 percent, and the Organization of Arab Petroleum Exporting Countries (OAPEC) began a selective proscription on countries including the United States that supported Israel. In addition, the peaking of U.S. oil production in 1970 was another factor that contributed to the shock (Vassiliou, 2018).

In 1979, during the second shock average prices doubled from what was already relatively a high level. The trigger of the Second Oil Shock was the Iranian revolution and the removal of large amounts of Iranian crude from the global market. The shock was worsened by panic buying. Average annual prices of Arab light crude rose about 20 double, from $1.80 per barrel in 1970 to $36.83 per barrel in 1980 (Vassiliou, 2018).

In the 1980s, the high prices collapsed during the oil countershock. Organisation of petroleum exporting countries (OPEC) attempted to support the prices, yet it was hard to preserve the production regulation. Also, Saudi Arabia tried to do so but failed. Six months later, after September 1985, prices decreased 70 percent (Vassiliou, 2018).

Due to various factors such as the high taxes of the United Kingdom, underinvestment in Mexico, and the implosion of the Soviet Union, prices and OPEC's power made a partial recovery in the decade. Prices dipped below $10 a barrel in 1998 and 1999 before they dramatically increase (Vassiliou, 2018).

Around 2003, the third Oil Shock began and prices were doubled or even more than doubled especially in 2006, 2007, and 2008. Prices for all world crudes were in an average of $54.63 a barrel in the first week of 2007 and by June 2008 exceeded $135. The inflexibility of the global demand for and global supply of crude oil were the causes of the rapid increase of oil demand from China, India, and other countries. Taking US dollars into consideration, it also played a crucial role in the increase of demand as its value decreased; whereas, the reason behind the increase in oil prices is not yet fully understood. There were some opinions from observers about the prices, where these later claimed that prices increased by speculators, for this reason, oil became attractive to investors and increased in prices (Vassiliou, 2018). Historically, from 1970 to 2008, the oil and gas industry passed through three oil shocks in three specific periods of time where petroleum prices dramatically rose.

2.10. Peak Oil

Peak oil is directly related to oil consumption and the discovery of new reserves. If oil is a nonrenewable resource, its consumption will eventually exhaust it, and sort of peak in production will occur. So the main questions that are asked are how much oil is really left and when the peak will be reached. The same is true for natural gas (Vassiliou, 2009).

2.11. Conclusion

This chapter aimed to represent the evolution of petroleum use before Christ's age, then the discovery of oil in America in the 19th century, and the development of the modern petroleum industry in the 20th century. In ancient times, crude oil seeped on the surface of the ground was being used by human beings for different purposes. For instance, Mesopotamians, Sumerians, Egyptians used oil seeped on the ground for construction, sealing of ships and water tanks, embalming mummies, and even was used in medicine as

a cure against multifarious diseases. Also was used for lamps and heating homes by the Chinese.

Formerly, Kerosene was a highly wanted substance for illumination. After detecting that oil could be refined into kerosene, Drake drilled the first oil well in 1859 in America particularly in Titusville, Pennsylvania. The first well led to the start of the modern petroleum industry; many drillings took place in the same area in Pennsylvania and even in other different places in America seeking oil. Science helped oilmen to locate oil by following scientific methods such as geological and geophysical explorations, oil then was discovered and produced in a controlled manner in America and other countries in the world. It was produced in the United States and Russia first that were top oil and gas producer countries especially from 1900 to 1940. Then Venezuela, Romania, Iran Indonesia, and Mexico became new important producer countries during the first third of the 20th century. In the following 20 years, Saudi Arabia ranked third after the United States and the Soviet Union. Iran and Venezuela were fourth and fifth. The same thing for natural gas, the United States was the world's dominant producer of natural gas for a long part of the 20th century until 1972 then was followed by the Soviet Union to become both major natural gas producer countries until 2002.

Production in Post World War II particularly marked a sharp transition to the automotive era. The invention and diffusion of the automobile led the industry to shift to producing gasoline and other transportation fuels that empowered the development of petrochemistry. A few years later, in the 1970s, the industry experienced many shocks where the prices rose because of different stimulus, for instance, the Yom Kippur War, the Iranian revolution, and the inflexibility of the global demand and global supply of crude oil.The next chapter will shed light on the modern petroleum industry and precisely, the economic side of the industry.

Chapter Three

3.1. Introduction

The modern petroleum industry had its first start in the 19th century. The first well drilled by Drake sparked the first true modern oil boom. Many oil wells were later discovered in the United States and other different countries in the world, such as Russia, Canada, Romania, Indonesia, Saudi Arabia, Algeria, and other nations. This chapter is devoted to providing the reader with the first steps of the rise of the modern petroleum industry and will focus on a part of the economic side of the modern petroleum industry. This chapter starts with the impact of the 1st commercial oil well discovered in Titusville, Pennsylvania on the development of the industry. Second, it tackles the evolution of the industry through the years, the standard oil company monopolization of the industry, and the seven sisters that dominated the petroleum industry for much of the 20th century in the Middle East. Also, a focus will be on the largest oil fields that were discovered in the United States, Russia, and later in other regions in the world. Next, it concentrates on the relation between oil prices and economic growth; in addition to, world oil demand, oil price limits, and also petroleum products consumption and use.

3.2. The First Well and its Impact on the Rise of the Modern Petroleum Industry

The first commercial oil well was discovered and drilled by Edwin Drake in Titusville Pennsylvania in 1859. As noted by Speight, after this well was completed, the surrounding areas were instantly rented and extensive drilling took place. As a result, the production of crude oil in the United States rose from around 2000 barrels (1 barrel = bbl = 42 US Gallon = 158.8 Liters) in 1859 to around 3,000,000 in 1863 and about 10,000,000 in 1874 (1999). Based on the result given, the discovery of the first well by Edwin Drake was the spark that led towards seeking other reserves and the birth of the modern petroleum industry.

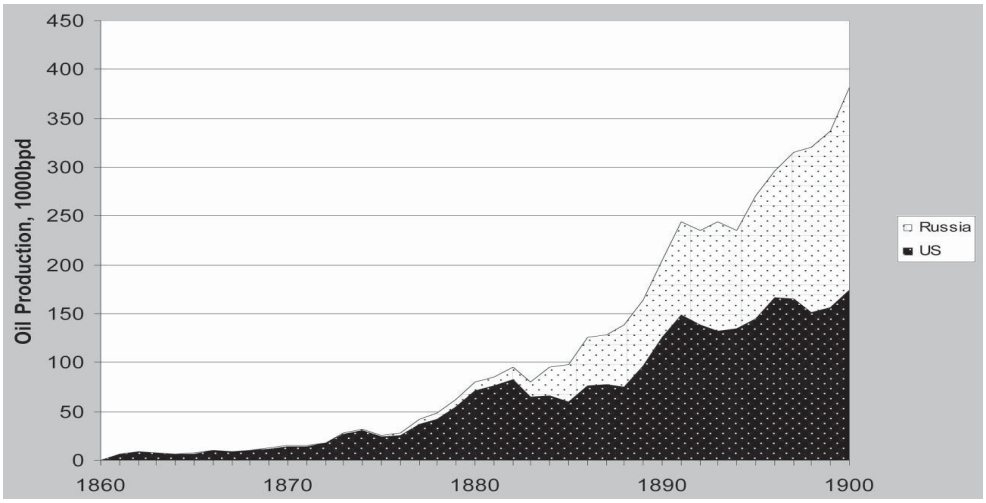
In 1861, oil was delivered by wooden barrels, and at first was sent to London across the Atlantic (Speight, 1999). And by the 1870s, through the command of Standard Oil that was founded by John D. Rockefeller (Johnson, 1997 as cited in Speight, 1999), pipelines, refineries, and tank cars became the main elements of the petroleum industry.

