Oil production in Libya using an ISO 14001 environmental management system

To the Faculty of Geosciences, Geo-Engineering and Mining (3)

Of the Technische Universität Bergakaemie Freiberg is submitted this

THESIS

To attain the academic degree of

Doktor ingenieur (Dr.-ing.)

submitted

by BSc. petroleum engineer MSc. petroleum engineer Biltayib. M. Biltayib

born on 17 February in 1974, Sirte, Libya

Freiberg, 06. 01. 2006. Date of submission

Dedication

To my father and mother who supported me and lighted up my life since my birth to this date.

To my brothers and sisters for their effort, moral support and endless encouragement.

Biltayib. M. Biltayib

Acknowledgements

First of all I wish to express my sincere thanks and gratitude to my supervisor Prof. Dr. Jan C. Bongaerts for their friendly assistance, guidance, discussion and criticism that made study interesting and successful.

I am grateful to the staff of IMRE, TU Bergakademic Freiberg, Dipl.-Ing. Stefan Dirlich, Kristin Müller, who gave useful contributions at various times during the development of this thesis.

I appreciate the support of the staff of AGOCO , Dipl.-Ing. Soliman Daihoum, Mr. Hassan Omar, Dipl.-Ing Ibrahim Masud during the data collection.

Finally thanks to my special friends, Dr. Mohamed Abdel Elgalel, khalid kheiralla, Khaled raed, Dr. Aman Eiad , Dr. Saad Hamed, Mahmud Guader, Samuel Famiyeh, Abdallminam, Salem kadur, Abdalgader Kadau , Mohammed Mady, Abu yousf and his familly, Nizar and his son Rany, Mohammed Adous, Mohammed Almallah, Mustafah Wardah, Ali almagrabia, Samer, Ali almear, Ahamed Alkatieb, Mohammed Almasrea, salahedeen keshlaf , Radwan Ali Sead, Sadek Kamoka , Mohamed Arhuom, Dr. Abdalla Siddig, Mahmud Aref , Mohamed Nasim for their encouragement, advise and support during my stay in Germany.

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List of Abbreviations

(ACGIH): American Conference of Governmental Industrial Hygienists

(AEO): Assumption Energy Outlook

(AFEAS): Alternative Fluorocarbons Environmental Acceptability Study

(AGOCO): Arabian Gulf Oil Company

(APPEA): Australian Petroleum Production and Exploration Association

(API): American Petroleum Institute

(BP): British Petroleum Company

(CFT): A Cross Functional Team

(CFC): Chlorofluorocarbons

(CIS): Commonwealth of Independent States

(DWD): Deep Well Disposal

(EMS): Environment Management System

(EIA): The Energy Information Administration

(ECT): The Energy Charter Treaty

(EMR): Environmental Management Representative

(EMT): Environmental Management Team

(EPA): Environmental Protection Agency

(E&P Forum): An association of about 50 oil companies and petroleum industry organisations.

(ESP): Electrical Submersible Pumps

(FSU): Former Soviet Union,

(GDP): Gross Domestic Product

(IEA): The International Energy Agency

(IFP) : Institut français du pétrole

(IGO): Intergovernmental Organizations

(ISO): The International Organization for Standardization

(IUCN): The World Conservation Union

(LNG): Liquefied Natural Gas

(LOS): The Law of the Sea

(LPG): Liquefied Petroleum Gas

(LDC): London Dumping Convention

(MEA): Multilateral Environmental Agreements

(MARPOL): The International Convention for the Prevention of Pollution from Ships

(Non-OPEC): Countries are not members of the (OPEC)

(NGO): Non-Governmental Organizations

(NORM): Naturally Occurring Radioactive Materials

(NOC): National Oil Corporation

(OPEC): Organisation of Petroleum Exporting Countries

(ODS): Ozone Depleting Substances

(OSPAR): The Oslo and Paris Commissions

(PDCA) : Cycle for “Plan, Do, Check, Act”

(SOC): Srite Oil Company

(SMEC): Senior Management Environmental Committee

(TLV): Threshold Limit Values

(UAE): United Arab Emirate

(UNEP): United Nations Environment Programme

(UKOOA): The United Kingdom Offshore Operators’ Association’s

(UNCLOS): The United Nations Convention on Law of the Sea

(UNFCCC): The United Nations Framework Convention on Climate Change

(VOC): Volatile Organic Compounds

(WOC): Waha Oil Company

(WTO): World Trade Organization

(WLGP): The Western Libyan Gas Project

(ZOC): Zueitina Oil Company

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Abstract

Environmental management has become a part of societal life and a dominant issue for every sector of economies in the developed world. However, due to the absence of EMS the Libyan petroleum companies are not able to compete in the international petroleum sector. The rules and regulations specified by developed countries concerning environmental protection are becoming highly challenging. These have posed tremendous difficulties for both the government of Libya, as well as the petroleum companies to meet the national and international legislative requirements.

Since 1999, Libya has been transformed by aligning itself according to the requirements and expectations of the industrial nations of the world and has, therefore, in this process of transformation, already become one of the competitive nations in the petroleum sector. The country has started to attract international investment by companies and individuals from all over the world. The change of Libyan economic policy towards open markets and the signing of many international agreements incorporating legal concerns related to biodiversity, climate change, endangered species, hazardous wastes, marine dumping, and ozone layer protection in their system. This has subsequently enabled the Libyan petroleum industry to make efforts to set up some basic procedures to improve environmental performance. This is an enormous interdisciplinary work, which requires a lot of effort.

The present work aims to introduce an internationally accepted environmental management system according to the ISO 14001 standard to enable the oil industry remove the prevalent deficiencies as far as environmental management is concerned in the industry. This work uses AGOCO as a model company for case study analyses, which would provide an excellent opportunity for the implementation of EMS in accordance with ISO 14001 in all petroleum companies of Libya. The detailed analysis is based on the cumulative assessment of the current environmental management manual of AGOCO, interviews with some of the company's personnel and telephone communications with some employees of the company. The analysis reveals the strengths and weaknesses in the concerning EMS planning, implementation, checking and review. Using AGOCO as a benchmark for all other petroleum companies, the work has resulted in the formulation of procedures to be followed by the other companies in compliance with the international standards.

Introduction

Petroleum has become a vital commodity as a source of energy as well as a raw material in manufacturing. Petroleum resources are often located in convenient places for the oil to be extracted, processed and sent to be used by the community or to the market. The production activities that follow a successful exploration programme involve some risks and potential impacts on the environment. Clearly identifying these risks and impacts and developing detailed management plans to avoid, prevent or minimise them is a vital and integral part of planning these exploration and production activities.

A common tool that is now available for organisations to avoid or minimise these risks and potential environmental impacts is an Environment Management System (EMS). An EMS is defined as a comprehensive system for managing all environmental aspects of the operation and integrating environmental matters into the operation's overall management system. As far as the Libyan oil industry is concerned, environmental management systems have not been in consideration. However, in Libya numerous cases of oil or produced water spillages occur each year in the oil industry and some of them reach significant watercourses.

Hence, the oil industry must make a sincere effort to prevent those environmental problems.

The objectives of this research work were:

- To enable the Libyan oil industry to become competitive in the global market, since the ISO 14001 EMS is an internationally accepted Environmental Management Standard, which may become a de-facto in the global market place;
- Assist the oil industry to achieve a sustainable use of natural resources by protecting all areas concerned with oil exploration and the community in which they operate whilst enhancing quality and improved financial performance.
- To define a sequential approach towards the implementation of an EMS as a benchmark for the existing, new and potential oil industry in Libya.

The research work uses the Arabian Gulf Oil Company (AGOCO) as a model company for the integration of ISO 14001 EMS in the Libyan oil industry. The company was chosen due to its current level of environmental commitments, its market share in the Libyan oil industry (40 percent market share), and its area of operation (8 locations).

The practical importance of this research work is to be used as a benchmark for the oil industry in Libya, since other companies in the industry can use the outcomes. Hence, other oil ccompanies in the region can use them as a "study guide" towards the certification of ISO

14001 EMS. This will contribute to the reduction of potential environmental impacts.This research work addresses four major areas:

- The first area gives an overview of the global and Middle Eastern oil and gas production, consumption, and reserve patterns, markets, exploration, and production operations and general environmental impacts associated with the exploration and production of oil. All this information has been covered in the first three chapters of this thesis. Environmental agreements and guidelines to control environmental impact in the petroleum industry have described in chapter four. The petroleum industry and environmental laws in Libya is given in chapter five.
- The second area uses AGOCO as a model company for the integration of ISO 14001 in the oil sector and has been discussed in chapter six. It contains an overview of this company, i.e. exploration, production and development techniques, and concludes with potential environment impact by AGOCO operations.
- The third area of this work consists of formulation of the recommendations which could assist AGOCO regarding the development of guidelines for the implementation of the ISO14001 EMS. This has been given in chapter seven which starts with an initial environmental review to understand the company's current level of environmental commitment. The analysis of the results obtained in this initial review will eventually result in the implementation guide towards the company's ISO 14001 EMS certification and has been given in chapter eight .
- The final area of this work contains the conclusions, the future of EMS in AGOCO, the oil industry in Libya and the entire national economy.

CHAPTER ONE
PETROLEUM FORMATION, HISTORY AND MARKET

Crude oil is a natural product resulting from changes that occurred in organic matter deposited in layers in the sediments of seas and lakes some 150 to 300 million years ago. The production of a large deposit of fossil fuel requires a large initial accumulation of organic matter, which is rich in carbon and hydrogen [1]. Crude oil and natural gas are hydrocarbons made up of carbon, hydrogen, and oxygen. Natural gas is mostly methane (CH_4). Methane usually makes up more than 80 percent of the energy gases present at a location. Other natural gases include ethane, propane, butane, and hydrogen [56].

The first big discovery of oil took place in the USA near oil Creek, Pennsylvania, in 1859. The success of this drilled well marked the beginning of the modern petroleum industry, which was given further impetus by the invention of the motorcar [99]. In the first decades of its existence, from the middle of the 19^{th} century to the early 20^{th} century, the oil industry developed mainly in the United States and Russia. Lighting with oil lamps was the first main market for this emerging industry. The demand for this new source of light increased quickly, pushed also by the use of oil as a new source of energy and so exploration rapidly extended to South America (Mexico and Venezuela) and to the Middle East where huge fields were discovered [2].

Global reserves of oil and gas are being used up far faster than significant new supplies can be found. The most conservative estimate of the supply of an energy source is the amount of known reserves, “proven” accumulations that can be produced economically with existing technology [3]. Oil and gas are predicated to remain dominant commodities in the world ‘s energy supply for at least the next 25 years [82].

In 1973, during the first oil crisis, oil and natural gas represented 69 percent of the world’s primary energy demands [4], [5]. In decades to come, oil and natural gas are likely to continue to play major role. According to the prospects identified at the World Energy Conference in 1999, world energy demand, rising steadily since 1960, and driven by demographic growth and accelerated industrialization, could range from 11.5 to 13.6 billion tons (Gt) oil equivalent (toe) in 2020, compared with 8.5 in 1998 and 5.6 in 1973 [6].

Figure 1 shows world demand for oil, gas and coal, nuclear, hydropower and other renewable energies in three periods 1973, 1998 and 2020. Hydrocarbons, at the rate of 27 percent for oil and 24 percent for natural gas, will still acount for 51 percent of world primary energy supply in 2020, while coal, nuclear, hydropower and other renewable energies will

acount 49 percent of world supply in 2020. This might be due to increased investment in renewable energies in many countries such as USA, Japan , France.

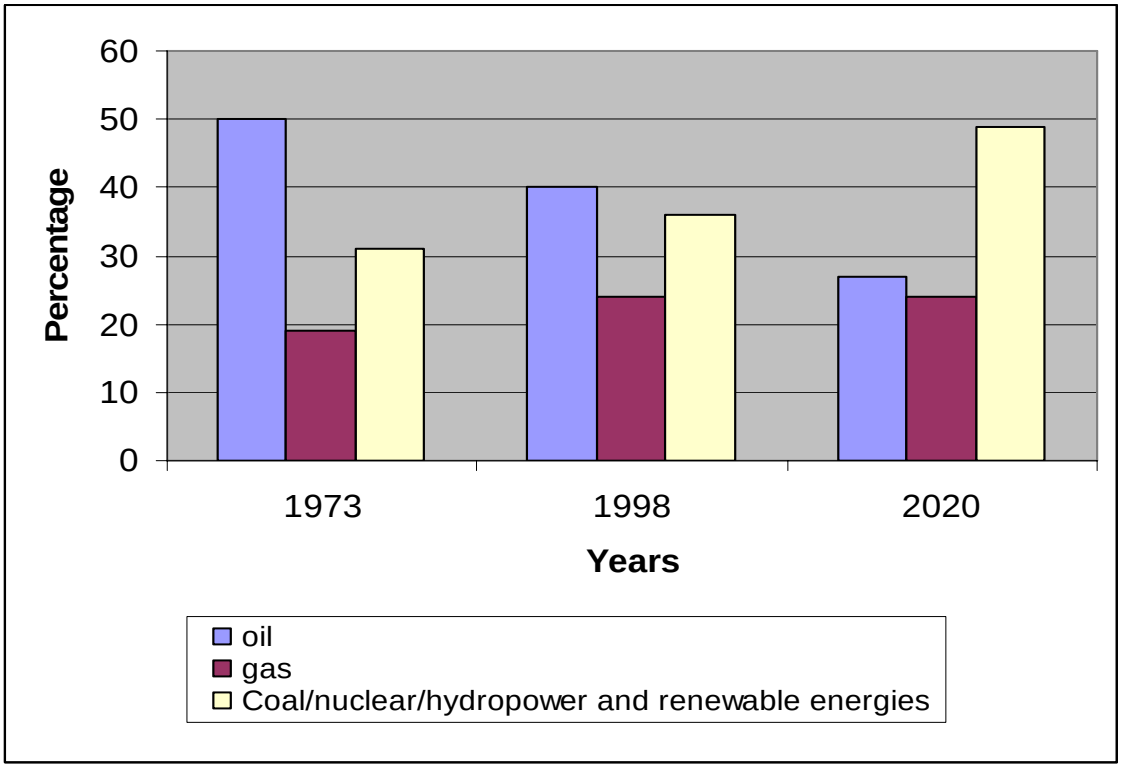

Figure (1) World demand for primary energy

Source: [5]

Oil supply and demand are very unevenly distributed around the world. Some low-population, low-technology, oil rich countries (Libya, for example) may be producing fifty or a hundred times as much oil as they themselves consume. At the other extreme are countries like Japan, highly industrialized and with no petroleum reserves at all. The United States alone consumes over 11 percent of the oil used worldwide[7].

