

## CURRICULAR FOR THE NEQ

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NANA SIR OFORI  
ATTA I NATIONAL  
ENERGY  
COMPETITION  
2019

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UNDER THE AUSPICES  
OF THE PRESIDENT  
OF THE EASTERN  
REGIONAL HOUSE OF  
CHIEFS,

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OSAGYEFO AMOATIA OFORI PANIN,  
THE OKYEHENE AND NANANOM OF  
THE EASTERN REGION

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## CURRICULAR FOR NANA SIR OFORI ATTA I NATIONAL ENERGY QUIZ

### Meaning of Petroleum

The word 'Petroleum' comes from the Greeks. 'Petro' means rock and 'Oleum' means oil.

**Definition: Petroleum** is a substance occurring naturally in the earth in solid, liquid, or gaseous state and composed mainly of mixtures of chemical compounds of carbon and hydrogen, with or without non-metallic elements such as sulfur, oxygen and nitrogen.

Petroleum is the end product of the partial decay of living organisms which once inhabited the world's oceans. As they died, they sank to the bottom of the oceans where they were preserved. It exists in the form of crude oil, natural gas or solid material.

**Petroleum** is therefore, a blanket term that covers all the naturally occurring hydrocarbons such as gas, crude oil and other solid substances. Petroleum has a lot of energy. For example, Light Crude Oil (LCO) in electric power generation, fuel for cars, etc. We can turn it into different fuels—like gasoline, kerosene, and heating oil.

Plastics, fertilizers, etc are made from petroleum, too.

### SYNOPSIS ON THE GLOBAL ENERGY SECTOR

The petroleum industry includes the global processes of exploration, extraction, refining, transportation (often by oil tankers and pipelines) and marketing petroleum products. The largest volume products of the industry are fuel oil and gasoline (petrol). Petroleum is also the raw material for many chemical products, including pharmaceuticals, solvents, fertilizers, pesticides, and plastics. The industry is usually divided into three major sub-sectors: upstream, midstream and downstream. Midstream operations are usually included in the downstream category of business.

Crude Oil accounts for over 90% of global energy consumption, ranging from as low of about 32% for Europe and Asia, up to a high of about 53% for the Middle East. Increased economic growth and improvement in welfare has led to increased energy consumption especially in U.S, China, India and the African continent. About 30% of global oil comes from offshore. The world consumes about 30 billion barrels of oil per year.

### FORMATION OF OIL AND GAS (HYDROCARBONS)

**Introduction to Petroleum Geology:** This section introduces senior high school (SHS) students to Geology and how it relates to the petroleum industry. It focuses on the petroleum system processes with emphasis on the combination of conditions that should be met for the formation & accumulation of oil and gas.

The content includes the following aspects of geology:

- The petroleum system
- Conditions necessary for accumulation of petroleum
- The generation of the source rock
- Kerogen & its types
- Stages of petroleum maturation:
  - Diagenesis
  - Catagenesis
  - Metagenesis
    - Essential features for a reservoir to be effective
    - Characteristics of carbonate and sandstone (or clastic) reservoirs
    - Primary and secondary migration
    - How petroleum traps are formed
    - Structural, stratigraphic, combination and hydrodynamic traps

### **The content**

How is Oil and Gas formed?

Fossil fuels were formed millions of years ago – Organic materials buried in the ground by sand and rock until the pressure and heat from the earth turned them into hydrocarbons (coal, oil & gas).

**Petroleum System:** A petroleum system consists of a mature source rock, migration routes, traps, reservoir rocks and rocks that serve as seals to the reservoir rocks.

All components of this system must be present at the right time for oil and gas to be successfully accumulated in commercial quantities.

How The Petroleum System Works:

Decaying organic matter deposited and buried in a sedimentary basin over millions of years forms into an organic rich petroleum source rock (such as carbonaceous mudstone or shale).

#### POINTS TO NOTE:

- The source rock may be predominantly oil-prone or gas prone depending on the source of the organic material.
- Woody material tend to generate more gas whereas algal material is more oil-prone.
- The source rock matures over time under the appropriate temperature and pressure conditions in kitchen areas and yields up petroleum in the form of oil and gas.
- Petroleum is initially expelled by pressure from the source rock and then migrates to shallower depths along porous and permeable conduits.
- The petroleum migrates to shallower depths because is less dense than water which is the primary fluid that fills the pore spaces in the rocks of the earth's upper crust.
- In some cases, the migrating petroleum simply seeps to the surface and is degraded and lost.
- In some cases, the migrating petroleum flows into a reservoir rock.