As declared by Speight (1999), the United States and Russia were two countries where many oil developments occurred. In addition, as shown in figure 2 the United States and Russia were two major petroleum producers from 1860 to 1900. And as confirmed by Speight, they also were so even during World War I (1999). However, Romania, Indonesia, and Mexico had also supplies of oil. Subsequently, a focus was also on other

areas such as the Middle East and also the United States and Indonesia during the 1920s and 1930s, unlike the other European and African countries which were not considered as major petroleum-producing countries.

Figure 3.1

U.S. and Russian oil production, 1860–1900.



Note. From "The A to Z of the Petroleum Industry" by M. S. Vassiliou, 2009, Scarecrow press, p.589. Copyrigt 2009 by M. S. Vassiliou. Permission not sought.

More importantly, in post-world war II, the Middle East countries started to discover new giant reserves. Besides the United States keeping being the large petroleum producer country, it also was a great consumer of petroleum (Speight, 1999).

The first oil well drilled by Edwin Drake in Pennsylvania was the first step that led to the discovery of other surrounding reserves and also in other different regions in the world. Furthermore, various giant fields were discovered in the following years. These giant fields will be stated later in this chapter.

3.3. Evolution of the Modern Industry

In the 19th century, the modern petroleum industry began in a variety of locations including the United States “Pennsylvania and West Virginia”, Russia “the Baku area”, Canada, Austro-Hungarian Galicia, and Romania. As Vassiliou (2009) confirmed, Edwin Drake’s 1859 well near Titusville, Pennsylvania, is popularly considered the “first modern oil well”. Although there were contemporary and even earlier efforts, precisely in West Virginia and Russia, yet the first well drilled by Drake sparked the first true modern oil boom. In the second part of 19th century, Pennsylvania dominated U.S. and world oil production until the discovery of other

sources in the United States and in Russia.

The Standard Oil Company had a major influence throughout the world through monopolizing oil refining in the United States in the 19th century. As stated by Vassiliou, the Standard Oil Company achieved dominance through clever management, efficient operations, and particularly the implementation of a number of anti-competitive practices (2009). Through the years, the company grew and could reduce its costs and increase its advantage against competitors. The company selectively lowered prices in markets where competitors worked, while maintaining prices high in other markets until it forced competitors to choose between whether to go bankrupt or to be acquired by Standard Oil. Later, much of the unfavorable popular reputation originated in the petroleum industry with Standard Oil. Standard Oil's virtual monopoly led to the passage of the Sherman Antitrust Act in 1890 and attempts to break the company up. Afterward, in 1911, Standard oil was dissolved by order of the U.S. Supreme Court (Vassiliou, 2009). There were many successor companies which are Exxon "Standard Oil of New Jersey", Mobil "Standard Oil of New York and Vacuum Oil", and Chevron "Standard Oil of California". These three companies, adding to Royal Dutch Shell, Gulf, Texaco, and BP "Anglo–Persian/Anglo–Iranian Oil Company", formed the so-called "Seven Sisters". Then the world industry was dominated by the Seven Sisters together with Compagnie Française des Pétroles (CFP). In short, the modern petroleum industry began in a variety of locations in the world starting with the United States where the Standard Oil Company influenced the world then it was followed by the seven sisters.

3.4. The Seven Sisters Domination of the Industry

The Seven Sisters with CFP dominated the world industry through a series of complex alliances controlling production in the Middle East **(**Vassiliou, 2009) as shown in figure 3.2. CFP, BP, Shell, Exxon, and Mobil were all members of the Iraq Petroleum Company (IPC) consortium, which virtually monopolized petroleum production in Iraq for much of the 20th century**.**

Table 3.2

Major Middle Eastern Consortia of the Seven Sisters and CFP

	Iran Consortium 1954–1979	Iraq Petroleum 1928–1975	Aramco 1933–1980	Kuwait Oil 1934–1975	Abu Dhabi Petroleum 1935–1974	Abu Dhabi Marine 1954–1974	Qatar Petroleum 1935–1976
BP	40%	23.75%		50%	23.75%	66.67%	23.75%
Shell	14%	23.75%			23.75%		23.75%
Exxon	7%	11.875%	30%		11.875%		11.875%
Mobil	7%	11.875%	10%		11.875%		11.875%
Gulf	7%			50%			
Texaco	7%		30%				
Chevron	7%		30%				
CFP	6%	23.75%			23.75%	33.33%	23.75%
Others	5%	5%			5%		5%

Note. From "The A to Z of the Petroleum Industry" by M. S. Vassiliou, 2009, Scarecrow press, p.557.Copyrigt 2009 by M. S. Vassiliou. Permission not sought.

In addition, BP and Gulf were equal associates in the Kuwait Oil Company, which controlled the industry in Kuwait. Chevron, Texaco, Exxon, and Mobil were associates in Aramco, which dominated petroleum production in Saudi Arabia. All of the Seven Sisters and CFP were members of the Iran Consortium, which effectively controlled Iran's industry between 1954 and 1979, even though the industry had been nationalized in 1951.

In the 1970s, OPEC broke the power of these multinational companies. By 1980, nationalizations led to breaking the various alliances, both within and outside of OPEC's participation framework. As a result, Control of the industry passed from multinational companies to producer countries, and decisively, OPEC held the pricing power. Yet, in the 1980s, as the market was flooded with non-OPEC production, OPEC lost much of its power.

3.5. The Top Five Oil-Producing Countries for 20-Year Intervals since 1861

The following table classifies the top five producing countries in each specific interval of time from 1861 to 2006.

Table 3.3

Top Five Oil-Producing Countries for 20-Year Intervals since 1861

Interval	First	Second	Third	Fourth	Fifth
1861–1880	United States	Russia	Canada	Romania	Poland[a]
1881–1900	United States	Russia	Poland[b]	Indonesia	Canada
1901–1920	United States	Russia	Mexico	Indonesia	Romania
1921–1940	United States	USSR	Venezuela	Mexico	Iran
1941–1960	United States	Venezuela	USSR	Saudi Arabia	Iran
1961–1980	United States	USSR	Saudi Arabia	Iran	Venezuela
1981–2000	USSR/Russia[c]	United States	Saudi Arabia	Iran	Mexico
2001–2006	Saudi Arabia	Russia	United States	Iran	Mexico

Note. From "*The A to Z of the Petroleum Industry*" by M. S. Vassiliou, 2009, Scarecrow press, p. 561.