Increasing world economic growth will lead to an increased demand for oil and natural gas and, hence, It is expected that investment in exploration and production activities will rise in producer countries. The level of exploration and production activities in any country is influenced generally by the expected oil prices which reflect this country's competitive position with respect to others[11].

The price of oil is difficult to predict because there are a number of factors that can influence oil price movements. The 1950s and 1960s were periods of relative stability in terms of the oil price since the 1970s the price of oil has been subject to three major shifts: it rose dramatically in 1973/75 and again in 1979/81 and it fell steeply in 1986. Another sharp decline in oil prices put the industry and producing nations in danger at the end of 1997 until

summer 1999 when the price recovered. This event was caused by the financial disturbance emanating from the collapse of previously rapidly growing Asian economies[8], [9].

An unprecedented OPEC cohesion brought prices back up to the $25 – $30 level through 2000 and 2001, only to be disrupted again by the terrorist attacks in the US in September of 2001. After this event, the oil price recovered and stabilized until April 2002 when the Venezuelan crisis started. With the war in Iraq oil prices soared to $35 in february 2003 [10]. During 2004 the price for oil increased to $50 because of increasing violence in Iraq and political problems in Nigeria that lead to reduced production [23].

The dominance of the oil price cycle, and the convergence of price cycles and political and economic events, are clear from the past. Any basic industry always operates with the reality that the past can be a witness when it comes to market volatility. Supply and demand balances are subject to minute disturbances that can translate into wide disruptions in price.

Technological advances have been made throughout the exploration and service industry, facilitating discoveries in harsh frontier environments. The role of technology is multifaceted. Technological advances have been critical as the industry seeks to become more efficient in the face of sharp commodity price cycles [43].

Natural gas, previously viewed to be an unwanted by-product of oil production, became an exploration target in the search for cleaner fuels [75]. The rise of natural gas coincided with heightened attention to global environmental issues and the emergence of global climate change from anthropogenic greenhouse gases as a perceived threat. Natural gas is prone to its own volatile price cycles best exemplified in the large, mature US gas market. It is also becoming more evident in Western Europe and it is key to the South American market, such as Argentina. The natural gas industry is subject to complex policy and regulatory arrangements affecting the infrastructure. Long distance pipelines and local distribution systems are essential for the bulk of delivered gas supplies [12].

Lessons on oil price cycles learned from the past show that price for oil has a major effect on the exploration industry:

- The oil price volatility is a function of rapid market adjustments and the shift in the growth of demand to emerging market nations, subject to economic and financial cycles.
- The oil price volatility will remain a fact of life for oil, because of unforeseen political and economic circumstances, which change the oil and gas industry’s conditions e.g. technology, reserves estimates.

- Higher real prices deter consumption, but eventually encourage the emergence of significant competition coming in the shape of new sources of oil.
- In contrast, a low price causes marginal oil production to be taken off line and discourages new exploration [11].

1.1 Summary

The discovery of oil mark as far as into the 19th century in Pennsylvania and oil occurrence of depend on the quantity of organic matter, environment of deposition and the time frame. The discovery of large deposits always requires a large initial accumulation of organic matter rich in carbon and hydrogen.

It can be seen that oil and gas have been the largest sources of energy for the past two decades and still continue to be the main sources of energy in the future. However, the trend may be change in the later part of the century and beyond. This might be due to the persistent rise in the price of oil, consumers seeking ‘clean’ sources of energy, depletion of oil resources, cheaper sources of alternative energy and the political instability in the producing countries.

The next chapter reviews world oil and gas production, consumption, reserves and the economics of petroleum.

CHAPTER TWO
WORLD OIL AND GAS PRODUCTION

Since the first oil field was discovered and drilled by Colonel Drake in 1859 in Pennsylvania, oil production has grown rapidly in parallel with the world population over the past two hundred years [2].

In 1860, world oil production reached 500,000 barrels per year. By the 1870s production reached 20 million barrels annually. In 1879, the first oil well was drilled in California; and in 1887, in Texas. As production boomed, prices fell and the profits of the oil industry declined. During the early twentieth century, oil production continued to climb. By 1920, it reached 450 million barrels per year - prompting fears that the USA was about to run out of oil. Government officials predicted that the nation's oil reserves would last just ten years. Up until the 1910, the United States produced between 60 and 70 percent of the world's oil supply. Oil was discovered in Mexico at the beginning of the twentieth century, and in Iran in 1908, in Venezuela during World War I, and in Iraq in 1927. Many of the new oil discoveries occurred in areas dominated by Britain and the Netherlands: in the Dutch East Indies, Iran, and British mandates in the Middle East. By 1919, Britain controlled 50 percent of the world's proven oil reserves [13].

During world war II, the oil surpluses of the 1930s quickly disappeared. Six billion of the seven billion barrels of petroleum used by the allies during the war came from the United States. As early as the 1930s, Britain had gained control over Iran's oil fields and the United States discovered oil reserves in Kuwait and Saudi Arabia. After the war, Middle Eastern oil production surged upward. Gradually, the dependence of the United States on Middle Eastern oil increased [14].

At the beginning of the 20th century, oil supplied only 4 percent of the world’s energy, decades later it became the most important energy source. At present, oil supplies approximately 40 percent of the world’s energy and most of it is for transportation. In 1970, for example, 284 billion liters of oil were produced, but in 1997 this number increased to 434 billion liters[9].

World oil demand is expected to grow 50 percent by 2025[d]. To meet that demand, ever-larger volumes of oil will have to be produced. Since oil production from individual reservoirs grows to peak and then declines, new reservoirs must be continually discovered and

[d] U.S. Department of Energy, Energy Information Administration, International Energy OutLook2004, April 2004

brought into production to compensate for the depletion of older reservoirs. If large quantities of oil are not discovered, then oil production will no longer satisfy demand. This point is called the peaking of world oil production [16]. Therefore, oil production cannot keep up with an increasing consumption since the reserves are in fixed quantity.

This chapter will be focused on the production, consumption, economics and the political economy of global oil and gas reserves. The chapter will also deal with the above (production, consumption, and reserves) with more emphasis in the Middle East region.

2.1 World oil production

Production of oil occurs in many regions worldwide. Among these regions, the Middle East remains the highest producer. Figure 2 shows the percentages of crude oil production in different regions: The largest producers in 2003 are the Middle East and North America with 30 percent and 20 percent respectively. The remaining 50 percent is dispersed fairly throughout the globe.

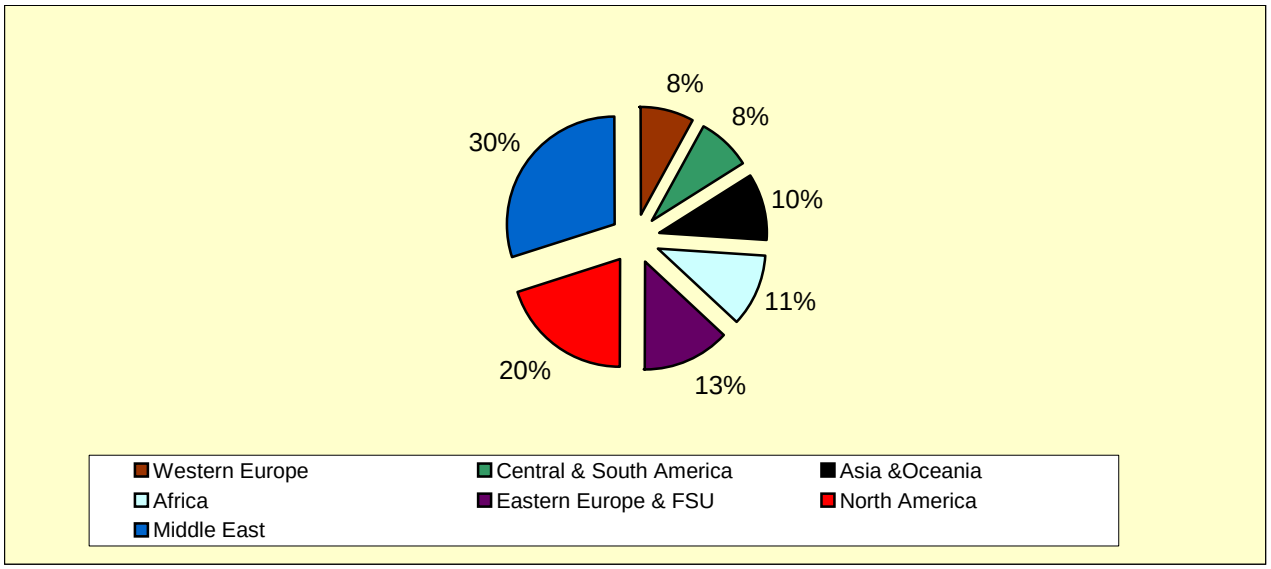

Figure (2) Percentage of the world's crude oil production in major areas in 2003

Source: EIA 2003

2.1.1 Peak oil production

The world's endowment of oil is finite and hence non-renewable. Therefore production must reach a peak and then decline. Peak oil production describes the point where half the world's original endowment of oil would be depleted. This includes cumulative production, known reserves and reserves projects to be discovered [37].

The oil fields discovery rate has been declining for 40 years despite extensive exploration with advanced technology. In 2002, the world used three times more oil than was discovered [44]. Hence, the world will inevitably become dependent on Middle East oil because supplies from many other oil producing countries are declining faster. Peak production has already occurred in many oil-producing countries (see Figure 3). All oil-producing countries are producing at near the maximum rate, except for a few countries in the Middle East.

Figure 3 shows the years remaining until some selected oil producing countries will reach their respective peaks. All oil producing countries will soon reach their peaks except for a few in the Middle East. The countries with negative values have been already reached their peak production and countries like Mexico, Iran, and Norway have also already reached their peak production. There are only four countries with higher promising peaks i.e. Kuwait, Saudi-Arabia, Iraq and UAE. World oil production will slow down and unless demand declines dramatically, the price will continuously rise and supply disruptions will occur.

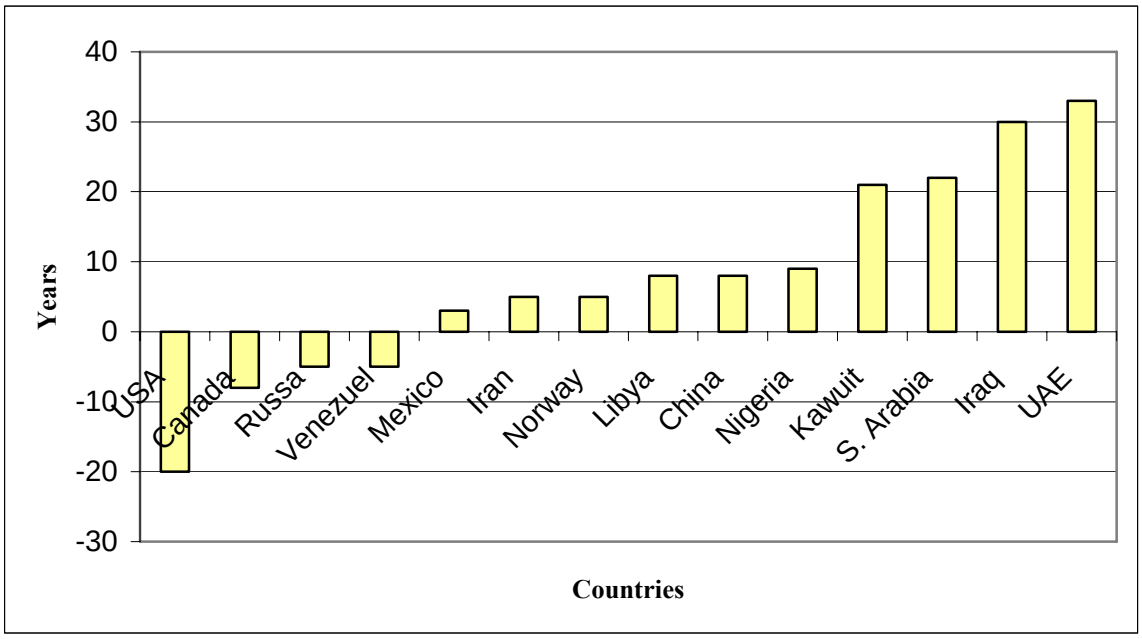

Figure (3) Years remaining for selected countries' peak oil production in 1999

Source: [106]

2.2 World oil consumption

Over the next two decades, oil is projected to remain the dominant fuel in the world energy mix, accounting for 40 percent of the total energy consumption worldwide. A significant key to the outlook for the future worldwide petroleum demand is the pace of economic growth in the developing and industrializing countries. At the present time, there

are signs that point to a long-range growth period for the worldwide economy and for the world oil market. There are expectations of significant future economic growth in major consuming areas. The economies of the newly emerging developing countries, such as China, are expected to expand at a significant pace this economic growth should translate into an increased demand for energy and petroleum products. The newly emerging developing countries are using energy more intensively, and a large share of economic growth is being fueled by oil [106].

Among the developing countries, the two countries with the highest rate of growth in oil use are China and India, whose combined populations account for a third of mankind. They are the biggest oil importing countries. In the next two decades, China's oil consumption is expected to grow at a rate of 7.5 percent per year. For India, the figure stands at 5.5 percent [30]. In the industrialized world, oil use grows more slowly than the world average, but it remains steady at 1.3 percent per year, as the oil markets reach saturation levels in all end use sectors. Oil use in the industrialized world is expected to decline, as natural gas becomes the fuel of choice for new electricity generation capacity [31]. According to an EIA prediction, in 2020, world oil consumption will rise by approximately 60 percent. Transportation will be the fastest growing oil-consuming sector [22].

2.3 World oil reserves

Oil reserves are very and unevenly distributed around the world: Some countries, such as Japan, are highly industrialized and have no petroleum reserves at all, and some others, such as the Middle East countries, have huge petroleum reserves with to low consumption. Proved oil reserves are those quantities of oil that geological information indicates and that can be recovered in the future from known reservoirs with certainty. Table 1 shows world crude oil reserves.