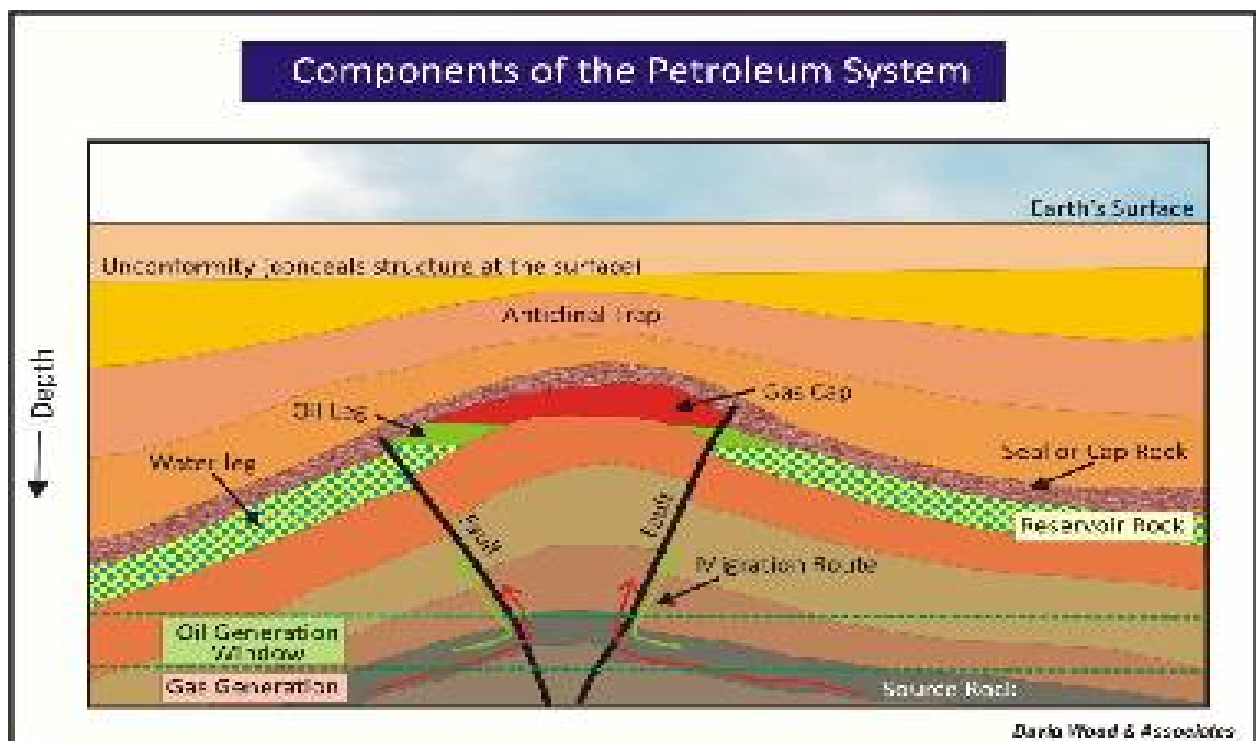


Figure 1.0: Diagram Showing the Petroleum System

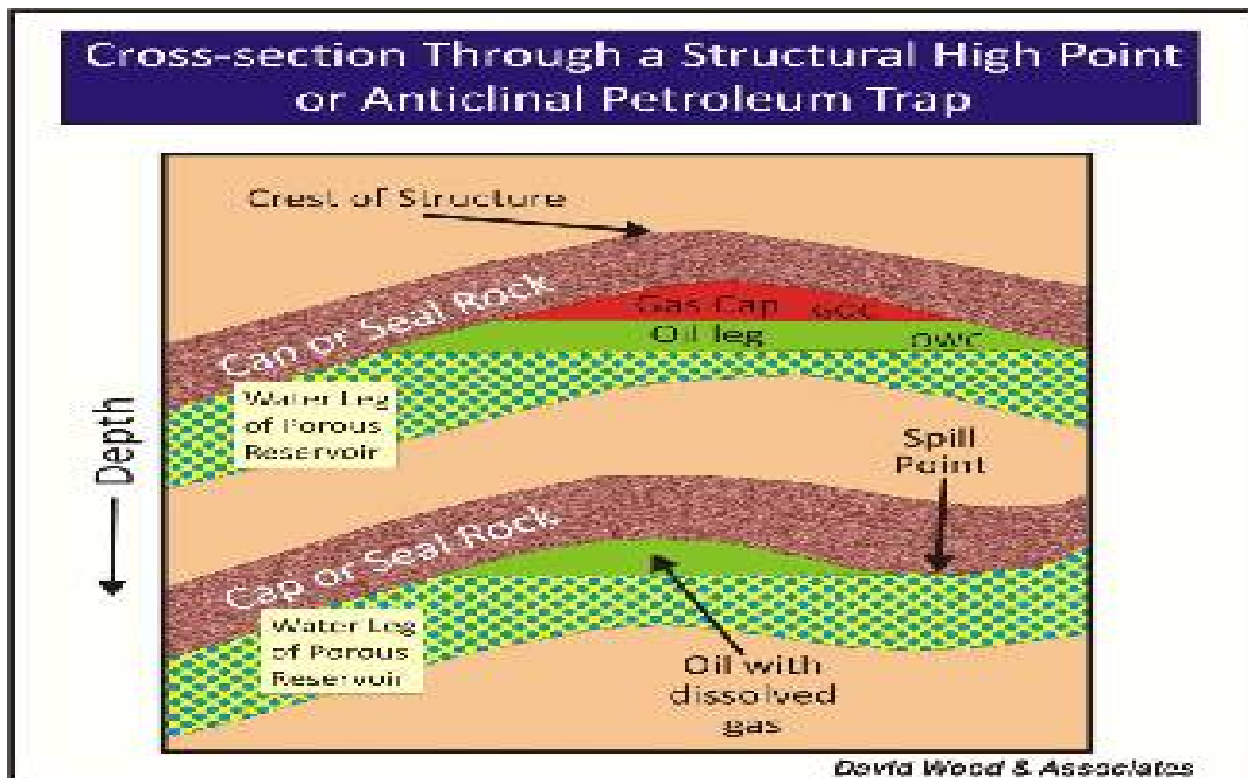


Figure 1.1: Cross section through an Anticlinal trap

## KEROGEN & ITS TYPES

### What is a Kerogen?

- Kerogen is the name given to insoluble, disseminated organic (carbonaceous) matter in sediments.
- Usually, the kind and amount of petroleum that are generated are governed by 3 factors, namely;
  1. The nature of the remains of living organisms preserved in the sediments.
  2. The abundance of the organic matter
  3. The extent to which the organic matter is heated.
- Of greater significance to petroleum geologists are the more abundant and smaller microscopic organisms that contribute to huge formation of hydrocarbons and not fishes and other large animals.
- The organic matter has been classified into three types (Type 1, 2 and 3).

- TYPE 1: From fine algae that flourish in some fresh water lakes especially in warmer climates.
- This type when later buried and heated, gives rise to high quality waxy oil.
- TYPE 2: This is found in marine sediments and consists of the single-celled plankton, algae and bacteria that live in abundance in certain regions of the ocean.
- This type of organic matter is the source of the greater part of the world's oil.
- TYPE 3: Consists of materials derived from land vegetation such as wind blown spores and pollen, and the fragments of plants incorporated into sediments-eg is coal.
- Primarily, this material gives rise to dry gas.
- However, the cuticle of some thick-leaved plants which flourish in the tropics, rubber and mangrove trees can produce waxy oils on heating.
- The process is illustrated by the general formulae:

In summary, OM + Transformation = Kerogen + Bitumen (by product)  