There are many different countries that are classified from first to fifth as top oil-producing countries according to each specific interval of time; 20-Year Intervals. The countries are the United States, Russia, Canada, Romania, Poland, Indonesia, Mexico, Venezuela, Iran, and Saudi Arabia. As shown in the table above, from 1861 until 1940, the United States and Russia were ranked first and second as top oil-producing countries. For, as stated by Speight (1999), many oil developments took place in these two countries. Precisely, in the first interval from 1861 to 1880, the United States and Russia were followed by Canada as the third oil producer country, Romania the fourth, and Poland the Fifth. In the second interval from 1881 to 1900, Poland took third place followed by Indonesia and Canada as the fifth country, and the same thing for the following intervals, as if there was a competition between those countries as top oil producers. Whereas, the United States preserved the first place until the period between 1961 and 1980, where Saudi Arabia ranked third, yet from 2001 to 2006 Saudi Arabia was the top oil producer country for the Giant reserves it discovered following the Second World War. Each interval of time is characterized by five top oil-producing countries.

3.6. Largest Fields

Many largest oil and gas fields were later discovered in different regions in the world. These fields are classified in the following tables from the largest field to the less large one.

Table 3.4

Largest oil Fields

Field	*Country*	*Discovered*	*Oil (Bb)* [a]	*Gas (Tcf)* [b]	*Total Oil & Gas (Bboe)* [c]	*Estimated Remaining Oil & Gas (Bboe)* [d]
Ghawar	Saudi Arabia	1948	66.1[e]	186.2	97.1	3.0–48.6
Greater Burgan	Kuwait	1938	46.0[f]	42.8	53.1	0.8–23.1
Rumaila N&S	Iraq[g]	1953	30.0	20.0	33.3	1.5–17.9
Bolivar Coastal Complex[h]	Venezuela	1926–1930	30.0		28.8	0.3–11.5
Kirkuk	Iraq	1927	25.0	8.2	26.4	0.2–9.9
Safaniya	Saudi Arabia	1951	21.1	3.9	21.8	0.8–11.4
Samotlor[i]	Russia	1965	20.0			
Cantarell Complex[j]	Mexico	1976	17–19			
Daqing Complex[k]	China	1959	18.5		18.5	1.3–10.9
Zakum	UAE (Abu Dhabi)	1964	17.2	12.4	19.3	1.8–12.0
Manifa	Saudi Arabia	1957	16.8	4.8	17.6	1.0–10.0
Baghdad, East	Iraq	1979	16.0	2.5	16.4	4.4–12.6
Shaybah	Saudi Arabia	1968	15.7	—	15.7	2.0–10.4
Ahvaz	Iran	1958	13.8	23.3	17.7	1.1–10.2
Prudhoe Bay	USA–Alaska	1967	13.0	—	13.0	1.5–8.5
Marun	Iran	1964	12.6	75.3	25.2	2.4–15.7
Zuluf	Saudi Arabia	1965	12.2	5.2	13.1	1.3–8.3
Majnoon	Iraq	1977	12.0	11.0	13.8	3.2–10.3
Gachsaran	Iran	1928	11.8	31.1	17.0	0.1–6.4
Murban Bab	UAE (Abu Dhabi)	1954	10.3	29.3	15.2	0.7–8.2
Abqaiq	Saudi Arabia	1940	10.3	14.2	12.6	0.2–5.7
Kashagan	Kazakhstan	2000	10.0	20.0	13.3	13.3
Fereidoon	Iran	1960	10.0	—	10.0	0.7–5.9
West Qurna	Iraq	1973	9.8	9.4	11.4	2.0–8.0
Berri	Saudi Arabia	1964	9.1	12.2	11.2	1.1–7.0
Pravdinsk-Salym	Russia	1964	9.1	2.9	9.6	0.9–6.0
Statfjord	Norway	1974	9.0	2.0	9.4	1.8–6.8
Qatif	Saudi Arabia	1945	7.2	16.5	10.0	0.3–4.8
Samaria	Mexico	1958	7.0	17.5	10.0	0.6–5.7

(Bermudez Complex)

Note. From "The A to Z of the Petroleum Industry" by M. S. Vassiliou, 2009, Scarecrow press, p.575.Copyrigt 2009 by M. S. Vassiliou. Permission not sought.

Table 3.5

Largest gas fields

Field	*Country*	*Discovered*	*Gas (Tcf)*[a]	*Oil & Condensate (Bb)*[b]	*Total Oil & Gas (Bboe)*[c]	*Estimated Remaining Oil & Gas (Bboe)*[d]
North Field	Qatar	1971	900.0	10.673	160.7	24.7–110.6
Pars South	Iran	1991	350.0	19.1	77.4	47.7–70.3
Urengoy	Russia	1966	335.4	2.7	58.6	3.5–17.5
Yamburg	Russia	1969	153.8	0.537	26.2	3.5–17.5
Zapolyarnoye	Russia	1965	121.0	1.026	21.2	2.2–13.4
Hassi R'Mel	Algeria	1957	100.0	4.064	20.7	1.2–11.7
Astrakhan	Russia	1976	89.6	4.689	19.6	4.3–14.5
Northwest Dome	Qatar	1976	80.0	—	13.3	2.9–9.8
Karachaganak	Kazakhstan	1979	49.2	5.001	13.2	3.5–10.1
Rag-E-Safid	Iran	1964	59.9	3.084	13.1	1.2–4.0
Bovanenko	Russia	1971	76.4	—	12.7	1.9–8.8
Orenburg	Russia	1966	62.8	0.7	11.2	1.2–7.2
Arkticheskoye	Russia	1968	63.0	0.3	10.8	1.4–7.1
Shtokman	Russia	1988	60.0	0.1	10.1	5.1–8.8
Leningrad	Russia	1990	55.0	7.3	9.2	5.3–8.2
Kyrtaiol'skoye	Russia	1970	55.0	—	9.2	1.3–6.2
B. Structure	Iran	1972	50.0	—	8.3	1.4–5.8
Kangan	Iran	1972	50.0	—	8.3	1.4–5.8
Moran	India	1956	48.0	0.043	8.0	0.4–4.5
Pars North	Iran	1966	47.0	—	7.8	0.9–5.0
Natuna	Indonesia	1973	45.0	—	7.5	1.3–5.3
Groningen	Netherlands	1959	43.0	0.011	7.2	0.5–4.2
Severo Urengoy	Russia	1971	35.0	—	5.8	0.9–4.0
Urengo Vostochnyy	Russia	1978	32.4	—	5.4	1.4–4.1
Chayvo, Odoptu, Arkutun-Dagi	Russia	1979	17.1	2.3	5.2	1.4–4.0
Hassi Messaoud	Algeria	1956	7.7	3.84	5.1	0.3–2.9
Troll	Norway	1979	22.8	1.319	5.1	1.4–3.9

Note. From "The A to Z of the Petroleum Industry" by M. S. Vassiliou, 2009, Scarecrow press, p.579. Copyrigt 2009 by M. S. Vassiliou. Permission not sought.