Table (1) World crude oil reserves

Regions	Crude oil (Billion Barrels) January 01.2005	Crude oil (Billion Barrels) World oil Year – End 2003
North America	215.291	41.4450
Central and South America	100.595	75.1600
Western Europe	16.2550	16.3820
Eastern Europe and FSU	79.1900	89.0130
Middle East	729.341	686.345
Africa	100.784	104.644
Asia and Pacific	36.2460	37.7030
World Total	1,277.702	1,050.691

Source: www.eia.doe.gov/emeu/international/reserves.html

Figure 4 shows a graphical representation of the percentage distributions of proven oil reserves worldwide. From this, it can be seen that the Middle East region dominates as far as oil reserves are concerned with the greatest supply of oil. The least region of reserve as can be seen from the Figure is Western Europe. Of the proven trillion barrels of the world oil reserves estimated, it can be seen that 6 percent are in North America, 9 percent in Central and South America, 2 percent are in Western Europe, 4 percent are in Asia and Pacific, 7 percent are in Africa, 6 percent are in the East Europe and Former Soviet Union. At present, 65 percent of global oil reserves are in the hands of Middle Eastern regime [30].

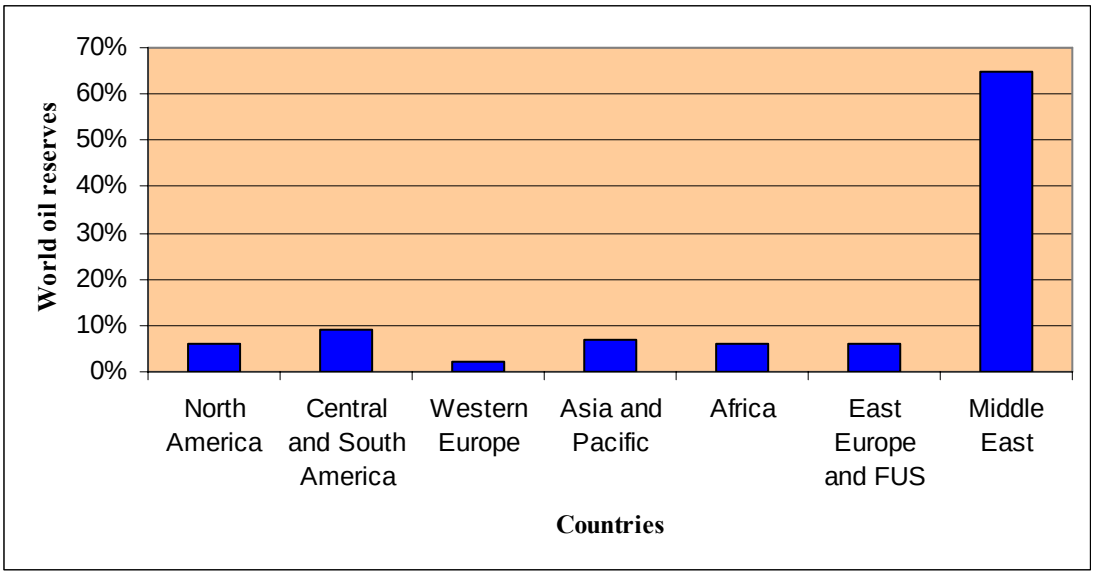

Figure (4) Share of global reserves by 2003

Source: adopted from [30]

2.4 Middle East oil production

2.4.1 History

The start-up of the oil industry in the Middle East dates from 1908 when oil was discovered in Southwest Iran. Iranian oil production rapidly expanded during and after World War I, but fell sharply in the early years of World War II. Recovery began in 1943 with the reopening of supply routes to the United Kingdom. The oil was produced by what became known as the Anglo-Iranian Oil Company. In the post-war period political difficulties arose with the Iranian government. The conflict centred on Iran's dissatisfaction with the financial terms of the concessions and the monopoly position of the company and its close association with the British government. The subsequent breakdown in relations between the government of Iran and Anglo-Iranian Oil led to the nationalisation of the Iranian oil industry in 1951 [18].

Following nationalisation, Iranian oil production steeply declined. A compromise was reached in 1954 when a group of oil companies, including British Petroleum (formerly Anglo-Iranian Oil), received exploitation and marketing rights for Iranian oil, but the National Iranian Oil Company retained sole ownership of all fixed assets of the Iranian oil industry. In 1973, Iran took control of its oil industry and, with joint arrangements with foreign oil companies, continued the expansion of its oil production that began with the 1954 compromise. Continued expansion of Iranian oil production was made possible by a succession of discoveries that included five super-giant fields [19]. During the Iranian revolution and the long war with Iraq, Iran's oil production declined significantly. Currently, Iran attempts to improve its oil production capabilities with assistance from foreign oil companies (other than those from the United States, which are prohibited by the U.S. Government from participating).

During world war II, oil development was only possible at a small scale in the Persian Gulf region although large fields had been located in Iran, Iraq, Kuwait, and Saudi Arabia. By the end of the war, it had become evident that the Gulf would become a major oil exporting region when adequate outlets became available. In the post-war years, a rapid rise in world oil demand was coupled with a rapid production expansion in the Gulf. With the nationalization of Iranian oil in the early 1950s, Kuwait became the Gulf's leading oil producer, holding this position until 1965. Later on, Saudi Arabia rose to prominence as an oil-rich state. Since then, it has achieved pre-eminence as the largest holder of oil in the world [20].

In an atmosphere of competition between the established British companies in Iran, Iraq, and Kuwait, and the incoming American oil companies, Saudi Arabia granted a

concession to the Arabian American Oil Company (Aramco) in 1933. The first discovery was in 1935, but oil accumulations of a commercial size were not located until 1938. Initial production was modest. The discovery that transformed the prospects for the oil industry was that of Ghawar in 1948. Its production began in 1951 and reached a peak of 5.7 million barrels per day in 1981. This is the highest sustained oil production rate achieved by any single oil field in the world history. However, it is the largest oil field in the world, and was originally thought to be several separate smaller fields. In addition to Ghawar, Saudi Arabia was found to contain ten other super-giant fields, including the world's largest offshore field [131].

A national oil company was established in Saudi Arabia in 1956 to conduct the exploitation of petroleum resources outside of the Aramco concession. Since that time, oil production has become increasingly governed by the state. In 1974, the Saudi government purchased a majority participation in Aramco and the company became fully nationalised as Saudi Aramco in 1988 [21].

2.4.2 Middle East oil production

The Middle East contains approximately 65 percent of the world's proven oil reserves, while accounting for just 30 percent of global production of crude oil. This provides the region with enormous reserves, compared with rest of the world and suggests that much of any future increase in global production will have to come from the Middle East. More specifically, it will have to come from Saudi Arabia, Iraq, UAE, Kuwait and Iran [15], [22]. Table 2 shows the reserves, percentages of world reserves, production rate and the highest production a years. The countries are ranked in order of current production (see Table 2).

Table (2) Middle East countries, reserves, and percent of world reserves, 2004-production rate

Countries	**Proven Reserves** Billion barrels (2004)	**Percent of world reserves** (percent)	**Production rate (2004)** Million barrrel per day (mbd)	**Highest production / d** Million barrrel per day (mbd)
Saudi Arabia	261.7	25	8.86	9.64 in (1981)
Iran	100.1	9	3.93	6.03 in (1974)
Iraq	115.0	11	2.30	3.50 in (1980)
UAE	63.00	9	2.34	2.34 in (1998)
Kuwait	98.90	9	2.34	3.28 in (1972)

Source: [23], [131].
Source: world oil, vol. 224, No. 8(Aug. 2003) from energy information administration, international energy Annul 2002(March – June 2004).

The following can be deduced from Table 2:

- Saudi Arabia, holder of the largest world's oil reserves and the largest crude producer, is the swing producer having the capability to change the tone of world markets. The highest oil output was acieved in 1981.
- Iran is OPEC's second largest producer and also holds significant reserves. The highest oil output was achieved in 1974, and it is unlikely that level could be re-reached without the import of quantities of oilfield equipment and foreign expertise.
- Iraq holds huge oil reserves and the highest oil output were achieved in 1980. Post war Iraq needs rebuilding, therefore it will increase oil production, but it is difficult to achieve that same level of 1980. However, Iraq cannot reach the1980 level at this time, as violence still continues and so as a result the oil structure is under attack.
- The United Arab Emirates are the holder of significant reserves and are considered as one of the larger producers in world and the highest out put was in 1998.
- Kuwait holds significant reserves and the highest out put was in 1972.

The world will depend heavily on the five oil producing countries of the Gulf region, Iran, Iraq, Kuwait, Saudi Arabia, and the UAE [23], [131]. However, significant additions to the production capacity throughout the forecast period till 2050 for Middle Eastern countries will be adding to the output. Figure 5 shows oil production in the Middle Eastern countries from 1930 to 2003. Figure 5 also shows that oil production will increase until 2020 and will be declining after that time. During the period from 1930 to 1960, oil production in Middle Eastern countries was not high, because in that time most of middle east countries were in the begining of exploration. During the period from 1960 to 1972, oil production has been increasing due to technological improvement, high demand from the developed world and increased military expenditures. In the 1973, Middle Eastren countries reduced oil production because of the Arab and iserall war. Since 1974, there has been a fluctuation in oil production depending on the market price. Finally, it can be seen that the oil production in Middle Eastern countries by 2020 would likely be at its peak.

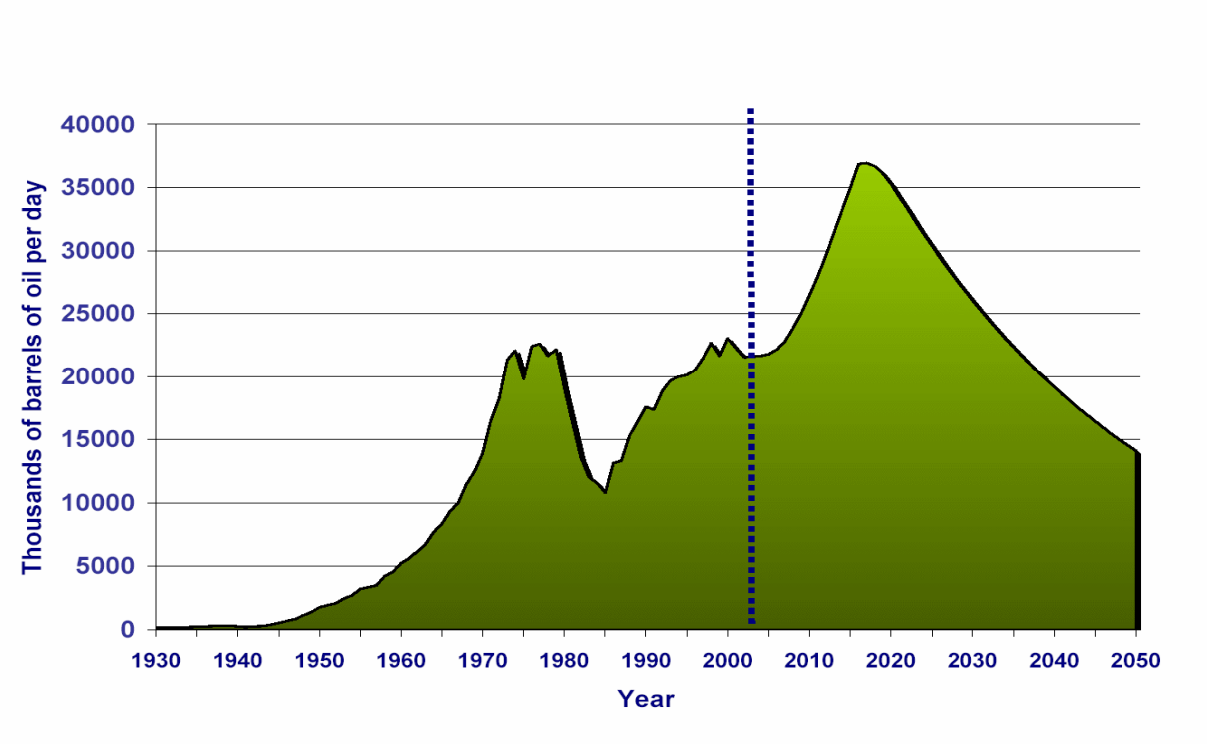

Figure (5) Middle East: oil production forecast from 1930 - 2050

Source: energyfile.com (2003)

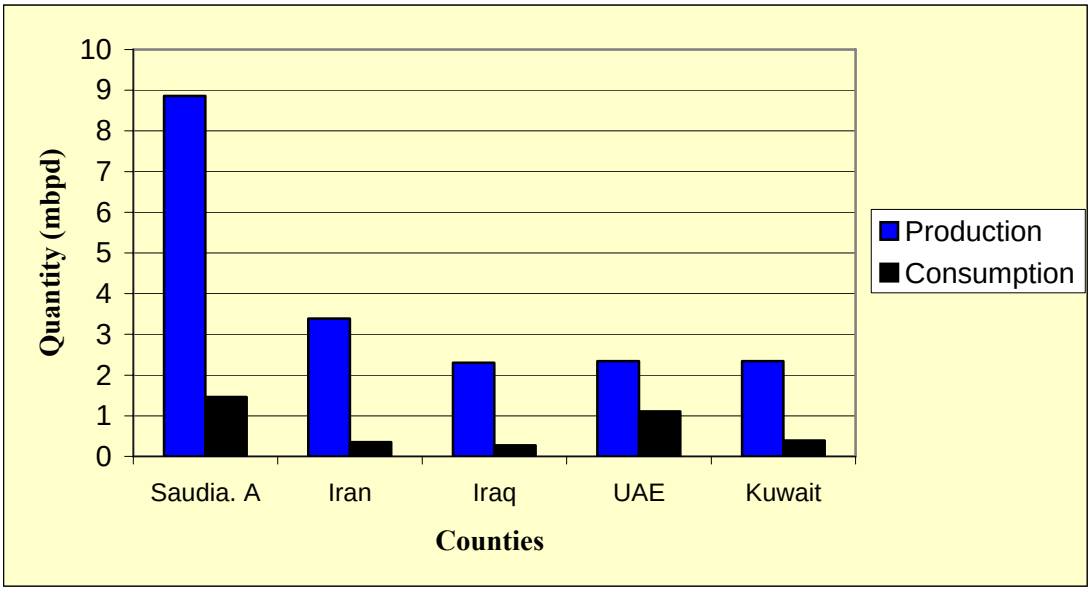

Figure (6) Middle Eastern oil production and consumption in 2004

Source: [131]

From Figure 6, it can be seen that Saudia Arabia is leading in oil production in the Middle East, producing seven times the volume than it consumes and then Iran and other Middle eastern countries. From Figure 6, it can also be seen that Saudia Arabia produces 8.86 (mbpd) and consume 1.465 (mbpd). This means Saudia Arabia has the potential to export or store 7.395 (mbpd). Iran, Iraq, UAE, and Kuwait have the potential to export or store 3.39, 2.3, 2.34, 2.34 (mbpd) respectively. The difference between production and consumption is always positive, hence ther are net exports of oil. The Gulf region and especially Saudi Arabia will be the major supplier of oil, satisfying the rising demand.