 Kerogen + Bitumen + more Transformation = Petroleum

Note: OM means 'Organic Matter'

### **CONDITIONS NECESSARY FOR ACCUMULATION OF PETROLEUM**

- Before oil & gas can form and eventually accumulate, the following must be existent;
  - Source rock
  - Reservoir rock
  - Trap
  - Overburden rock

#### **What is Source Rock?**

Source rock is a rock from which hydrocarbons are capable of being generated or have already been generated.

A source rock is made up of organic rich sediments that may have been deposited in a variety of environments including deep marine, lacustrine and deltaic. **Example of source rock is shale.**

### **What is a Reservoir Rock?**

A reservoir rock is a rock with adequate pore space to accumulate and contain large quantities of the migrating petroleum.

Typical petroleum reservoirs are porous sandstones and fractured carbonates (eg. Limestones).

To be commercial, the reservoirs must be located at depths that can be reached and exploited by drilling.

The greater the depth, the more expensive it will be to recover the petroleum to the surface.

**In order to contain the petroleum, the reservoir rock has to be configured into a trap.**

### **What is a Petroleum Trap?**

In the petroleum system, there must be a trap on the reservoir rock to concentrate the gas or oil.

The trap may be a contorted structure (structural trap) in the subsurface formed by deformation of the rock strata by earth movements that occur over time due to dynamic nature of the earth's crust.

The trap may also be a complex feature formed from transition from one geological formation to another (stratigraphic trap).

A trap may also be a fault trap when it is formed by sealing fractures and faults ;preventing the petroleum from escaping from the reservoir rock.