Depending on the information given by Vassiliou (2009), and as shown in the two tables above, first, the largest oil fields are discovered in Saudi Arabia, Kuwait, Iraq, Venezuela, Russia, Mexico, China, UAE, Iran, Alaska, Kazakhstan,

and Norway, and are classified in accordance with the quantity of oil and gas produced and the estimated remaining oil and gas. For instance, as Ghawar oil field discovered in 1948 produced a significant quantity of oil around 66.1 e. It is regarded as the top giant oil field in the world with an amount of 3.0–48.6 (Bboe) of estimated remaining oil and gas followed by Greater Burgan as the second giant oil filed located in Kuwait that was discovered in 1938 and followed by the other less large fields. Second, the largest gas fields are discovered in Qatar, Iran, Russia, Algeria, Kazakhstan, Indonesia, Netherlands, and Norway. According to Vassiliou (2009), Qatar is regarded as the top gas producer country followed by Pars South field in Iran, Urengoy and Yamburg, Zapolyranoy in Russia, Hassi R'mel in Algeria, and other largest gas fields.

3.7. Other Giant Oil and Gas Fields of Historical Interest discovered in the world

In addition to the largest oil and gas fields that are stated above, there were other giant oil and gas fields of historical interest discovered in the world.

Table 3.6

Other Giant Oil and Gas Fields of Historical Interest

Arranged by Year of Discovery

Field	*Country*	*Discovered*	*Oil (Bb)*[a]	*Gas (Tcf)*[b]	*Total Oil & Gas (Bboe)*[c]	*Estimated Remaining Oil & Gas (Bboe)*[d]
La Brea	Peru	1868	1.000	15.0	3.5	0–0.578
Surakhanskoye	Azerbaijan	1870	0.900	—	0.9	0–0.153
Bradford	USA–Pennsylvania	1871	0.658	—	0.658	0–0.113
Bibi Eibat	Azerbaijan	1871	2.000	—	2.000	0–0.344
Lima–Indiana	USA–Ohio/Indiana	1876	0.514	—	0.514	0–0.095
Brea	USA–California	1884	0.439	0.5	0.525	0–0.108
Coalinga	USA–California	1887	0.906	—	0.906	0–0.195
Starogrozny	Russia	1893	0.650	—	0.605	0–0.152
Midway–Sunset	USA–California	1894	2.692	0.5	2.780	0.002–0.658
Balakhany Sabunchino	Azerbaijan	1896	2.400	—	2.400	0.002–0.584
Kern River	USA-California	1899	1.676	—	1.676	0.002–0.425
Panuco	Mexico	1901	0.971	—	0.971	0.001–0.253
Salt Creek	USA–Wyoming	1906	0.676	—	0.676	0.001–0.189
Comodoro Rivadavia	Argentina	1907	3.244	—	3.244	0.006–0.919
Moreni–Gura Ocnitei	Romania	1907	0.800	—	0.800	0.001–0.227
Masjid-e-Suleiman	Iran	1908	0.800	—	0.800	0.002–0.363

Buena Vista Hills	USA-California	1909	0.678	1.1	0.859	0.002–0.250
Cerro Azul	Mexico	1909	1.250	—	1.250	0.003–0.364
Maykop	Russia	1909	—	3.2	0.537	0.001–0.156
Cushing	USA-Oklahoma	1912	0.500	—	0.500	0.001–0.152
Fyzabad Group	Trinidad & Tobago	1913	0.510	—	0.510	0.001–0.157
Sho-Vel-Tum	USA–Oklahoma	1914	1.355	—	1.355	0.004–0.423
Mene Grande	Venezuela	1914	0.700	—	0.700	0.002–0.219
Monroe	USA–Louisiana	1916	—	7.2	1.203	0.004–0.386
Ventura Avenue/Rincon	USA–California	1916	1.012	2.4	1.417	0.005–0.455
Cabinas (Bolivar Coastal)	Venezuela	1917	0.500	—	0.500	0.002–0.163
Infantas–La Cira	Colombia	1918	0.500	—	0.500	0.002–0.165
Santa Fe Springs	USA–California	1919	0.633	0.8	0.773	0.003–0.259
Elk Hills	USA–California	1919	1.407	1.4	1.647	0.007–0.551
Seminole	USA–Oklahoma	1926	0.822	—	0.822	0.006–0.303
Yates	USA–Texas	1926	1.955	—	1.955	0.013–0.721
Seria	Brunei	1929	1.730	2.0	2.063	0.017–0.793
East Texas	USA–Texas	1930	5.382	—	5.382	0.048–2.097
Poza Rica	Mexico	1930	2.000	—	2.000	0.018–0.779
Wilmington	USA–California	1932	2.788	1.3	3.006	0.031–1.204
Awahli (Bahrain)	Bahrain	1932	0.962[e]	6.8	2.088	0.022–0.836
Tuyrnazy	Russia	1937	1.000	—	1.000	0.015–0.429
Dammam	Saudi Arabia	1938	0.912	2.4	1.306	0.020–0.569
Laochunmiao	China	1938	0.500	—	0.500	0.008–0.218
Dukhan	Qatar	1940	1.598	9.0	3.100	0.056–1.387
Kuang	Indonesia	1940	0.600	—	0.600	0.011–0.269
Duri	Indonesia	1941	1.691	—	1.691	0.010–0.227
Leduc	Canada–Alberta	1947	0.500	—	0.500	0.015–0.247
Redwater	Canada–Alberta	1948	0.832	—	0.832	0.026–0.416
Nahr Umr	Iraq	1948	6.500	9.9	8.150	0.255–4.076
Matzen	Austria	1949	0.475	0.6	0.582	0.019–0.295
Zubair	Iraq	1949	8.200	5.9	9.187	0.308–4.658
Lacq	France	1951	—	8.1	1.348	0.052–0.703
Sui	Pakistan	1952	—	11.2	1.873	0.077–0.990
Wafra	Kuwait	1953	1.667	1.2	1.867	0.083–1.001
Nahorkatiya	India	1953	0.500	—	0.500	0.022–0.268
Pembina	Canada–Alberta	1953	1.800	—	1.800	0.080–0.965

Arranged by Year of Discovery (*continued*)

Field	*Country*	*Discovered*	*Oil (Bb)*[a]	*Gas (Tcf)*[b]	*Total Oil & Gas (Bboe)*[c]	*Estimated Remaining Oil & Gas (Bboe)*[d]
Belayim Land	Egypt	1955	0.500	—	0.500	0.025–0.276
Raudhatain	Kuwait	1955	7.193	6.7	8.318	0.423–4.583