The next section will deal with natural gas reserves, production, and consumption.

2.5 Natural gas

2.5.1 Introduction

Natural gas is seen as a desirable alternative for electricity generation in many parts of the world, given its relative efficiency in comparison with other energy sources, as well as the fact that it burns cleanlier than either coal or oil and thus is an attractive alternative for countries pursuing reductions in greenhouse gas emissions. Natural gas is also an important energy resource in the industrial sector [35].

Natural gas has been used for a long time because its production is associated with oil production, but the high cost of transportation has limited its expansion to local and regional markets and it was not competitive with other energy sources on the international markets. Natural gas has also emerged as the world's fastest-growing energy source and it is playing an increasing role in the world energy scene. This has led to the involvement of the major oil companies in gas projects around the world with high amounts of investments [100]. Another important reason pushing the demand for natural gas to oil is the relative cheaper price of gas to oil.

In the industrialized world, natural gas is expected to make a greater contribution to energy consumption among the major fuels. In particular, it is increasingly becoming the fuel of choice for new power generation capacity because of its environmental and economic advantages [32].

In the developing countries, natural gas is expected to increase usages for both power generation and industrial applications. Strong growth in natural gas use in the developing world will average 3.8 percent per year between 2001 and 2025[34].

2.5.2 Natural gas production

As already mentioned, natural gas production has grown fastest of all the fossil fuels, and it will continue to grow rapidly for several decades [36]. While the share of oil in the world's total energy produced declined to 36.7 percent in 2000 from 45 percent in 1970, the share of oil went up to 22.8 percent from 17.2 percent [35]. During the last 20 years, natural gas production in Europe has remained steady, while production in the Middle East, Asia, and Australia has increased steadily. Natural gas production and consumption have increased steadily in most producing areas except for the Former Soviet Union (FSU), where production has declined continuously since 1991, because of economic restructuring [100]. In just in 20 years, global production of natural gas has increased approximately 1.7 times and the US Energy Information Administration predicts its use to double by 2020, because of world wide environmental considerations, and low price [22].

Table 3 presents data about world gas production by regions using the Multicycle Model. The Multicycle Hubbert model[f] developed by Al-Fattah and Startzman in 2000, to forecast future gas production trends for major gas producing countries [36].

Table (3) World gas production by region - Billion cubic feet (bcf)

Region	Peak production Bcf/year	Peak time Year	Cumulative production 2002	Future production recovery	Ultimate gas recovery	Percent of the Produced
Western. Hemisphere	30,985.75	2000	1,247.07	992.660	2,239.73	55.68
Western Europe.	10,293.66	2000	240.590	253.220	493.810	48.72
Eastern Europe & FUS	32,638.06	2029	728.620	2,239.09	2,967.70	24.55
Africa	6,967.290	2015	65.5500	385.600	451.150	14.53
Middle East	27,961.45	2039	101.810	2,219.18	2,320.99	4.390
Asia Pacific	11,649.92	2010	145.060	596.660	741.720	19.56
Total	88,427.73	2019	2,528.70	6,686.41	9,215.11	27.44

Source: [35]

At present, the Western Hemisphere has only 9 percent of the world's estimated recovery (see Figure 7) and its production in 2002 was 37.1 percent of the total world gas

[f] The Hubbert model provides a structured and complete approach to forecasting the production of petroleum. It is part of the general family of models which go under the name of "Logistic". Logistic modeling is a well known forecasting system, commonly used and reasonably effective.

production (see Figure 8) making it the biggest gas producer in the region in the world. The Multicycle Model suggests that production in this region had already peaked in 2000. Its ultimate recovery is expected to be 2,240 trillion cubic feet (tcf), and more than half of the total proved reserves (around 56 percent) already has been produced (see Table 3).

The amount of gas produced in Western Europe in 2002 was approximately 12 percent of the world total (see Figure 8). In 2002, Western Europe possessed less than 3.5 percent of the world's gas recovery (see Figure 7). A multicyclic model suggests that Western Europe region reached a plateau during 1999-2002 with a peak of 10.293 tcf/year in 2000. The ultimate expected recovery is to be around 494 tcf, and 49 percent of it already has been produced (see Table 3). More than half of the major producers in this region are either past or about to be at their peak.

Thirty six percent of the world's estimated recovery is in Eastern Europe (see Figure 7) making it the region with the largest indicated gas recovery. It is also the second largest gas-producing region in the world (see Figure 8). Eastern Europe and the former Soviet Union have the highest ultimate recovery worldwide. Only approximately 25 percent has been produced so far (see Table 3).

Natural gas production in Africa has increased over the years. This trend will continue until 2015, when production is expected to peak (see Table 3). The ultimate recovery should be around 452 tcf, which is the lowest of all regions. However, recoverable gas is high at 85 percent of the total.

Much of the natural gas seems to be in the Middle East. This region has the world's second highest estimated future gas recovery (see Figure 7), and it has barely tapped into those resources. Production in the Middle East is expected to peak in 2039 (see Table 3). Its cumulative production is merely 4 percent of its ultimate recovery, which means that around 2,219 tcf of gas still remain to be produced.

The recovery in the Asia Pacific region is approximately 8 percent of the global total (see Fgure 7), and production was close to 11 percent in 2002 (see Figure 8). The multicyclic model suggests that production will peak in 2010 and the ultimate recovery could be close to 742 tcf. With slightly more than 19 percent of its total recovery produced so far, this region still has a considerable amount of gas to be recovered in the (see Table 3).

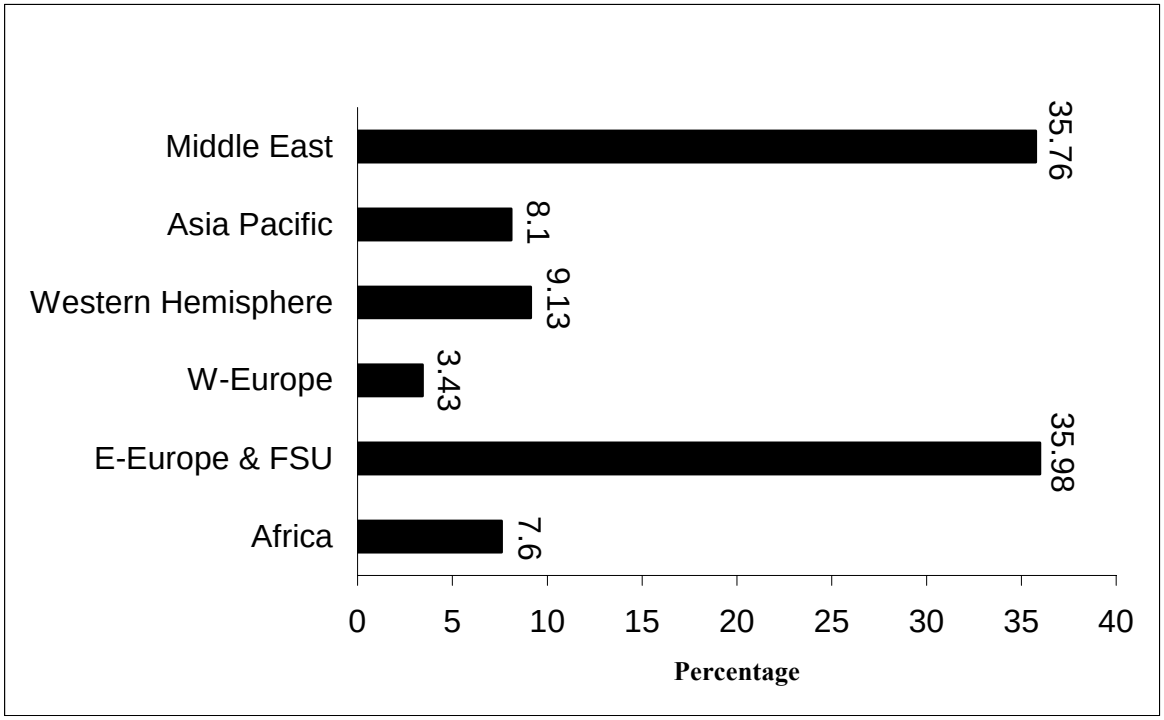

Figure (7) Estimated global natural gas recovery in 2002
Source: Adopted from [35]

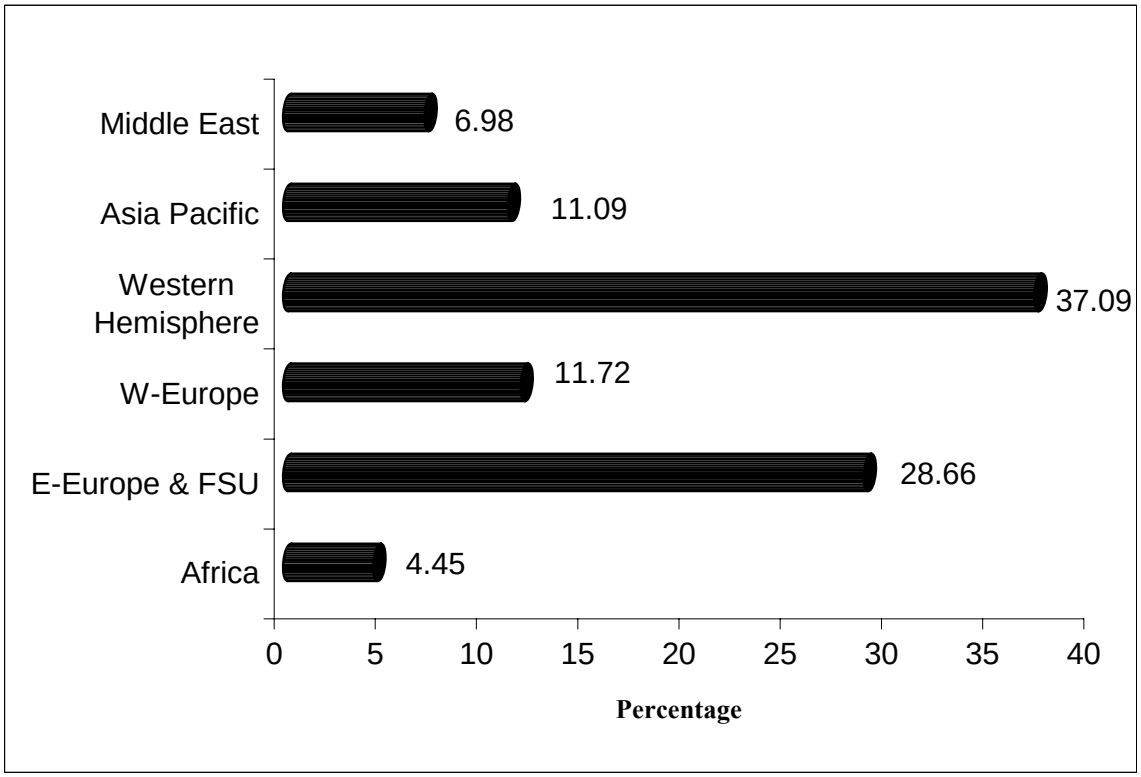

Figure (8) Distribution of global natural gas production by region in 2002
Source: Adopted from [35]

2.5.3 Natural gas consumption

Figure 9 illustrates the rise in world natural gas consumption from 1970 to 2025. As clearly shown in the Figure, consumption of natural gas has increased considerably in the years. From Figure 9, it can be seen that there has been a consistent increase in the consumption of natural gas from 1970 to 2025. During the first three decades from 1970-1980, 1980-1990, 1990-2000, the average decades increases in consumptions were 47.2, 37.7 and 19.1 percent respectively. It can also be seen from Figure 9 that, from the year 2000 to 2005, world gas consumption increased from 87 to 100 trillion cubic feet, i.e. 14.9 percent increase. Finally, it has been projected that the average world consumption will increase from 100 to 176 trillion cubic feet by the year 2025, i.e. 76 percent increase.

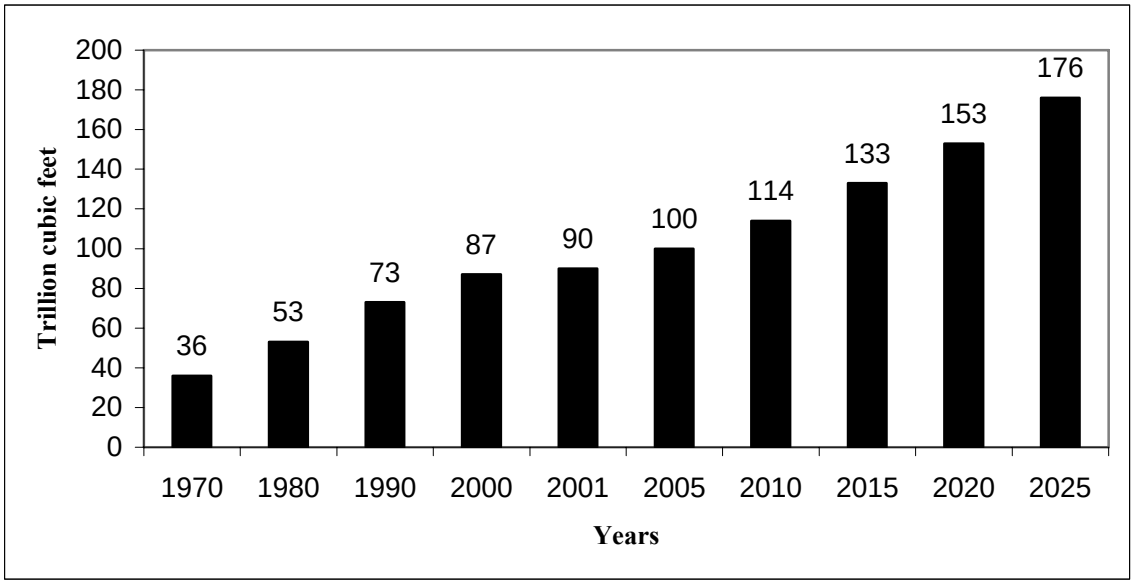

Figure (9) World natural gas consumption

Source: Energy Information Administration, international Energy outlook , 2003

2.5.4 Natural gas reserves

Since the mid-1970s, natural gas reserves have had a general upward trend, and natural gas reserves are more evenly distributed worldwide than those of oil. As of January 2003, proved world natural gas reserves were estimated at 5.501 (tcf). This was 50 tcf more than the estimate for 2002. Most of the increase is attributed to developing countries: Africa and Asia had the largest revisions in proved natural gas reserves between 2001 and 2002 [38]. Natural gas reserves in industrialised countries have also increased by 18 (tcf) between 2002 and 2003 [34]. In 2005, 75 percent of the world's natural gas reserves are located in the Middle

East, and Former Soviet Union. Reserves in the rest of the world are fairly evenly distributed on a regional basis (see Figure 10).