### **Types of Traps**

The simplest system for classifying traps divides them into 3;

1. Structural traps
2. Stratigraphic traps
3. Combination traps.



A structural trap has a concave roof caused by the deformation of the reservoir rock and the impervious roof rock.

**There are 3 forms of structural traps, namely; 1.Anticline trap, 2. Fault trap and 3. Salt dome trap.**

🚧 Stratigraphic traps occur as a result of variations in the rock strata such as a change in the local porosity and permeability of the reservoir rock, a change in the kinds of rocks laid down, or a termination of the reservoir rock.

🚧 Combination traps are traps formed by a combination of structural and stratigraphic circumstances (a situation where neither completely controls the trap).

#### STAGES OF PETROLEUM MATURATION:

- There are 3 stages of petroleum maturation, namely;
  - **Diagenesis**
  - **Catagenesis**
  - **Metagenesis**

##### Features of Diagenesis:

- It is the Immature Zone
- Up to 1.5 Km in depth
- Organic matter decays to produce biogenic gas and bitumen and kerogen

##### Features of Catagenesis:

- Breakdown of kerogens to form hydrocarbons
- 1.5 km to 3.6 km depth
- Wet gas and oil is produced in this zone
- Main stage of oil formation from kerogens
- First order thermal cracking
- Transformation of oil into gas also occurs in later catagenesis

##### Features of Metagenesis:

- **Occurs Between metamorphism and catagenesis**
- **Characterized by generation of dry gas**