Hassi Messaoud	Algeria	1956	3.840	7.7	5.120	0.279–2.861
Augila-Nafoora	Libya	1956	0.834	1.5	1.084	0.059–0.605
Moran	India	1956	0.043	48.0	8.043	0.438–4.494
Kotur-Tepe	Turkmenistan	1956	1.460	1.5	1.710	0.093–0.955
Gazli	Uzbekistan	1956	0.027	16.6	2.801	0.152–1.565
Marmul	Oman	1957	0.700	—	0.700	0.041–0.397
Soku	Nigeria	1958	0.138	5.4	1.034	0.065–0.594
Amal (Libya)	Libya	1959	3.322	3.5	3.906	0.262–2.275
Kenai	USA-Alaska	1959	—	3.1	0.523	0.035–0.305
Khafji	Neutral Zonef	1959	8.646	1.0	8.815	0.591–5.134
Suwaidiyah	Syria	1959	0.711[g]	0.3	0.753	0.050–0.439
Uzen	Kazakhstan	1961	1.658	0.6	1.758	0.135–1.053
Ust'Bakyskoye	Russia–Siberia	1961	2.300	—	2.300	0.177–1.377
Yibal	Oman	1962	1.330	4.5	2.081	0.172–1.264
Bubulime	Albania	1963	—	5.0	0.833	0.074–0.513
El Borma	Tunisia	1964	0.640	0.8	0.772	0.073–0.482
Gidgealpa	Australia	1964	—	5.0	0.833	0.079–0.520
Bach Ho	Vietnam	1964	0.950	1.3	1.167	0.111–0.728
McArthur River	USA–Alaska	1965	0.550	0.7	0.670	0.068–0.424
Miranga	Brazil	1965	0.590	—	0.590	0.060–0.373
Mellion-Rousse	France	1965	—	3.5	0.583	0.059–0.369
Salzwedel	Germany	1965	—	3.5	0.583	0.059–0.369
West Sole	UK–North Sea	1965	—	3.0	0.500	0.051–0.316
Algyo	Ungary	1965	0.200	3.7	0.815	0.083–0.516
Fateh	UAE-Dubai	1966	1.100	—	1.100	0.120–0.706
Malongo N & S	Angola	1966	0.850	—	0.850	0.093–0.546
Kingfish	Australia	1967	1.250	—	1.250	0.146–0.813
Kuparuk River	USA–Alaska	1969	2.595	—	2.595	0.348–1.736
Sacha	Ecuador	1969	0.650	—	0.650	0.087–0.435
Emeraude Marin	Congo–Brazzaville	1969	0.500	—	0.500	0.067–0.335
Ekofisk	Norway–North Sea	1969	3.800	3.9	4.452	0.597–2.978
Maui	New Zealand	1969	0.075	5.3	0.957	0.128–0.640
Beurdeshik	Tajikistan	1969	—	3.0	0.500	0.067–0.335
Forties	UK–North Sea	1970	2.000	—	2.000	0.287–1.357
Central Luconia F-06	Malaysia	1970	—	3.4	0.565	0.081–0.383
Kudu	Namibia	1971	—	3.6	0.600	0.092–0.413
Brent	UK–North Sea	1971	0.243	2.1	0.599	0.092–0.412
Drake Point	Canada–NWT	1973	—	6.0	1.000	1.000
Malossa	Italy	1973	—	1.8	0.618	0.109–0.437
B Structure	Thailand	1973	—	7.3	1.215	0.215–0.859
Hibernia	Canada–Newfoundland	1979	1.850	2.0	2.183	0.585–1.678
Serrablo	Spain	1979	—	3.5	0.583	0.156–0.448

Meskala	Morocco	1980	—	5.0	0.833	0.239–0.649
Espoir	Ivory Coast	1980	1.000	—	1.000	0.287–0.779
Unity	Sudan	1980	0.900	—	0.900	0.259–0.701
Sajaa	UAE–Sharjah	1980	0.246[h]	3.3	0.799	0.230–0.623
Feni	Bangladesh	1980	—	3.3	0.548	0.158–0.427
Tengiz	Kazakhstan	1980	5.829	11.9	7.812	2.244–6.087
Margham	UAE–Dubai	1982	0.234[i]	2.7	0.681	0.225–0.545
Hides	Papua–New Guinea	1987	0.070[j]	8.0	1.403	0.655–1.205

Arranged by Year of Discovery (*continued*)

Field	*Country*	*Discovered*	*Oil (Bb)*[a]	*Gas (Tcf)*[b]	*Total Oil & Gas (Bboe)*[c]	*Estimated Remaining Oil & Gas (Bboe)*[d]
Rabi-Kounga	Gabon	1987	1.000	—	1.000	0.467–0.859
Masila Complex	Yemen	1990	0.900	—	0.900	0.517–0.806
Yadana	Myanmar	1990	—	5.0	0.833	0.479–0.746
Cusiana	Colombia	1992	1.445	3.1	1.961	1.294–1.805
Mars Deepwater	USA–Gulf of Mexico	1993	0.700	—	0.700	0.495–0.653
Roncador	Brazil	1996	3.200	—	3.200	2.786–3.113
Margarita	Bolivia	1998	1.357[k]	6.5	2.432	2.432
Ceiba	Equatorial Guinea	1999	0.500	—	0.500	0.500
Halfdan	Denmark	1999	0.492	0.3	0.545	0.545
Azadegan	Iran	1999	6.110	2.0	6.443	6.443
Bonga SW	Nigeria	2001	1.250[l]	0.5	1.333	1.333

Note. From "The A to Z of the Petroleum Industry" by M. S. Vassiliou, 2009, Scarecrow press, p.583.Copyrigt 2009 by M. S. Vassiliou. Permission not sought.

As table 3.7 illustrates, following the first discovery and drilling for oil in the United States, there were other interesting discoveries in many regions in the world which were giant oil and gas fields.

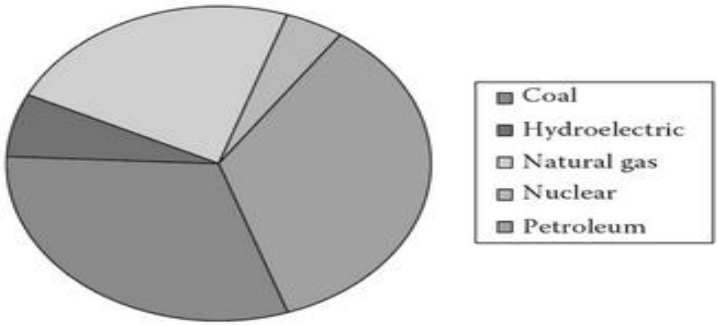
3.8. Oil Prices and Economic growth

As British petroleum (BP) noted, oil is the primary energy source in the world as shown in figure 3.7 (2002). For the aim of maintaining economic growth, the world has depended on low-cost oil for a century (Yergin, 1991 as cited in Speight, 1999). However, maintaining the rate of economic growth is dependent on the volume of oil that can eventually be produced, and the volume of oil produced is also subject to speculation

because of the uncertainties of reserve estimation, and this affects the price of oil (Speight, 2011b as cited in Speight, 1999). Certainly, Economic growth is directly related to oil prices, where this later also counts on oil production and reserves estimation.

Figure 3.7

Distribution of world energy resources



Note. From "*The chemistry and technology of petroleum"* by J. G. Speight,1999, CRC press, p.26 . Copyright 2014 by Taylor & Francis Group, LLC. Permission not sought.

3.8.1. Pricing Strategies

In essence, the price of a barrel of oil is strongly dependent on its grade which means it is determined by factors such as its specific gravity or API and its sulfur and the location as well (Speight, 1999).