Worldwide, on average, annual discovered reserves have grown approximately four times the quantity being consumed. Natural gas reserves may increase further as the search for this desirable fuel intensifies from the relatively limited exploration of the past. Previous gas discoveries often resulted from searching for oil. At present, however, many exploration companies are building up their gas portfolios. Table 4 illustrates the distribution of global natural gas reserves. Despite the high rates of increase in natural gas consumption, particularly over the past decades, most regional reserves to production ratios have remained high.

Table (4) Natural gas reserves by region (tcf)

Regions	End 2003	January 1, 2005
North America	268.8530	260.4940
Central and South America	240.9370	250.5200
Western Europe	170.0540	182.4870
Eastern Europe and FSU	2,693.227	1,964.160
Middle East	2,539.650	2,522.125
Africa	443.2000	476.5090
Asia and Oceania	449.9100	383.9130
World Total	6,805.830	6,040.208

Source: [34]

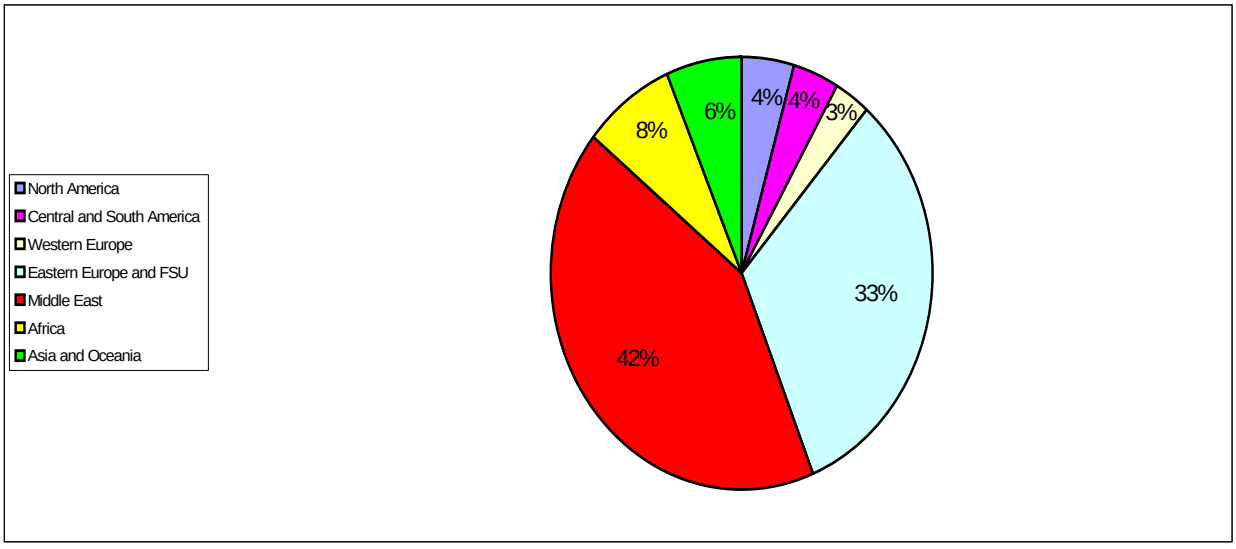

Figure (10) Percentages of world natural gas reserves by region in January 2005

Source: [34]

The data on resources of natural gas show that it might be possible to provide the opportunity to reduce the dependency on other energies, (e.g. oil, coal, and nuclear). Concerns about acid rain, air pollution and global warming will no doubt result in an increased use of natural gas as a source of energy in the future. In a more distant future, this could also imply that natural gas will be used in fuel cells for transportation for the generation of electricity.

It can be concluded that the Middle East, Eastern Europe and the Former Soviet Union are the most abundant in natural gas reserves as well as production. Increases in consumption of natural gas will result in an increase in production in Eastern Europe, the Former soviet and in the Middle East, which hold most of the world's proven gas reserves. The reasons for the rapid increase in gas consumption are its availability in abundance, low price and clean burning characteristics compared to coal and crude oil, and, as already mentioned, worldwide concern for the global warming with regard to air quality and green house effects.

2.6 World petroleum economics

Since oil and gas are abundant resources, the rate of economic growth and the level of world economic activity are major factors determining worldwide demand for energy and oil. The demand for energy to fuel economic growth and the demand for oil as the major energy fuel will determine the level of world crude oil production. The international exploration industry responds to the supply and demand balance and the resulting movements in price. Besides these economic factors, however, other important political circumstances dominate the economics of petroleum [11]. In the following sections we discuss these circumstances.

2.6.1 The role of non-OPEC countries

Non-OPEC countries are not members of the Organization of Petroleum Exporting Countries (OPEC). Non-OPEC[c] production, worldwide regional economic growth rates and the associated regional demands for oil are factors affecting world prices. Most non-OPEC countries are not only producers but they are also considered as main energy consumers. Usually, they produce less than their own need from energy. For instance, some of them consume more than twice of their own oil production [40]. The non-OPEC countries have less than one-fourth of the World's proven oil reserves and together hold approximately 500,000 barrels per day of 'spare oil' at any time. In 2003, the non-OPEC countries produced 62 percent of the world's oil (total liquid) [107].

[c] Non-OPEC countries are (Russia, Mexico, China, United States, Kazakhstan, Azerbaijan, Norway, Canada, United Kingdom).

Since 1970, non-OPEC production as a share of world total oil production reached a high of 71 percent in 1985 and a low of 48 percent in 1973 with a 61percent average. Non-OPEC oil production is expected to follow a gradually rising path with an increase of more than 1.4 percent per year until 2020[41].

In order to understand the functioning of non-OPEC oil production, one should take into consideration that it depends upon world oil prices. In this sense, production is higher in the case of a high oil price, because more marginal wells are profitable at a high price. Similarly, a low world oil price is associated with lower production levels. Hence, estimates of non-OPEC production paths can be made for projected trends of the oil price, as illustrated in Figure 11 for three such price scenarios. One should also consider that non-OPEC oil reserves require high costs to be developed for production in comparison to OPEC reserves. Hence, these high costs and the oil price instability have a significant impact on the production of the non-OPEC countries [22].

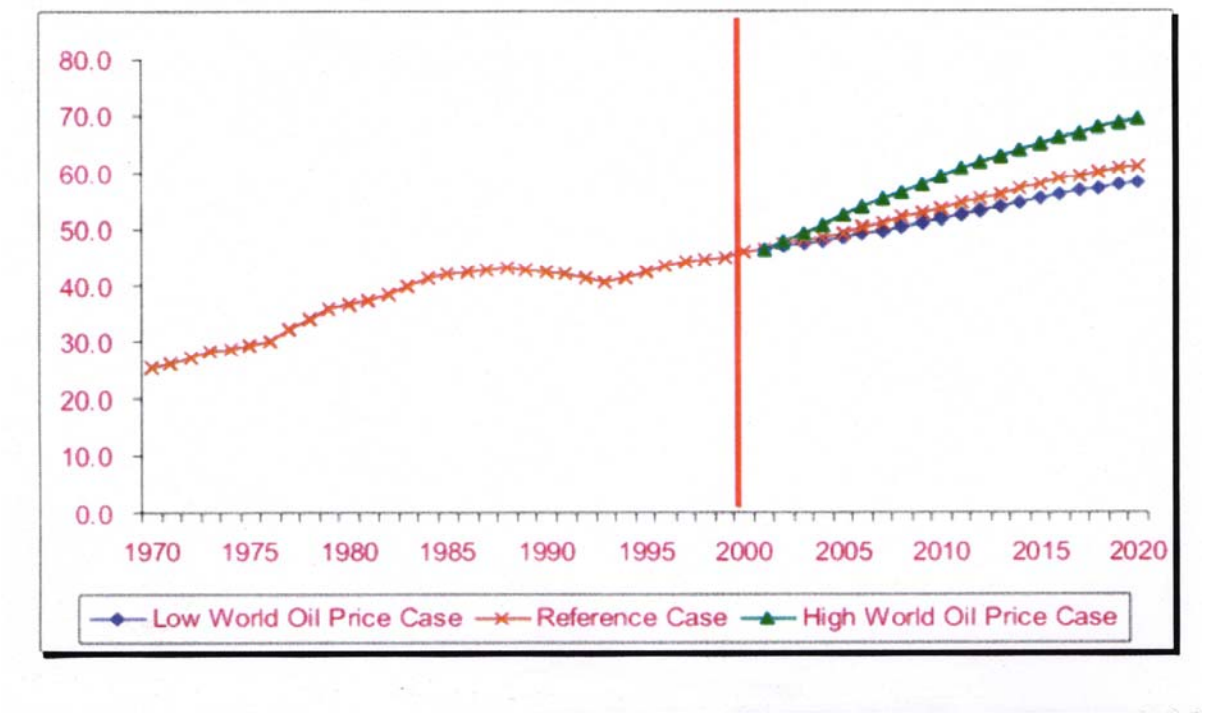

Figure (11) Non -OPEC oil production from 1970 to 2020

Source: Energy Information Administration. AEO2001

2.6.2 The role of OPEC countries

World supply comes from a wide variety of OPEC sources. The OPEC countries are the largest producers of total world production. Therefore and in contrast to the non-OPEC countries, the amount of oil production by countries in the Organisation of Petroleum Exporting Countries (OPEC) is a key factor influencing the world oil price. Since the demand for oil is predicted to increase – as already discussed above - OPEC will become the primary source of oil and it will have to satisfy this worldwide increase in oil consumption. This is easily understood because its member nations hold a major portion of the world's total reserves exceeding 814 billion barrels, more than 80 percent of the world's estimated total at the end of 2001[127], [41].

In OPEC, countries costs to develop and produce oil are low in comparison to those of non-OPEC countries. In particular, in the Middle East these costs average just over $2 per barrel compared with approximately $4.5 per barrel in the US and Western Europe and 5.75 $ per barrel in Canada [35].

The Assumption Energy Outlook (AEO) of 2001 delivers forecasts on which OPEC based its principal assumptions leading to three world oil price path cases examined: the low oil price case, the reference case, and the high oil price case. Again in contrast to the production strategies of non-OPEC countries, the quantities estimated for OPEC production in the low oil price case are higher than the quantities assumed in the high oil price case (see Figure 12). OPEC members share some key characteristics that allow them as a group to have a significant influence on the world oil markets despite their lack of a monopoly over the production of world oil. They are important world oil exporters and very large producers, but they are at the same time very small consumers. OPEC oil industries are mostly nationalised, allowing the political establishments of OPEC to increase or decrease oil production not only in response to developments of the oil price. Even so, OPEC member governments tend to rely heavily on oil revenues. OPEC spare production capacity estimates for 2002 were as high as 8 million bbl/d [54] ,[22].

As aforementioned, OPEC members have large reserves and OPEC countries will remain major suppliers of the oil market. Hence, there will be more optimism when huge oil reserves exist to meet an increased demand. However, if world oil demand accelerates rapidly, the question remains whether OPEC producers can respond as quickly in order to avoid a disturbance in the oil market, in particular, one may ask whether they can do so without reforming their upstream policies to accommodate private investment and

participation. If the answer to these questions is negative, the consequences are clearly negative for the world economy [33].

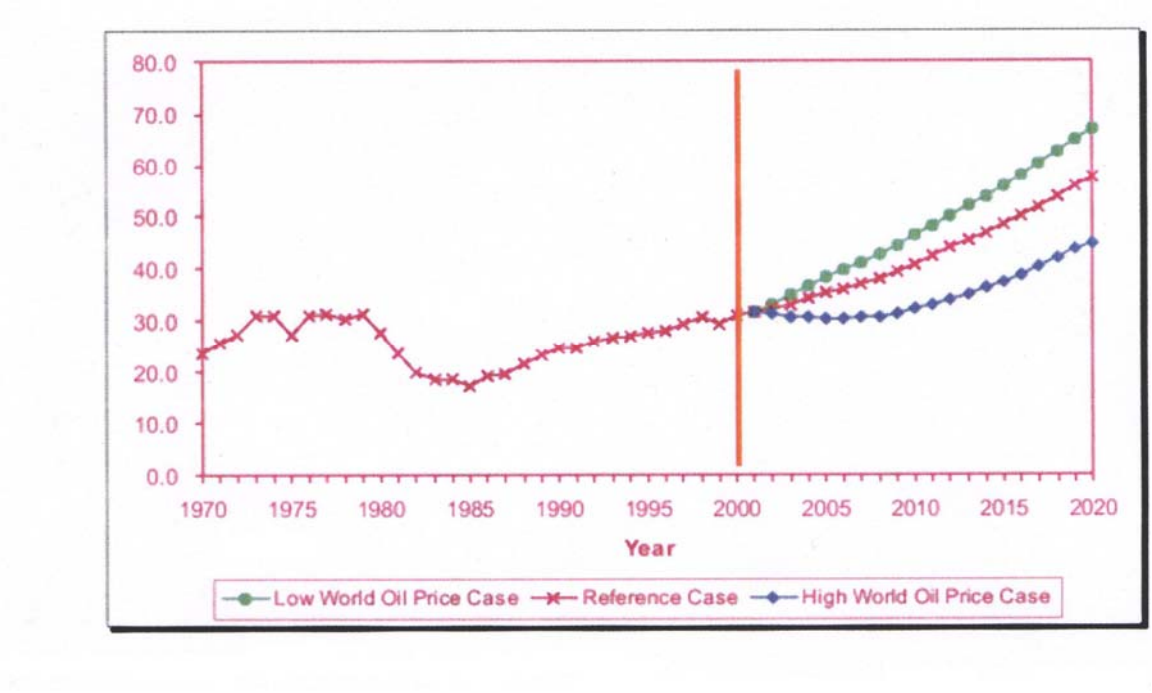

Figure (12) OPEC oil production from 1970 to 2020
Source: Energy Information Administration. AEO2001

Finally, a comparison between non-OPEC countries and OPEC[d] countries is of importance. First and from the above discussion, it becomes obvious that OPEC production countries tend to produce more in case of a low world price case than in the case of a high price, whilst the non-OPEC countries produce less in the case of a low price in comparison with a high price, as can seen from Figures 11 and 12. Hence, one can also say that, given the huge reserves of OPEC countries, OPEC is able to exert a larger effect on the oil market. Since non-OPEC countries do not have such reserves, they are not in a position to do the same. Second; most non-OPEC countries are reaching production maturity, whereas the long-term outlook for the supply conditions of OPEC countries remain optimistic even with moderate world oil prices over the long term. Third, most non-OPEC countries are net importers. Fifth, significant increases in the world oil demand will have to be met primarily by OPEC members.