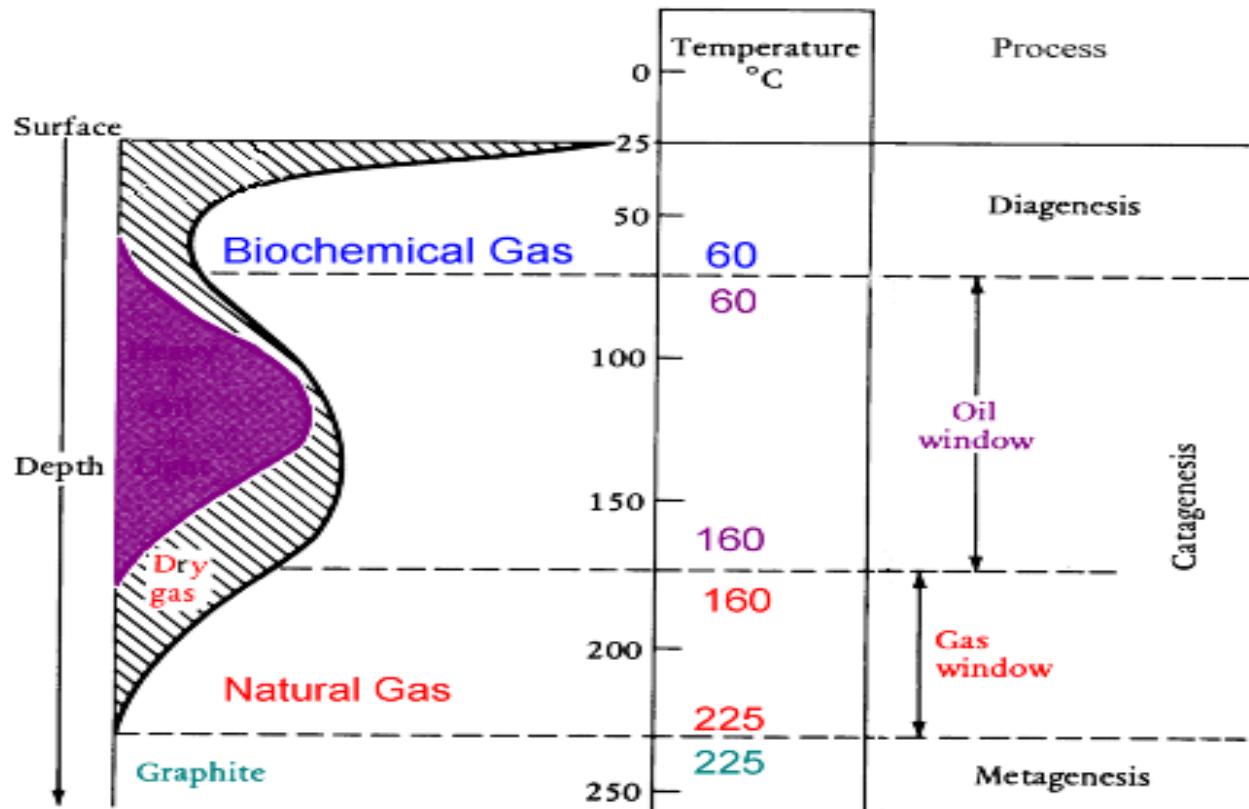


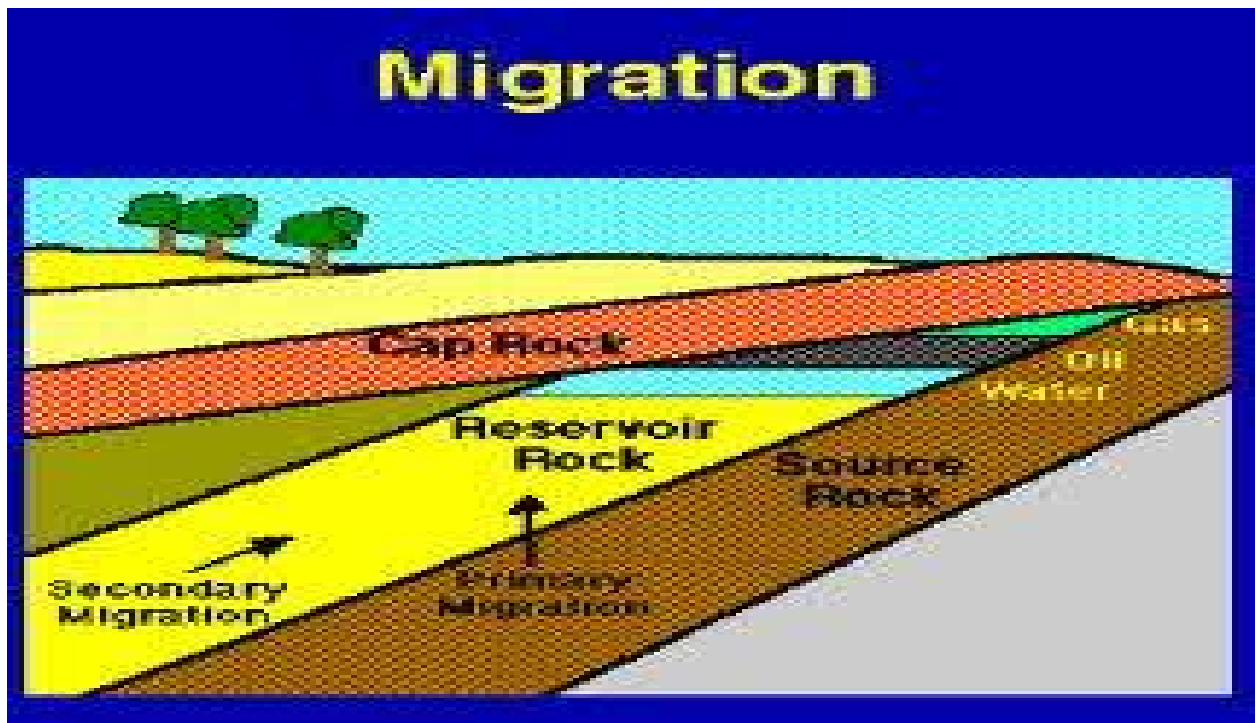
Figure 2.0: Diagram showing the Stages of Diagenesis, Catagenesis and Metagenesis

## PETROLEUM MIGRATION

**Primary migration** is the movement of hydrocarbons out of the source rock into the reservoir rock.

**Secondary migration** is the movement of hydrocarbons through the reservoir rock into a trap.

The movement of gases and fluids out of the trap into the surrounding rocks is called 'leakage'.



**Figure 2.1: Diagram showing primary and secondary migration**

## **KEY STAKEHOLDERS IN THE GLOBAL OIL AND GAS BUSINESS**

In the Global Business of Oil and Gas, the following are the key participants:

- National Governments
- National Oil Companies
- International Oil Companies
- Organization of Petroleum Exporting Countries(OPEC) - [www.opec.org](http://www.opec.org)
- Others e.g. HSE, Environmentalists, Chiefs, Residents etc

### **NATIONAL OIL COMPANIES**

- National Oil Companies(NOC's) currently form the top 10 Biggest Oil Companies
- They want control over their reserves
- NOC's want share in economic rent-tax the industry heavily
- NOC's want Technology transfer from foreign skilled persons to their citizens
- Have political objectives

- They have economic Objectives
- Take Health, Safety and Environmental concerns seriously
- **Ghana National Petroleum Corporation is an example of a state owned National Oil Company(NOC)**