3.8.2. Oil Price History (1948-2005)

Over the past decade, crude oil prices have been swinging whether due to obvious shortage or oversupply. Historically, as stated in Speight (1999), from 1948 to the 1960s, crude oil prices diversified from $2.50 and $3.00. The price rose from $2.50 in 1948 to $3.00 in 1957. However, the prices were stable at $3.00 from 1958 to 1970. Apparently, before 1960, or before establishing the OPEC, Crude oil prices didn't exceed $3.00. OPEC had a great impact on regulating oil prices. Besides OPEC, other factors affected the price of crude oil.

3.8.2.1. The establishment of the OPEC

The organization of petroleum exporting countries OPEC was formed in 1960 with five founding members; Iran, Iraq, Kuwait, Saud Arabia, and Venezuela. Six other countries including Algeria, Qatar, Libya, Indonesia, United Arab Emirates, and Nigeria joined the OPEC and increased its membership ranks. As noted by Speight (1999), during this period, the petroleum exporting countries witnessed a rise in demand for their crude oil. The price of crude oil was about $3.00 per barrel in 1972, yet by the end of 1974, the

price of oil had quadrupled to over $12.00. Interestingly, OPEC played a crucial role to ensure the stabilization of oil markets and increasing and regulating oil prices.

3.8.2.2. The Yom Kippur War

The Yom Kippur War began on October 5, 1973, with the Egypt and Syria attack on Israel, this attack had a great impact on oil prices. A lot of countries from the western world supported Israel. As a result, an embargo was imposed on those countries by Middle East exporting countries (Speight, 1999). The countries targeted were Canada, Japan, the Netherlands, the United Kingdom, the United States, Portugal, and South Africa. The embargo affected oil prices; caused an oil crisis or shock with short and long-term effects on the global economy.

3.8.2.3. The Iran Iraq War

From 1974 to 1978, the crude oil price was consistently ranging from $12.21 per barrel to $13.55 per barrel (Speight, 1999). The events in Iran and Iraq that picture the overthrow of the shah Iran and the Iran-Iraq War led to the increase of crude oil prices. As stated in Speight (1999), in 1981 Crude oil prices rose to $35 per barrel. In mid-1985 oil prices were linked to the crude spot market. Whereas, early 1986 witnessed an increase in production by some OPEC members, and crude oil prices decreased to $8-$10 per barrel. From 1974 to 1986, the oil price was swinging. Before the Iran-Iraq war, the price was regular, and during the war, it rose, whereas, following the war and because of the increase in production, the price entered a steady decline.

3.8.2.4. The Gulf War

In 1990, the Iraqi invasion of Kuwait led to the start of the Gulf war, and crude oil prices rose again. However, after the war, oil prices decreased once again and from 1990 to 1997 oil prices raised as a result of an increase in world oil consumption (Speight, 1999).

As mentioned by Speight, in January 1999, the increase of oil production from Iraq coincidence with the Asian financial crisis led to oil demand reduction. Then by September 2000, the prices speedily increased, afterward fell until the end of 2001before regular increasing, reaching UD$50-40 per barrel by September 2004. In the following month, oil price surpassed US$55 per barrel, and by December exceeded US$55 per barrel; whereas, in June 2005 crude oil prices raised above $60 a barrel (1999).

3.8.3. Future of Oil

As Speight clarifies, theorists such as Hubbert assume that oil reserves will not be recharged and that world oil production must certainly reach a peak and then decline as these reserves are depleted. As an example, the prediction for the United States to reach a

peak became true and lost its excess production capacity after the peak in 1971. Yet, OPEC could manipulate prices. Subsequently, several other countries experienced an oil peak (1999). However, although the oil peak depends on the past production and discovery data used in the calculation, it is so hard to predict the oil peak in any country or region.

Briefly, maintaining economic growth is directly related to the price of crude oil, production and reserves estimation. As already mentioned, the price of crude oil was affected by many factors such as the establishment of OPEC and also various wars, but what is more important is that during the periods of price decline there was not a recognition of the need of, for example, the development of technologies that would maximize oil recovery. Maybe some would argue that the periods of oil price decline were motive to begin the development of technology with higher quality and expertise.

3.9. World oil demand

3.9.1. Crude Oil Consumption

According to Abdel-Aal & Alsahlawi, in the mid 20th century, Coal was still a dominant source consumed by people, yet after 1970 coal was replaced by oil (2013). Table 3.9 presents the percentage of world energy consumption by energy sources for the years 1960, 1970, 1980, 1990, 2000, and 2010.

Table 3.8

World Primary Energy Consumption in Percent Share (Energy Mix in Consumption), 1960–2010

	Year					
Energy Source	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**
Oil	34.21	46.06	43.55	38.70	39.10	38.00
Natural Gas	14.00	20.01	18.95	20.20	21.00	21.90
Coal	49.84	33.79	29.11	29.5	28.60	28.30
Hydrolelectric Power	01.93	02.08	06.00	06.50	06.20	06.04
Nuclear Power	0.006	00.13	02.39	05.10	5.10	5.4
Total	100	100	100	100	100	100

Note. From "Petroleum economics and engineering" by H. K. Abdel-Aal, & M. A. Alsahlawi, (Eds.),2013, CRC Press, p.11. Copyright 2014 by Taylor & Francis Group, LLC. Permission not sought.

The share of oil has reduced to 38.7 percent in 1990 because of the high prices and the implementation of energy conservation and environmental policies in oil-consuming countries. In this case Consumption of other forms of energy has increased, which lowered the consumption of oil. Yet compared to other energy sources, oil was still the most important source for energy consumption. Table 3.10 shows total world oil consumption has increased from 22.9 mb/d in 1960 to 87.4 mb/d in 2010.

Table 3.9

Share of World Crude Oil Consumption by Region from 1960 to 2010

Year							
Region	**1960[a]**	**1970**	**1980**	**1990**	**2000**	**2010**	**2010 Share of Total**
North America	11.70	16.59	20.00	20.32	23.57	23.45	25.8%
Latin America	1.20	20.87	33.22	36.23	48.55	6.10	7%
Western Europe	4.10	13.20	16.28	16.20	15.50	14.12	18%
Eastern Europe and Russia[b]	3.33	5.02	8.62	8.20	4.30	5.40	5%
Middle East	0.70	1.16	2.04	3.60	5.12	7.82	8.9%
Africa	0.30	0.72	1.37	1.94	2.44	3.29	3.9%
Asia and Pacific	2.00	6.65	10.48	13.82	21.13	27.24	31.5%
Total	**22.93**	**45.41**	**61.12**	**66.50**	**76.60**	**87.38**	**100%**

Note. From "Petroleum economics and engineering" by H. K. Abdel-Aal, & M. A. Alsahlawi,2013, CRC Press, p.11. Copyright 2014 by Taylor & Francis Group, LLC. Permission not sought.

In 1960, the United States was the largest oil consumer in the world. It had more than 55% of the world's consumption. However, over the years, the U.S. share of world oil

consumption has been declining to around 26 percent in 2010 compared to increasing consumption from other regions such as Asia and Pacific, Europe, and the Far East. Western Europe's share of world oil consumption reached its maximum in the mid-1970s up to 27 percent and started to decrease afterward as a result of substituting oil with other types of energy and applying oil conservation measures.