[d] OPEC countries are (Kuwait, Saudi Arabia, United Arab Emirate, Iraq, Venezuela, Libya, Iran, Qatar, Indonesia, Algeria, Nigeria).

2.6.3 Changing transportation technologies

One important feature with a significant effect on petroleum economics and the future of oil consumption are the technological developments in the transportation sector. These may constitute a great leap towards the more efficient use of fuel, and hence substantial reductions in oil consumption. The invention of hybrid engines using batteries in addition to fuel could reduce oil consumption. Furthermore, new devices that generate energy through hydrogen fuel cells will lead to a substantial reduction of oil consumption. These innovations will shift the course of society and fully implemented, would turn every oil market outlook upside down [11]. Of all the fossil fuels, coal emits the highest amount of carbon dioxide, natural gas has the lowest, and oil is in between. In response to current environmental pressures that culminated in the UN's Kyoto protocol and the requirement to reduce carbon dioxide emissions the consumption of oil may be gradually decrease. The Kyoto Protocol imposes on the industrialized countries a 5.2 percent reduction in their carbon dioxide emissions from the 1990 level, over the 2008-2012 time periods [42].

To a large extent, the declining market share of oil also reflects the rise of natural gas. For natural gas, transportation applications and the development of fuel cells bear important consequences. In both cases, natural gas demand could be positively impacted if, as many expect, stationary fuel cells become available for homes and businesses in the future [12].

As can be seen from this overview, because of rising environmental considerations, the world tends to search for new energy sources which have less effect on the environment. Hence, fossil fuels and oil in particular, in combination with technologies that reduce the environmental effect of energy consumption may lead to a decrease in the demand for oil.

2. 7 World trade in oil and gas

There is more trade internationally in oil than gas. Figure 13 shows the production and consumption of oil and natural gas by major areas of the world. From Figure 13, it can be seen that there is a discrepancy between production and consumption of oil in the major areas of the world. This reveals that oil deposits tend to be in countries and areas that are not major consumers of oil. For example, the Middle East and Africa are main producers, however, in Africa, more than two thirds of what is produced is exported. Other excess production areas are Central and South America and the Former Soviet Union. Areas such as North America, Europe and all of Asia, except the Middle East, are called deficit areas. The deficit areas, Pacific Asia and Europe consumed more than twice as much oil as they produced in 2003 [45].

The main consumer in Asia is Japan, which produces no oil of its own. In Europe only Norway and the UK produce oil in significant quantities, while the other European countries are major consumers. The United States consumes more than twice its own production of oil. The solution to this mismatch of deficit areas and oil as a major commodity of international trade is the tremendous transportation and distribution industry that has been set up to bridge the gap between these regions [46].

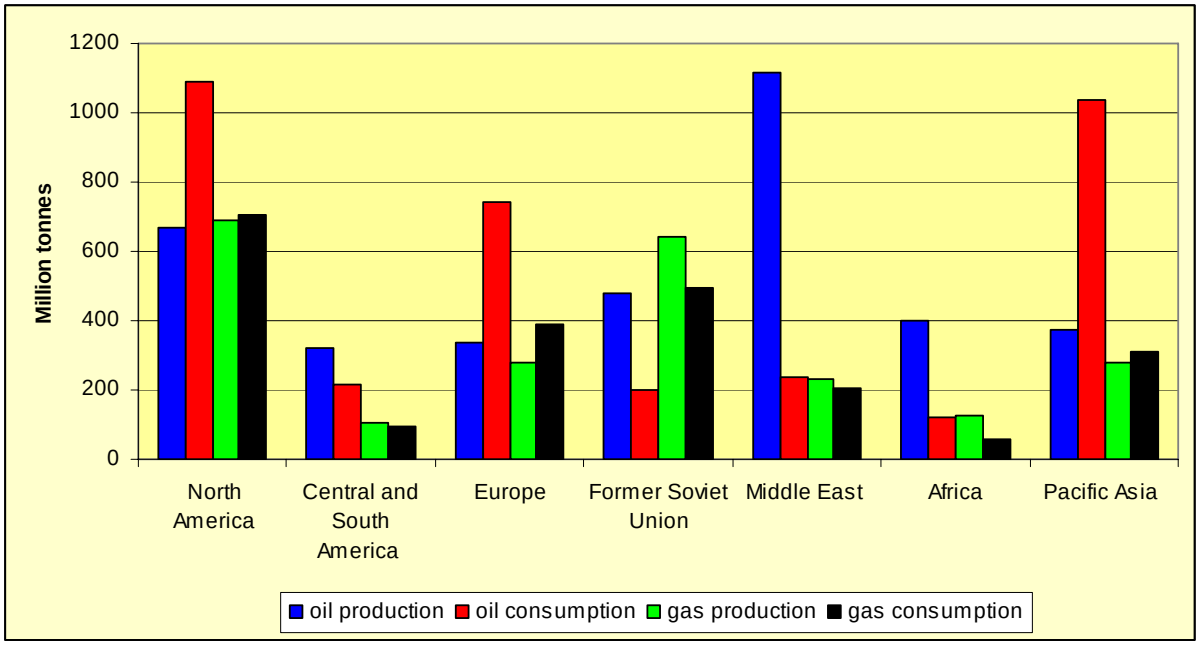

Figure (13) Production and consumption of oil and gas by region (2003)

Source: Bp statistical review of world energy 2005

The production and consumption of natural gas is in contrast with that of oil. Most of the regions, apart of Europe, consume more than their production (see Figure 13). This means that Europe could satisfy its extra consumption through import from other countries. However, due to difficulties in transportation and distribution of natural gas, it is not easily traded in the world markets. The facilities for distribution of natural gas often require high initial costs.

Solving the transportation and distribution problem to bridge the mismatch for natural gas has never been easy. The reason for this is that natural gas is much more difficult to transport than oil. One thousand cubic meters of natural gas have the same energy content as one ton cubic of oil, which takes up one meter of space. Hence natural gas requires about a thousand times more space than oil, at atmospheric pressure, for any given energy content [49]. Hence, because of transportation costs, there is hardly any world market for gas in comparison with oil. Although gas may be transported in a liquefied form in a tanker like oil,

the trade in liquefied gas is of a limited scope with Japan as the major recipient. In North America and Europe, imported gas is transported through pipelines. This makes for regional markets rather than a world market. The three largest market areas are North America, the Former Soviet Union and Europe.

However, the problem of gas transportation and distribution problems can be solved by liquefaction[h] and re-gasification[k]. Liquefaction and re-gasification plants are expensive installations, but the cost of transporting Liquefied Natural Gas (LNG) is comparatively low proportionate to distance. The cost of a pipeline is roughly proportionate to its length for any given dimension of pipeline. Figure 14 shows the costs of transporting gas through pipelines versus the liquefied form. LNG typically outperforms offshore pipelines at distances over 1,500 km and onshore pipelines at distances over 3,500 km. The high capital costs for transporting natural gas can affect industrial structures. For example, gas producers can refuse to develop gas fields unless they can secure a long term commitment from buyers [48], [49].

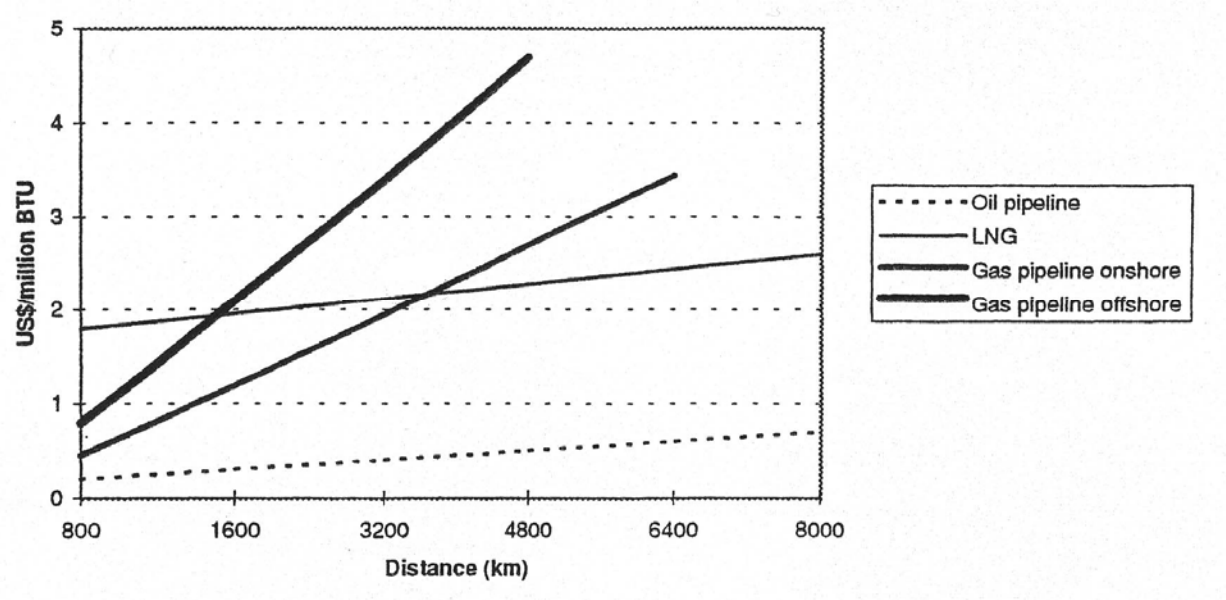

Figure (14) Cost of oil and gas transportation
Source: OECD/IEA, natural gas transportation, after jensen Associates, Inc

It can be seen from the above discussion that oil has an international market and it is relatively easy to transport than natural gas, because of the high cost of transportation. Nevertheless, the forecasts for a further penetration of gas into the markets of the world appear bright. Firstly, gas is becoming more available. Secondly, the advantage of gas as a source of electricity production has increased in recent years, because investment in nuclear

[h] The process of converting a gas to a Liquid, either by removal of heat or an increase in pressure
[k] The liquid natural gas that is at a temperature of -160° C is returned to the gaseous state by a simple heating operation.

power has come to a standstill since the events of 'Three Mile Island' (USA) and 'Chernobyl' (Ukraine). Furthermore, there are environmental advantages over coal and oil and there is an increased efficiency of gas turbines. For natural gas to be traded globally, there is the need for an extensive infrastructure as well as end use application [50].

2.7.1 World oil and gas prices

2.7.1.1 Oil prices

The price of oil and gas is the fulcrum for the industry's exploration decision-making for exploration. Over the past 30 years, oil prices have been highly volatile. In the future, no one can expect this volatile behaviour to recur, principally because of unforeseen political and economic circumstances [52].

Figure 15 shows oil prices development from 1970 to 2004. In 1973, OPEC countries began to assume a major influence on oil prices and began to nationalize their oil industry. By October 1973, as the Arab Israeli war began, the Arab members of OPEC declared an embargo on exports to the U.S resulting in increased crude oil prices [23]. In the late 1970s, political unrest in the Middle East also created conditions for the dramatic oil price increase of 1979-81. When anti – west Islamic fundamentalists gained control of the country, Iranian oil production declined dramatically, leading to price increases [53]. Surging prices form 1979 - 1981 caused several reactions among consumers: better insulation in new homes, increased insulation in many older homes, more energy efficiency in industrial processes, and automobiles with higher mileage. These factors along with a global recession caused a reduction in demand which led to falling crude prices from the time period between1981 - 1986. The higher prices also resulted in increased exploration and production outside of OPEC. From 1980 to 1986 non-OPEC production increased 10 million barrels per day. This increased in supply resulted also resulted in the lower prices within these periods.

The price of crude oil spiked again in 1990 with the uncertainty associated with the Iraqi invasion of Kuwait and the ensuing Gulf War, but following the war crude oil prices entered a steady decline until in 1994.

The price cycle then turned up again as the United States economy was strong and the Asian Pacific region was booming. From 1990 to 1997 world oil consumption increased 6.2 million barrels per day. Asian consumption accounted for all but 300,000 barrels per day of that gain and contributed to a price recovery that extended into 1997.

The price increases ended when the impact of the economic crisis in Asia was either ignored or severely underestimated by OPEC. In December 1997, OPEC increased its quota

by 2.5 million barrels per day (10 percent) to 27.5 MMBPD effective January 1, 1998. The rapid growth in Asian economies had come to a halt and in 1998 Asian Pacific oil consumption declined for the first time since 1982. The combination of lower consumption and higher OPEC production sent prices into a downward. Growing US and world economies resulted in the continued rise in the price of oil throughout 2000 to a post 1981 high.

In 2001, a weakening US economy and increases in non-OPEC production put a downward pressure on prices. In response, OPEC once again entered into a series of reductions in member quotas by September 1, 2001. In the absence of the September 11, 2001 terrorist attack, these reductions in OPEC member quotas would have been sufficient to moderate or even reverse the trend. The 9/11 attack, coupled with OPEC member quotas reductions joined by several non-OPEC countries, resulted in an increase in oil prices up till 2002[23]. In the beginning of 2003, political problems in Venezuela and military action commenced in Iraq, causing production to plummet sent prices into a rise. Since then the oil price continued to rise [132], (see Figure 15).