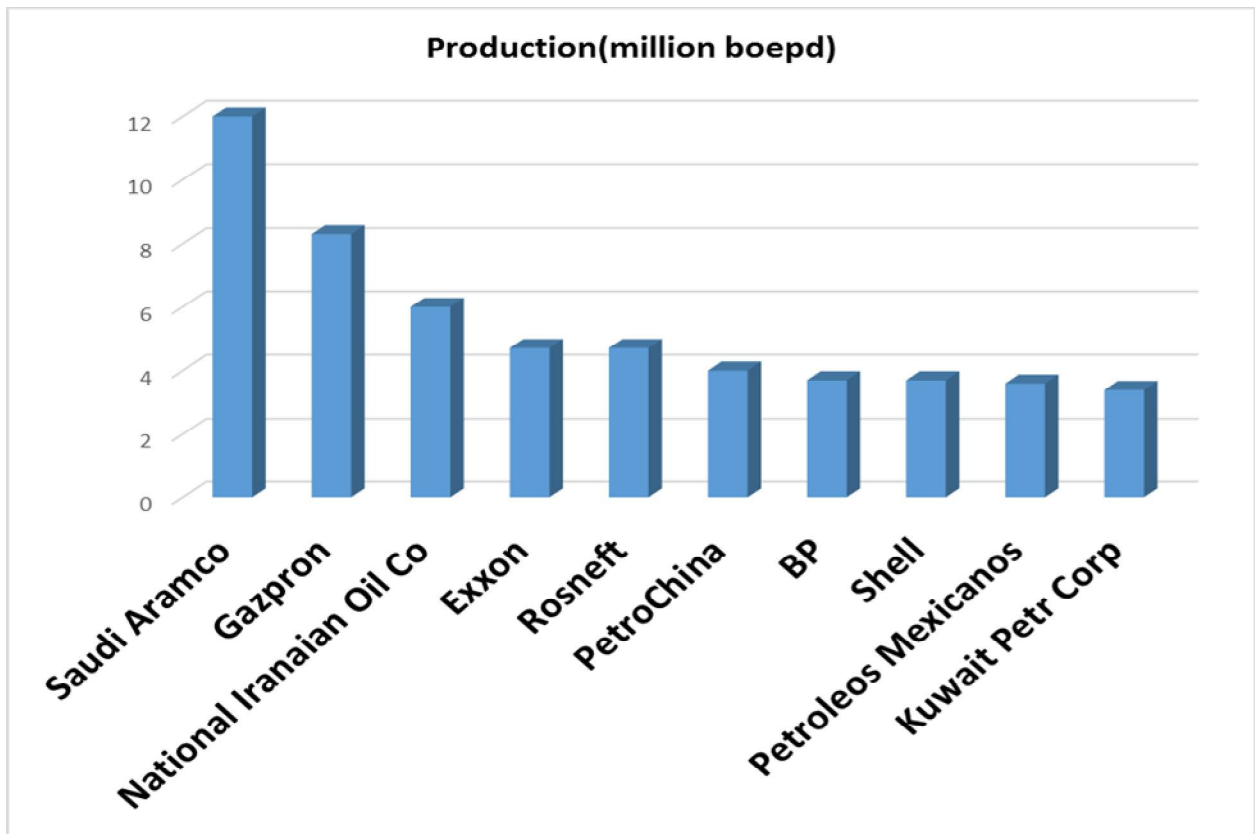


Figure 2.2: Bar Chart Showing Millions of Oil Equivalent Produced per day produced by NOC's

### INTERNATIONAL OIL COMPANIES (IOCS)

- IOCs include the Super Majors often known as Fully integrated oil and gas companies, e.g. Total, BP, Shell, etc, (previously known as the 7 sisters)
- Independent Oil companies, small to medium size-non integrated.  
They could be;
  - Investors - mostly oil companies and financial institutions such as Blackstone and JP Morgan,
  - Operators - usually small oil companies, e.g. Tullow Oil.
  - Service providers-service companies, contractors, vendors, big service companies such as Rigworld, Technip, Baker Hughes, Halliburton, Schlumberger in Indonesia.

## **INVESTORS**

- They are private equity firms in partnership with oil companies, e.g. Kosmos energy (Warburg Pincus and Blackstone Capital Partners)

### Objectives:

- Investors want to make profit
- Want control and minimal interference on sources of finance, market freedom, Stability in foreign exchange market.

## **OPERATORS:**

- Operators manage oil and gas fields on behalf of Partnership or Consortium. Example is Tullow Oil as Operator in the Jubilee Field.

### Objectives:

- Operator usually leads a partnership
- main aim is to share risk
- commonly 5-10 partners
- now more typically 2-5 partners

## **OIL SERVICE COMPANIES**

Service Companies are highly specialised and are low risk takers who provide various services to oil and gas companies.