3.9.2. Refined Oil Products

Petroleum products are derived from petroleum and have a commercial value in the markets as a bulk commodity. As already known the use of petroleum goes back to the pre-Christian time by ancient people. Thus, the use of petroleum is not such a modern issue that we tend to believe. However, since petroleum first came into use there have been many changes in emphasis on product demand. These changes in product demand have been responsible for the evolution of the petroleum industry, from the use of asphalt in ancient times to the use of gasoline, fuel oil, and other products in the modern petroleum era.

The steady demand for products, for example, liquid fuels, and even other products such as waxes, asphalt, establishes the main driving force behind the evolution of the petroleum industry and makes petroleum a popular national resource."Products derived from petroleum supply more than half of the world's total supply of energy"(Speight, 1999, p.717). Economically, petroleum products are highly demanded and provide a great amount of energy to the world. Products, such as Kerosene, gasoline, and diesel oil provide fuel for automobiles, aircraft, ships, tractors, and trucks; whereas, fuel oil and natural gas, are used for heating homes, generating electricity, and in commercial buildings. In addition, petroleum products are used for manufacturing synthetic fibers for producing clothes, paints, plastics, insecticides, fertilizers, synthetic rubber, and soaps. Petroleum products usage in manufacturing is regarded as the main driver of modern industry.

3.9.3. Consumption of Refined Oil Products

Abdel-Aal & Alsahlawi declared that in 1988, free world consumption of refined oil products was about 2373.6 million tons. It has increased by 81.5 percent from 1965 to 1988. Gasoline and fuel oil represent around 83 percent of total refined oil products consumed (2013). Many countries are regarded as big consumers of oil products. For instance, as Abdel-Aal & Alsahlawi stated, the United States is the largest consumer of oil products, it consumes more than a third of total free world consumption. Also, Western Europe has raised its consumption of refined oil products by 54 percent from 1965 to 1988. Japan's consumption has also increased by almost threefold for the same period (2013).

This indicates that oil product consumption by industrialized countries is very high compared with developing countries or crude oil producers as shown in table 3.10.

3.10. How Does Oil Price Affect Oil Recovery?

John & Richard stated that it is becoming increasingly difficult to discover new reservoirs that contain large volumes of conventional oil and gas. For instance, many explorations were done in multifarious places with difficult conditions or with less hospitable climates in the world, such as arctic conditions in Siberia and deepwater offshore regions near West Africa (2017). Yet as confirmed by John & Richard, large volumes of oil remain in the reservoirs that have already been discovered and developed (2017). For recovering oil from already existed fields, new techniques of development have been used and recovered approximately one-third of the oil in known fields (John & Richard, 2017). That means almost two-thirds remain in the ground where it was originally found. So oil recovery demands the use of new techniques of development that require high costs to be applied. Thus, oil recovery depends on cost, and production from existing reservoirs may increase if companies tend to pay for it and if the market will support that cost.

Many oil-producing companies choose to seek and produce less expensive oil for they can compete in the international marketplace. Table 3.11 shows that as the price of oil increases, more sophisticated technologies can be justified. In addition, It also includes a price estimate for alternative energy sources, such as wind and solar. Technological advances are helping wind and solar energy become economically competitive with oil and gas as energy sources for generating electricity.

Table 3.10

Sensitivity of Oil Recovery Technology to Oil Price

	Oil Price Range	
Oil Recovery Technology	1997$/bbl	2016$/bbl 5% Inflation
Conventional	15–25	38–63
Enhanced oil recovery (EOR)	20–40	51–101
Extra heavy oil (e.g., tar sands)	25–45	63–114
Alternative energy sources	40–60	101–152

Note. From "*Introduction to petroleum engineering" by* R. F. John and L. C. Richard,2017, John Wiley & Sons, p.15. Copyright 2017 by John Wiley & Sons, Inc. Permission not sought.

3.11. Oil Prices Limits

John & Richard view that the price of oil does not rise without a limit (2017). As the table given above illustrates, the alternative energy sources become cost-competitive when the price of oil rises. For instance, oil price rose above $101 per barrel in 2016. So If the oil price stays for example at $101 per barrel or higher for a long period of time, energy consumers then will spontaneously begin to shift to less expensive energy sources. As John & Richard clarify, "The impact of price on consumer behavior is illustrated by consumers in European countries that pay much more for gasoline than consumers in the United States. Countries such as Denmark, Germany, and Holland are rapidly developing wind energy as a substitute to fossil fuels for generating electricity" (2017, p.15). These European countries are oil and gas importers and compared to producer countries, they pay much money for oil and gas. For this reason, they rush to develop other less expensive energies to substitute fossil fuels.

Historically, many oil-exporting countries have seen supplying much quantity of oil to keep the price below to maximize their income and minimize competition from alternative energy and expensive oil recovery technologies. As an example, Saudi Arabia has attempted to increase the supply of oil to drive down the cost of oil (John & Richard, 2017). Yet this attempt creates problems for organizations that are trying to develop more costly sources of oil, such as shale oil in the United States. It also creates problems for oil-exporting countries that are relying on a relatively high oil price to fund their government spending. Oil price can always be limited whether by supplying more quantities of oil to reduce its price or by an attempt to minimize the dependence on imported oil through developing technologies that reduce alternative energy costs.

3.12. Conclusion

This chapter was devoted to showing the reader the first steps of the rise of the petroleum industry and focused on a part of the economic side of the industry. The first steps of the rise of the modern petroleum industry were marked after the discovery of the first commercial oil well in Titusville, Pennsylvania in 1859 by extensive drilling that took place in the surrounding areas for producing oil in high quantities and exports it to the world. As a result, the production of crude oil in the United States rose from around 2000 barrels in 1859 to around 3,000,000 in 1863 and about 10,000,000 in 1874.

In the late, 19th century and the beginning of the 20th century, the United States and Russia were the top petroleum-producing countries in the world. A few years later, oil

was discovered in Romania, Canada, Indonesia, Middle East, Algeria, and other countries. Also, high quantities of oil and gas were obtained in different regions in the world and even the largest oil and gas fields were discovered. For instance, Saudi Arabia is famous for the giant field Ghawar which was discovered in 1948. And Qatar is famous for North Field that was discovered in 1971. Since the beginning of the modern petroleum industry, the Standard Oil Company influenced the world then it was followed by the seven sisters BP, Shell, Exxon, Mobil, Gulf, Texaco, and Chevron. The Seven Sisters with Compagnie Française des Pétroles CFP dominated the world industry and controlled production in the Middle East.

Economically, economic growth is directly related to the price of crude oil and production and even reserve estimation. From 1948-2005, Oil Price was affected by many factors such as the establishment of OPEC and also various wars, for instance, the Yom Kippur War, the Gulf war, and Iran Iraq war. In this specific period, there had been oil shocks and even a decrease in prices.

Through the years, world oil demand was in increase, where totals world oil consumption had increased from 22.9 mb/d in 1960 to 87.4 mb/d in 2010. In 1960, the United States was the largest oil consumer in the world. It had more than 55% of the world's consumption. However, the U.S. share of world oil consumption had been declining compared to increasing consumption from other regions such as Asia and Pacific, Europe, and the Far East. Moreover, petroleum products demand increased over the years. These products, such as Kerosene, gasoline, diesel oil fuel oil, fuel oil and natural gas, and so on, established the main driving force behind the evolution of the modern industry. Finally, as fossil fuels are a non-renewable source of energy, their price is always limited by alternative energy sources such as wind and solar energy that are used as substitution.