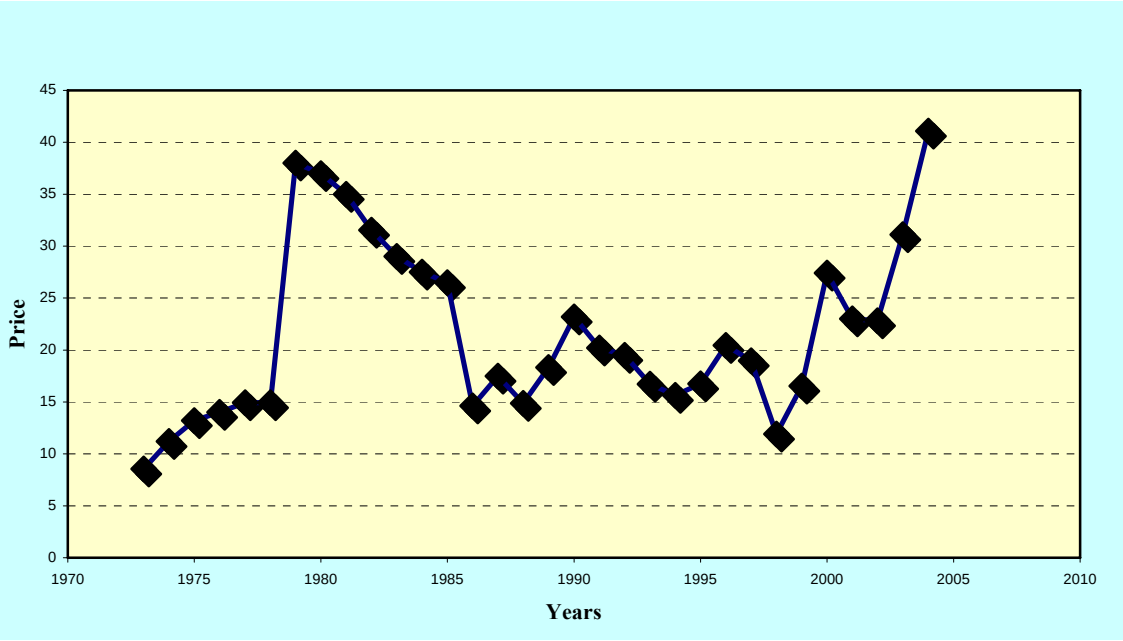

Figure (15) Historical oil prices from 1970 to 2004

Source: adopted from [23], [132]

2.7.1.2 Natural gas prices

Natural gas is a commodity traded on the open market like other commodities. As with most commodities, the price is dictated by supply and demand. When demand is high, the price rises, and when supply is high, the price drops. There are a several factors which

influence gas pricing. Firstly, the weather is the largest single factor affecting the natural gas price and the weather is also the most difficult to predict. For instance, in the event of colder weather than normal winter weather, the sales of gas will increase. Therefore, the rise in prices combined with the increased gas use is expected to increase the average consumer expenditure for natural gas. Secondly, a growing economy, especially in the manufacturing sector, creates additional demand for natural gas, contributing to price increases. Thirdly, international events, such as conflicts in oil producing regions, can drive up the price of crude oil. This in turns influences the price of natural gas as industries switch between fuels, driving up the demand for natural gas. Fourthly, the cost of drilling, producing or transporting natural gas can influence the price of the natural gas [101].

Figure 16 shows the price history of natural gas futures. After a decade of low natural gas prices, natural gas prices spiked during the winters of 2000-2001 and 2002-2003 and remained high through the winter of 2003-2004. Since April 2004, natural gas prices have been on a steep uphill climb. Rising crude oil prices have greatly contributed to rising prices in natural gas. With increasing competition for natural gas supplies, natural gas prices will be more volatile than they have been in past [AEO 2005]. Also, the future natural gas prices currently lock in Henry Hub[k] prices of between $5.0/MMBtu and $7.0/MMBtu over the next 6 years (see Figure 16).

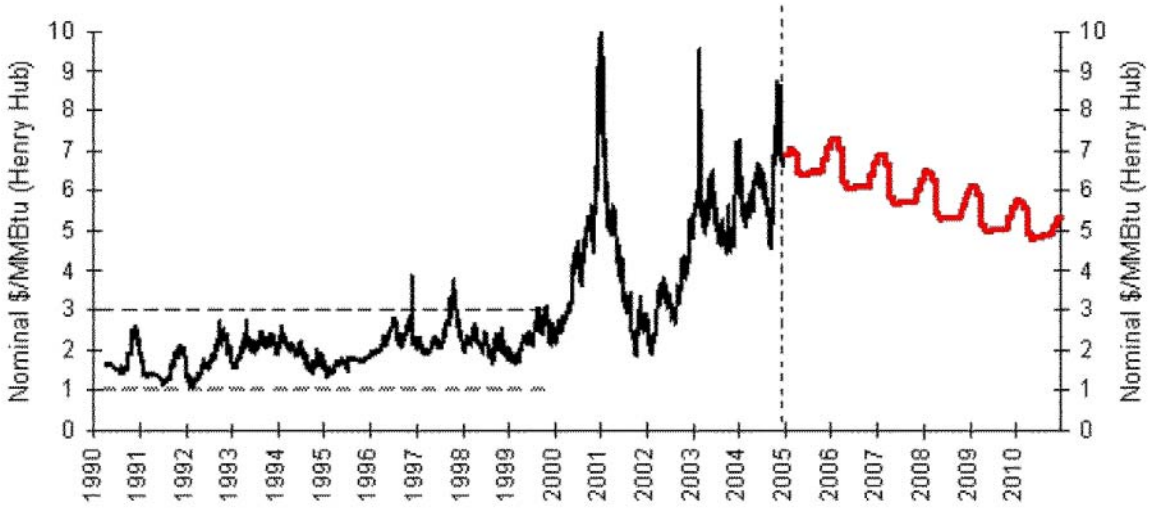

Figure (16) Natural gas futures prices

Source: NYMEX

[k] Henry Hub is the pricing point for natural gas futures contracts traded in the New York Mercantile Exchange, or NYMEX

2.8 Summary

Oil reserves are found in many regions around the world. Among these regions, the Middle East has the largest oil reserves. It can also be seen that the demand for oil is directly proportional to the level of development. The significant increase in world oil demand will have to be met primarily from the Middle East OPEC supplies.

The price of oil is also influenced by a number of factors. The factors that combine to contribute to the price jump include the exceptionally high growth in petroleum demand centering on China, the tight supply and demand situation in the US petroleum product market, a marked drop in surplus supply capacity in the international petroleum market, conflicts in major petroleum producing countries such as Saudi Arabia and Russia that resulted in concerns about supply interruptions.

The demand for natural gas as an alternative source of fuel is increasing. This is because natural gas is considered a clean energy compared to oil and coal. This is an advantage will lead to an increased use of gas, and make natural the primary energy source in the near future.

In the next chapter the focus will be on the upstream operations (drilling and production) and their potential environmental impacts.

CHAPTER THREE:
OIL UPSTREAM OPERATIONS AND THEIR IMPACT ON THE ENVIRONMENT

3.1 Overview of the oil and gas exploration and production process

Oil and natural gas are produced by the same geological process anaerobic decay of organic matter deep under the Earth's surface. As a consequence, oil and natural gas are often found together. In common usage, deposits rich in oil are known as oil fields, and deposits rich in natural gas are called natural gas fields [56].

The oil and gas industry comprises two parts: ‘upstream’, the exploration and production sector of the industry; ‘downstream’, the sector which deals with refining and processing of crude oil and gas products, their distribution and marketing. Companies operating in the industry may be fully integrated, (i.e. have both upstream and downstream interests), or they may concentrate on a particular sector, such as exploration and production, (E&P), or just on refining and marketing (R&M). The upstream sector is ranging from geophysical surveys to decommissioning and rehabilitation processes.

Scientific exploration for oil, in the modern sense, began in 1912 when geologists were first involved in the discovery of the Cushing Field in Oklahoma, USA. The fundamental process remains the same, but modern technology and engineering have vastly improved performance and safety.

In order to appreciate the origins of the potential impacts of the oil business upstream on the environment, it is important to understand the activities involved. This section describes the process. Table 5 provides a summary of the principle steps in the process and relates these to operations on the ground.

Table (5) Summary of the exploration and production process

Activity	Potential requirement on ground
Aerial survey	Low-flying aircraft over study area
Seismic survey	Access to onshore sites and marine resource areas Possible onshore extension of marine seismic lines Onshore navigational beacons Onshore seismic lines
Exploration and appraisal	Access for drilling unit and supply units Storage facilities Waste disposal facilities Testing capabilities Additional drill site and waste disposal facilities Accommodation
Development and production	Improved access, storage and waste disposal facilities Wellheads Flow lines Separation/ treatment facilities Increased oil storage Facilities to export product Flares Gas production plant Transport equipment Accommodation, infrastructure
Decommissioning and Abandonment	Equipment to plug wells Equipment to demolish and remove installations Equipment to restore site

Source: [57]

3.1.1 Exploration survey

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The exploration survey is the first stage of the search for crude oil which comprises three methods. Firstly, a Magnetic Method which measures the variations in intensity of the magnetic field which reflect the magnetic character of various rocks present. The second method is the Gravimetric Method that involves the measurements of small variations in the gravitational field at the surface of the earth. Using an aircraft or a survey ship, respectively, makes measurements on land and at sea. Thirdly, a Seismic Survey, as illustrated in Figure 17, is the most common method and it is often the first field activity undertaken. The Seismic Method is used for identifying geological structures and it relies on the different reflective properties of sound waves to various layers beneath terrestrial or oceanic surfaces [57]. An energy source transmits a pulse of acoustic energy into the ground that travels as wave into the earth. At each point where different geological layers exist, a part of the energy is transmitted down to deeper layers within the earth, while the remainder is reflected back to the surface. These signals are picked up by a series of sensitive receivers called geophones or seismometers on land, or hydrophones submerged in water. Special cables transmit the electrical signals received to a mobile laboratory where they are amplified and filtered and then digitised and recorded on magnetic tapes for interpretation [58].

Dynamite was once widely used as the energy source to generate acoustic waves but environmental considerations now generally favour lower energy sources such as vibroseis[e] on land (composed of a generator that hydraulically transmits vibrations into the earth) and the air gun (which releases compressed air) in offshore exploration. In areas where the preservation of vegetation cover is important, the short hole (dynamic) method is preferable to vibroseis [57].

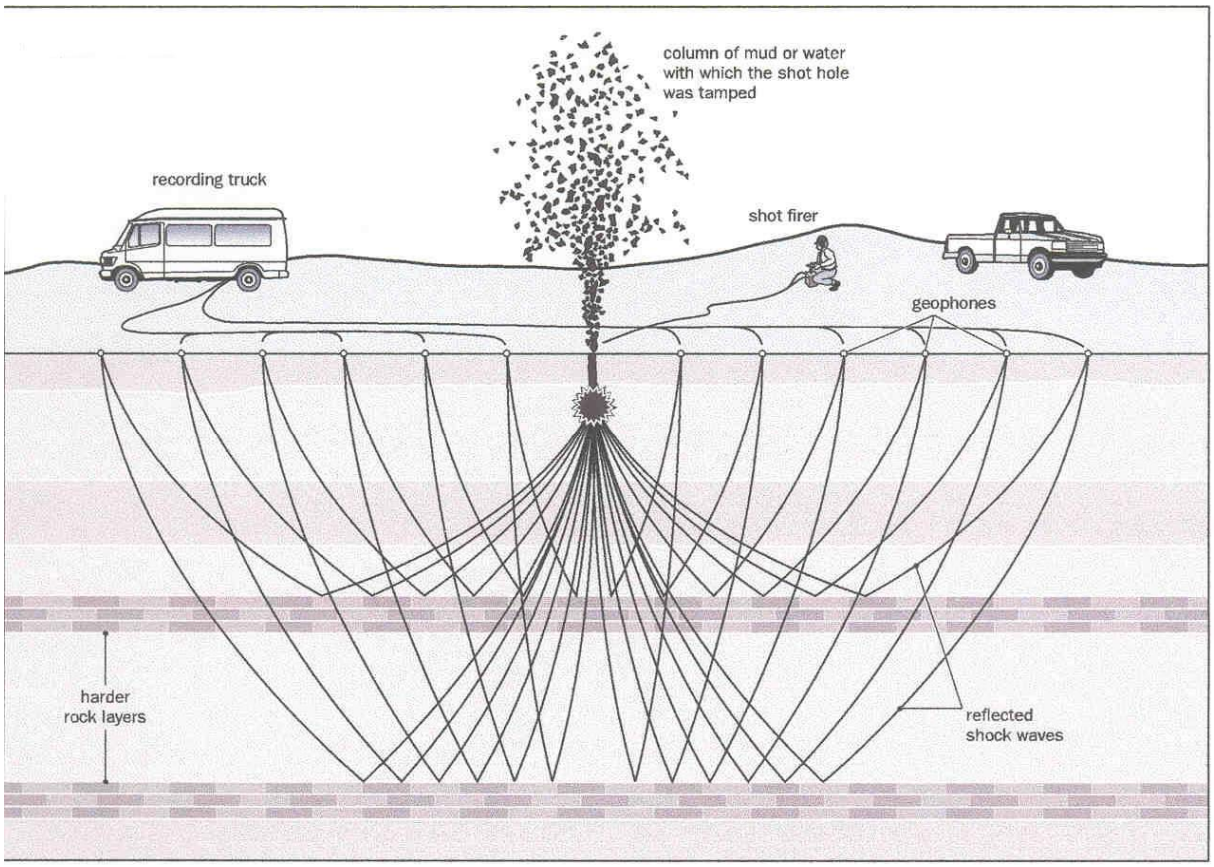

Figure (17) Seismic survey (fieldwork)
Source: [57]

3.1.2 Exploration drilling

The basic principles of drilling technology in petroleum wells are established and are described by many researchers [65], [60]. The drilling of petroleum well is a complex process that requires large heavy-duty equipment.