### Objectives:

- They Supply
  - equipment
  - specialist labour
  - specialist skills
- They usually work under the direction of the Operator.

## **VENDORS**

- **Vendors are highly Specialised Manufacturers**
- **Vendors are low risk takers**
- **Vendors Supply;**

- specialist engineering
- specialist equipment manufacture
- specialist maintenance skills

- **Work under the direction of the Operator**

## THE OIL BUSINESS - WHO'S WHO?

### -REGULATORS

- Regulators control the industry on behalf of the Government
- Regulators undertake Licence and Regulatory functions
- They include the following:
  - ☐ Ministry of Energy(In charge of drawing policy and providing direction for the oil and gas/energy sector)
  - ☐ Petroleum Commission of Ghana: In charge of co-ordinating upstream petroleum activities and ensuring regulatory compliance in Ghana.
  - ☐ National Petroleum Authority: A regulatory institution in charge of regulating the petroleum activities in the downstream sector in Ghana
  - ☐ Energy Commission
  - ☐ Ghana Maritime Authority
- Health Safety and Environmental function
  - ☐ Environmental Protection Agency (EPA)

## SUPPLY CHAIN OF THE PETROLEUM INDUSTRY

### Introduction to the Oil and Gas Industry in Ghana

Students in Senior High Students need to know the nature of the oil and gas industry. This aspect aims at introducing students to the **Downstream, Mid-stream and Upstream sectors** of the Oil and Gas industry. Students will learn about the key stakeholders or major participants in the various sectors of the industry.

- ▶ Upstream sector - mainly involves Exploration and Production (E&P) activities
- ▶ Midstream sector – involves crude oil transport and trading. E.g. Chase Petroleum, GNPC, etc.

- ▶ Downstream sector – involves refining crude oil and sale of refined oil products, e.g. gasoline, diesel, etc.

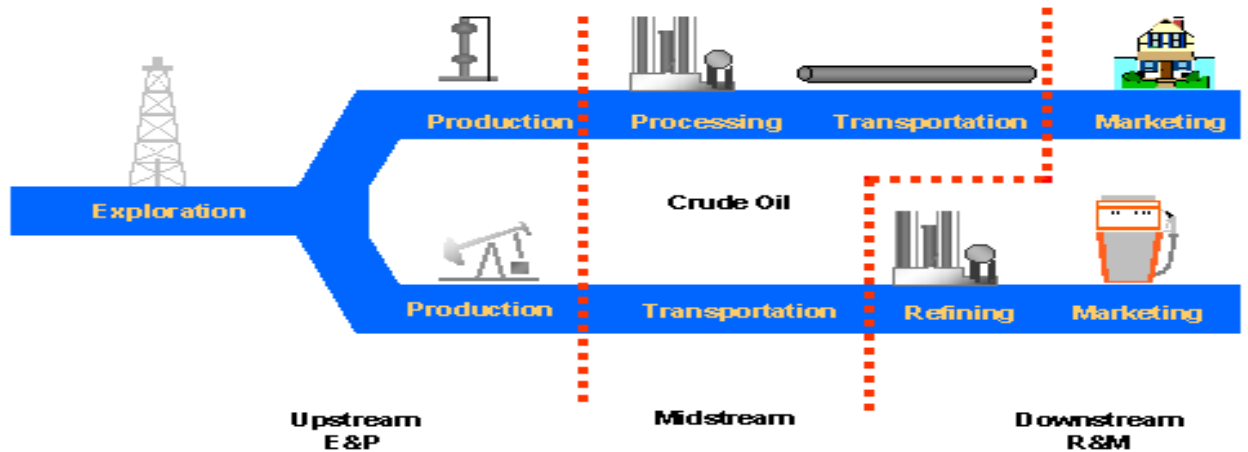


Figure 2.3: Diagram showing the Oil and Gas Value Chain

The petroleum industry is vast. Therefore, oil companies usually specialise to serve a segment of the market.

- ▶ Fully Integrated Oil & Gas Companies serve up and downstream segments of the market. E.g. Shell, ExxonMobil, Total, & BP.
- ▶ Independents Oil Companies are mostly involved in E&P activities. E.g. Tullow Oil, Anadarko Petroleum, Apache, Sterling Energy, ENI, etc

## THE UPSTREAM PETROLEUM SECTOR

- Opportunities:

1. Employment creation.
2. Strategic partnerships and supply services opportunities e.g. catering services.
3. Foreign direct and indirect investment in the country.
4. Stable and constant source of energy supply for economic development.
5. Potential capacity development for other sectors e.g. transport, education and petrochemicals.
6. Strategic role of government agencies such as GNPC. For example, the GNPC Foundation provides educational scholarships to Ghanaian students to study various programmes within Ghana and abroad.