General Conclusion

The 19th century was the oil discovery era and the birth of the modern petroleum industry. Petroleum is a precious commodity that has dominated the world since its first discovery in 1859 in Pennsylvania the United States. Every single thing that serves humans relies on petroleum. Thus, having general information about the beginnings of the petroleum industry interest many people whether, teachers, students, academic researchers, and even non-educated people. So this research work studied how the discovery of the first commercial oil well in 1859 in the United States of America led to the shaping of the modern petroleum industry through an analysis of the historical background of the industry.

Historically, before the discovery of the first oil well in 1859 in America, crude oil seeped on the surface of the ground and was used by ancient people, such as Sumerians, Egyptians for embalming mummies sealing of ships and water tanks, for lamps, and heating homes, and even was used as a cure against various diseases. Thus, oil was discovered and used before Christ when it was seeping on the ground.

Following the first oil discovery in 1859, the United State of America began to use Kerosene for illumination as it was a cheap product obtained through oil distillation. Also, production in Post WWII marked a sharp transition to the automotive era, the invention, and diffusion of the automobile that led the industry to shift to producing transportation fuels that empowered the development of petro-chemistry. Demand for these fuels increased and led to establishing the main driving force behind the evolution of the modern petroleum industry.

The United States of America was the leading oil producer country. Science and technology helped oilmen to locate oil by following scientific methods such as geological and geophysical explorations. Then, drillings that took place in the same area in Pennsylvania and even in other different places in America seeking oil led to the discovery of giant oil reservoirs that were commercially exploited in huge quantities and distributed to the world. Thus, the US monopolized the world oil market and became the leading oil producer country in the world.

Petroleum production was extremely high. It was produced initially in the United States and Russia that were top oil and gas producer countries. Thereafter, it was produced in other countries, such as Canada, Romania, Poland, Indonesia, Mexico, Venezuela, Iran, and Saudi Arabia that became new important producer countries. However, the US was the only country that dominated world oil production. Domination was via the establishment of the Standard Oil Company that had a major influence over the world through

monopolizing oil refining in the United States in the early 20th century and then it was followed by the seven sisters BP, Shell, Exxon, Mobile, Gulf, Texaco, Chevron, CFP that also monopolized petroleum production in the Middle East.

This research work provided a clear explanation of the information given about the petroleum industry in general, the historical background of the industry, the first discovery of oil in the US, how this discovery led to the birth of the modern petroleum industry, and why the US is regarded as the leading oil producer country in the world. Yet, some issues need a meticulous explanation by future researchers. The first issue is whether the US will keep being the leading oil producer country in the world for the next centuries? Or it will be competed by other countries emergence to the oil market as also giant and top petroleum producers. Second, will the world continue to rely on fossil fuels or it will shift to alternative energy sources? Did the countries that started to try with alternative energy sources succeded? Which are these countries? And what are the most alternatives used?

Glossary

Anticline: Structural configuration of a group of folding rocks in which the rocks are tilted in different directions from the crest.

API gravity: A measure of petroleum to see if it is light or heavy that is related to the density and specific gravity:°API = (141.5/sp gr @ 60°F) − 131.5

Asphalt: A product that is obtained by distillation and treatment of an asphaltic crude oil. It is nonvolatile and a manufactured product.

Associated gas: It is a natural gas that may be in contact with the crude oil of the reservoir or dissolved in it. It may be classified as a gas cap (free gas) or gas in solution (dissolved gas).

Acidizing: A technique that is based on injecting acid to improve the permeability of a reservoir.

Barrel: The unit that is used to measure liquids in the petroleum industry. It is equivalent to 42 US standard gallons.

Benzene: Benzene (C6H6) is a colorless aromatic liquid hydrocarbon.

Bitumen: A hydrocarbonaceous material that may be semi-solid or solid. It is found filling pores and splits of sandstone, limestone, or argillaceous sediments.

Cetane number: Cetane number indicates the ignition quality of diesel fuel. Diesel fuel ignition quality can be estimated through the following formula:

Diesel index = (aniline point (°F) × API gravity) × 100

A high cetane number means a short ignition delay time.

Coal: An organic rock.

Conventional recovery: Conventional recovery includes Primary and/or secondary recovery.

Cracking: The thermal processes through which petroleum constituents are converted to products of lower molecular weight.

Creekology: is a method used to search for petroleum, it appeared in the 19th century in the US south gas-oil states. It was the search for above-ground indications of oil, such as natural seeps.

Distillation: A process used to separate liquids with different boiling points.

Dome: A dome is a geological structure that is semi-spherical in shape

Enhanced oil recovery (EOR) process: A method followed to recover additional quantities of oil from a petroleum reservoir more than that economically recoverable by conventional primary and secondary recovery methods.

Exploratory well: A well that is drilled without detailed information of the structure of the rock underground in order to find hydrocarbons whose exploitation is economically profitable.

Feedstock: Feedstock means petroleum as it is fed to the refinery

Formation: An interval of rock with specific geologic characteristics.

Fossil fuel resources: A gaseous, liquid, or solid fuel material formed underground through chemical and physical transformation of plant and animal residues over geological time. They are natural gas, petroleum, coal, and oil shale.

Fracturing: A technique used to break apart reservoir rock by applying a fluid with very high pressure at the rock face.

Fuel oil: Fuel oil or heating oil, it is a distillate product that has a wide range of properties

Gas cap: A part of a hydrocarbon reservoir found at the top.

Gasoline: Is a fuel for the internal combustion engine.

Kerosene (kerosine): A petroleum fraction that was initially used as an illuminant in lamps.

Number 1 Fuel oil (No. 1 Fuel oil): is used in burners where vaporization is usually required before burning and a clean flame is specified.

Number 2 Fuel oil (No. 2 Fuel oil): is used in burners where complete vaporization is not required before burning. It is also called domestic heating oil, and has similar properties to diesel fuel and heavy jet fuel

Paraffin wax: A material that is obtained from the light lubricating fractions of paraffin crude oils. It is colorless, translucent, and highly crystalline

Permeability: is the flow of the water through the rock easily

Reserves: resources that are well-identified and can be profitably extracted and utilized.

Resource: is the total amount of a commodity such as petroleum that has been estimated to be ultimately available

Sedimentary: composed from deposits of sediments, such as sand grains or silts that are transported from their source and deposited in water as sandstone and shale, or from calcareous remains of organisms, as limestone

Strata: are Layers including an inner core that is solid iron-rich, outer core molten, mantle, and crust of the earth

Stratigraphy: one of the geology disciplines that studies the origin, composition, distribution, and succession of rock strata

Tar: a name that was used for petroleum in ancient texts. It is a volatile product, brown or black, oily, and viscous. It is obtained from the destructive distillation of many bituminous or other organic materials, particularly coal.

Trap: sediment that accumulates oil and gas and prevents further migration.

(Speight, 1999).

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