## **DRIVER OF ACTIVITY IN THE UPSTREAM INDUSTRY – Oil Price**

- ❑ The price of Petroleum as quoted in news generally refers to the spot price of basically light crude as traded on the New York Mercantile Exchange (NYMEX).

It could also refer to Brent as traded on the Intercontinental Exchange for delivery

- ❑ The price of a barrel of oil is highly dependent on its grade, determined by factors such as its specific gravity and its sulphur content, and its location.
- ❑ The demand for oil is highly dependent on global macroeconomic conditions. According to the International Energy Agency (IEA), high oil prices generally have a large negative impact on the global economic growth.
- ❑ The Organization of Petroleum Exporting countries (OPEC) was formed to control the price of oil, and essentially worked as a Cartel, its members produce about 45% of world output.

### **DOWNSTREAM**

### **PETROLEUM**

### **SECTOR**

#### **ACTIVITIES OF OIL MARKETING COMPANIES (OMCS)**

The downstream sector in Ghana covers the refining and distribution of crude oil and retail outlets activities.

Some downstream companies operating in Ghana are:

GOIL, Puma, Total, Shell, Oando, Glory Oil, Frimps Oil, Petrosol, etc

In the downstream sector, products distributed and sold include:

- ❑ Liquefied Petroleum Gas (LPG) - for both domestic and industrial use
- ❑ Petrol - for motor vehicles
- ❑ Jet fuel - for the aviation industry
- ❑ Diesel Oil - for heavy duty trucks, vehicles and industry
- ❑ Fuel Oils - for heating purposes in industry
- ❑ Asphalt (Bitumen) - for road construction and other insulation applications
- ❑ Lubricants - (for lubrication and hydraulics)

## LEGISLATIVE ENVIRONMENT (THE LAWS GOVERNING THE OIL AND GAS INDUSTRY)

Ghana National Constitution confers the rights of all petroleum resources found within its jurisdiction to the state.

- Ghana National Petroleum Corporation Act, 1983 (PNDCL. 64)
- The Petroleum (Exploration and Production) Act, 1984 (PNDCL. 84)
- Petroleum Revenue Management Act, 2010

Also, there are international conventions confirming the above right of the state including;

❑ **PSONR** is a UN convention (1962) UNGA Res.1803

- The state asserts and confirms that all petroleum found within its territory, both onshore and offshore is the exclusive property of the State

## LOCAL CONTENT LAW

**Cited in the Petroleum E&P Bill: Section 33(1– 4)**

- ▶ **Increased indigenous participation in the oil and gas industry**
- ▶ **Government declares that certain jobs and services within the industry should be given to nationals**
- ▶ **Instils confidence in the locals population that they have a fair share of their resource**

## PETROLEUM EXPLORATION

Exploration is the search by petroleum geologists and geophysicists for deposits of hydrocarbons, particularly, crude oil and natural gas.

### WELL DRILLING

- Drilling a well into a reservoir is the only way to prove the presence of oil & gas
- A well is created by drilling a hole in the Earth with an oil rig or drill ship which rotates a drill string and drill bit
- After the hole is drilled, a steel pipe – the casing - slightly smaller than the bit size, is lowered into the hole, and secured with cement
- Perforation with explosives through the casing of the well is done to make flow channels to the reservoir
- After perforation, the well is ready to flow oil and gas, if the reservoir has sufficient permeability and pressure, to test the flow rates

- Electronic tools are run in the hole to measure the properties of the rocks
- Samples can be taken by coring



**Image of an Offshore Drilling Ship and historical cost of hiring per day**

#### **OPPORTUNITIES - SUPPLY & DEMAND GAP**

- The industry is young but growing very fast
- Expected to create over 5000 direct jobs in the first 5 years (Ministry of Energy 2010)
- Excitement lies in the indirect job market – Support Services
- The need for strategic skills development
- The industry is new to many people; so opportunities abound in all the sectors
- Ghana has the potential to train manpower to serve the entire West African sub region

## **CURRENT ENVIRONMENTAL CONCERNS FACING THE OIL & GAS INDUSTRY**

- Greenhouse emissions mostly from the burning of fossil fuels. E.g. Pollution in China.
- Rise in global temperatures (Global warming).
- Initiatives to manage Greenhouse emissions; i.e. Kyoto Protocol, carbon credit scheme which has enabled carbon trading.
- Strong public and governmental scrutiny of Oil & Gas companies' operations worldwide. E.g. Anti-flaring law in Ghana.