A suitable drilling rig consists of a structure that can support several hundred tons is shown in Figure 18. A drill bit is attached to the bottom of the drill pipe by one or more drill

[e] Vibroseis is a seismic survey technique that uses a large vehicle fitted with vibrating plates or produce shockwaves.

collars. The entire assembly ends at the floor of a drilling rig and is connected to a rotary table. This table, along with a special joint, called the kelly, provides a rotational motion to the drilling assembly. Most of the wells are drilled with rotary drilling rigs. The typical drilling modules comprise power, hoisting, rotating and circulating systems. The support camp is self-contained and generally provides workforce accommodation, communication, vehicle maintenance, and a helipad for remote sites, fuel handling and storage areas, and provision for collection, treatment and disposal of wastes [60].

For land-based operations, a pad is constructed at the chosen site to accommodate drilling equipment and support service. In offshore operations several mobile offshore drilling units can be used. The choice of the offshore drilling units depends on depths of water, seabed conditions, wind speed, wave height and current speed. The rigs used in offshore are similar to a drilling rig on land, a major difference being the top drive used on an offshore drilling rig. A top drive is a power swivel located below the travelling block that drives the drilling string. The offshore rigs drilling such as jack–up and submersible rigs are only suitable for shallow water while drill ship or semi submersible unit are used for deeper water [61].

Geologists and geophysicists identify the geological structure that possibly contains commercial oil and gas. The way to confirm the existence of hydrocarbons is to drill exploratory wells. A well drilled to discover new oil and gas reserves is called a controlled exploratory well, and wells drilled in known extent oil fields are called development wells. The location of a drill site depends on the characteristics of the underlying geological formations [62].

As drilling commences, the bit is rotated and the teeth chip away the rock at the bottom of the well. Simultaneously, mud is pumped down the drill string, flowing out through nozzles in the bit and flowing up to the surface between the drill string and the wall of the hole. Its purpose is to balance underground hydrostatic pressure, cool bit and removed cutting [63]. The casing string is run into completed sections of the borehole and cemented into place. The casing provides structural support to maintain the integrity of the borehole and isolates underground formations. After the well has been completed and hydrocarbon formation is found, initial well tests are conducted to establish flow rates and formation pressure. These tests may determine the maximum gas and oil that the well can produce per day. After drilling the rig is dismantled and moved to the next site. If the exploratory drilling has discovered commercial quantities of hydrocarbons, a wellhead valve assembly[1] may be installed [58], [60]. If

[1] Wellhead valve assembly is designed for safe and convenient pup in, pump out, and retrieval of downhole hydraulic “free” pumps.

the well does not contain commercial quantities of hydrocarbon, the site is decommissioned and restored to its original state.

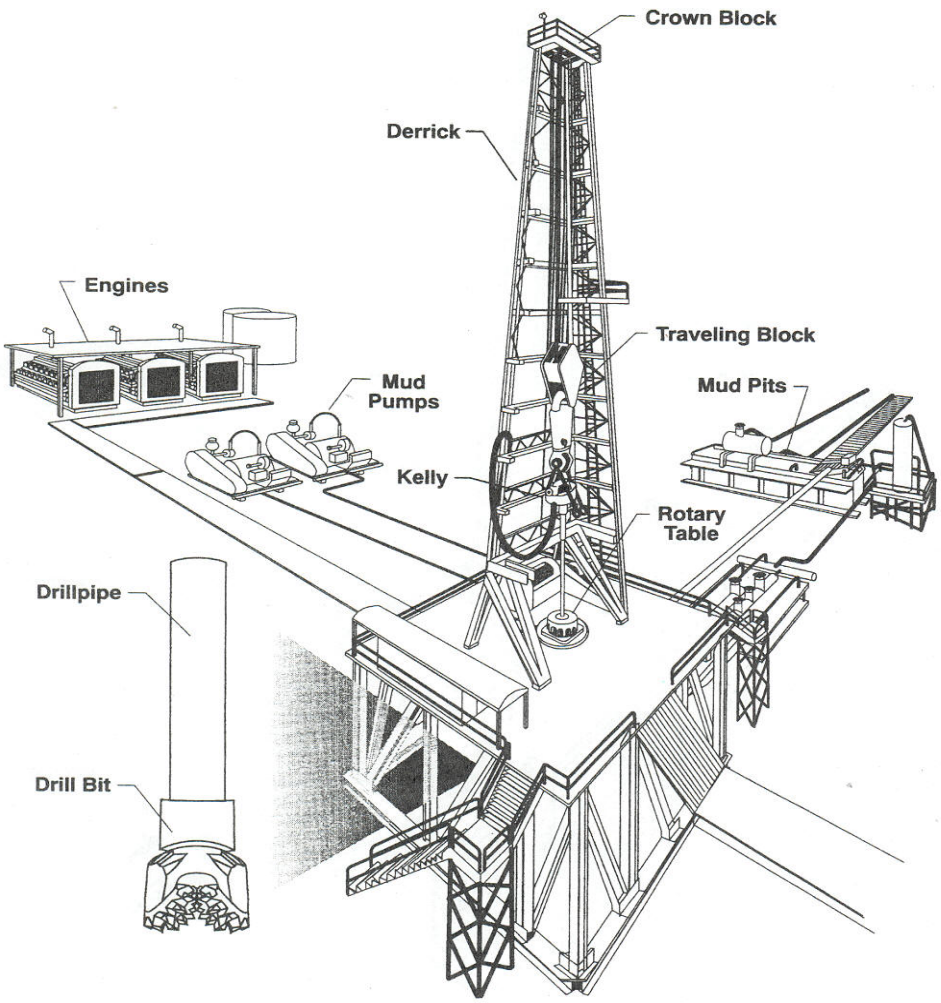

Figure (18) Rotary drilling rig with its important components
Source: [60]

3.1.2.1 Appraisal

When exploratory drilling is successful, more wells are drilled to determine the size and the extent of the field. Wells drilled to quantify the hydrocarbon reserves found are called appraisal wells. The appraisal stage aims to evaluate the size and nature of the reservoir, to determine the number of confirming wells required, and whether any further seismic work is necessary. The technical procedures in appraisal drilling are the same as those employed for exploration wells. Deviated or directional drilling at an angle from a site adjacent to original

discovery borehole may be used to appraise other parts of the reservoir, in order to reduce the land used [57].

3.1.3 Development and production

When a well has been drilled and the derrick is replaced to the next location, potential tests can be run to determine the optimum production rate. Oil and gas are produced from wells in several ways. These ways depend on whether the reservoir has sufficient pressure for oil and gas to flow to the surface or the reservoir has too low pressure for oil to flow to the surface where a pumping device is used [64].

After the size of oil field has been established, the subsequent wells drilled are called 'development' or 'production' wells. A small reservoir may be developed using one or more of the appraisal wells. A larger reservoir will require the drilling of additional production wells. Multiple production wells are often drilled from one pad to reduce land requirements and the overall infrastructure cost. The number of the wells required to exploit the hydrocarbon reservoir depends on the size of the reservoir and its geology. Large oilfields can require a hundred or more wells to be drilled. However, with a larger number of wells being drilled, the level of activity obviously increases in proportion.

As each well is drilled, it has to be prepared for production before the drilling rig departs. The heavy drill pipe is replaced by a lighter weight tubing in the well and one well may carry two or three strings of tubing, each one producing from different layers of reservoir rock. At this stage the blow out preventers[h] by a control valve assembly replaces or 'Christmas Tree'.

The production of gas or oil from the reservoir to the surface needs energy to over come friction forces in the system to lift the product to the sales line. The amount of oil and gas flowing into the well from reservoir depends on a number of factors such as the properties of the reservoir, the viscosity of the oil, the oil/gas ratio and pressure drop in the piping system. The above factors are not constant during the commercial life of a well, and when the oil cannot reach the surface, as reservoir pressure is too low, artificial lift is required, such as a pumping mechanism or the injection of gas or water to maintain reservoir pressures. It is now quite common to inject gas, water or steam into the reservoir at the start of the field's life in order to maintain pressure and optimise production rates and the ultimate recovery potential of oil and gas. This in turn may require the drilling of additional wells, called injection wells

[h] Blow out preventers is a series of hydraulically actuated steel rams that can close quickly around the drill string or casing to seal off a well.

[64],[65]. Other well stimulation methods can be used to enhance production rate. These comprise acidizing[p]and hydraulic fracturing[q] to enlarge flow channels. During production, both water and formation solids are commonly produced with oil and gas.

The development and production follow the finding of a commercially valuable deposit of oil and gas: development wells are drilled and tested. Arrangements are made for separating and gathering the oil and gas produced from the well. Such a production system is shown in Figure 19. The production system will be the first to attempt to separate water from the oil and gas. The oil must usually be free of dissolved gas before export. Similarly, the gas must be stabilized and free of liquids and unwanted components such as hydrogen sulphide and carbon dioxide. Crude oil is readied for the market by assuring that the water content is low 0.2 percent and the volatile hydrocarbons are removed [27]. The gas is sent to processing plants. The dehydration process is wet gas contacts dry glycol and the glycol absorbs water from the gas. Any water produced is treated before disposal.

In offshore production developments, permanent structures are necessary to support the required facility. Offshore platforms often have several flat services on top of each other to serve various functions such as power and drilling. Separators, gas compressors are located on the platform the treated oil or gas is then usually sent a shore [61].

[p] Acidizing, acids are used to dissolve acid-soluble materials around the wellbore to increase the formation's permeability.

[q] Hydraulic fracturing increase the permeability around a well bore by creating a high permeability channel from the wellbore into the formation. During Hydraulic fracturing, fluids are injected at a rate high so that the fluid pressure in the wellbore exceeds the tensile strength of the formation, rupturing the rock.

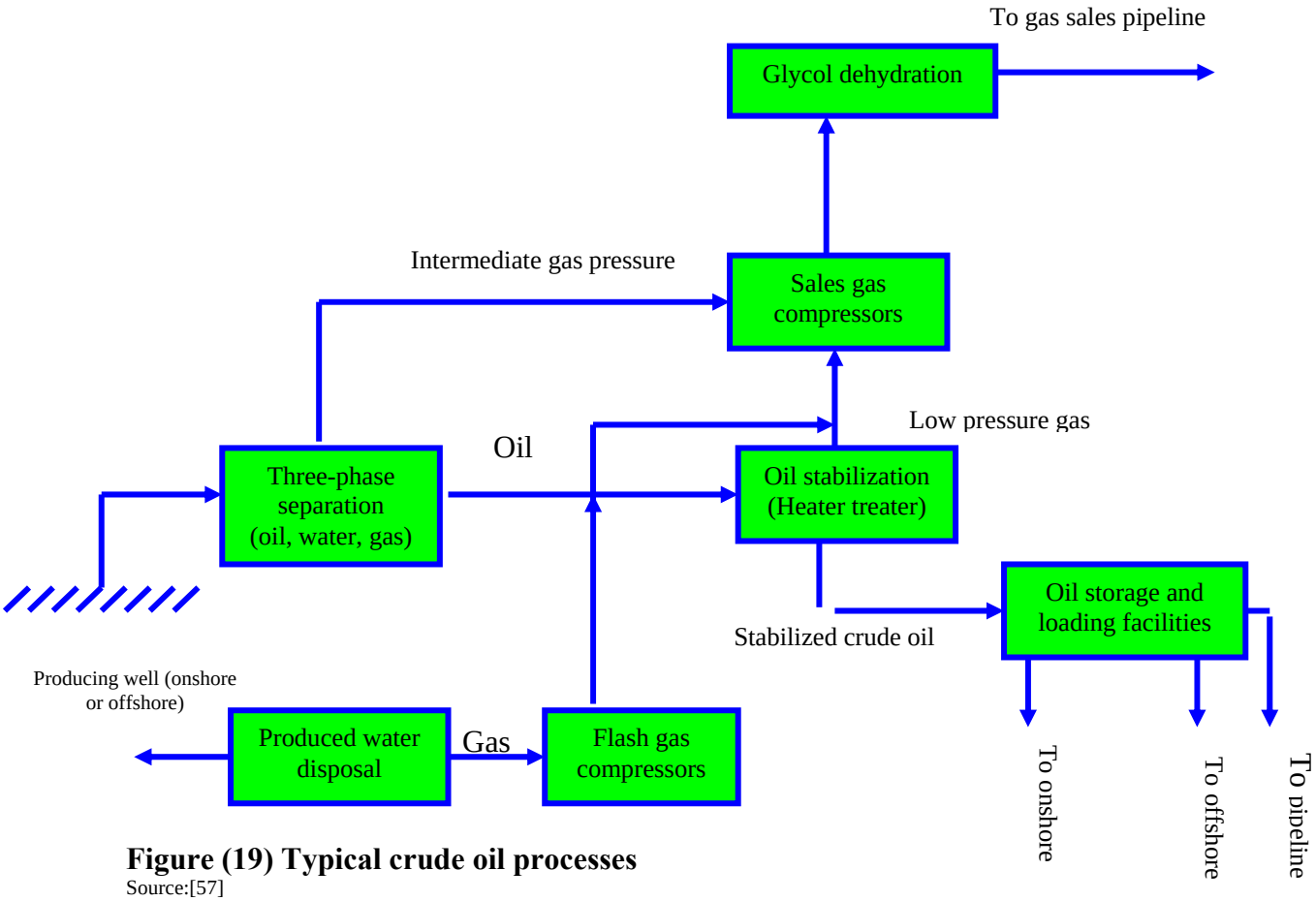

Figure (19) Typical crude oil processes
Source:[57]

3.1.4 Decommissioning and rehabilitation

The offshore and onshore industries install facilities and equipments required to produce hydrocarbons. These facilities and equipments become redundant when the hydrocarbons are no longer economic to produce and become subject to removal and disposal. The decommissioning of onshore production installations at the end of their commercial life may involve removal of buildings and equipments, in order to restore the site to environmentally sound conditions. For such sites, there is also a need to implement measures to encourage re-vegetation on them and they should be continuously monitored. In offshore operations, when the production from certain sites is no more economical, then the installed equipments should be removed and recycled or reused in other production operations [66]. The decommissioning of offshore structures is also subject to international and national laws. Hence, to facilitate the decommissioning process, it is recommended that offshore decommissioning should be dealt on a case-by-case basis [57].

Planning for decommissioning is an integral part of the overall production process. There are, however, certain common steps that should be followed in any decommissioning process. The basic generic steps in any decommissioning process are shown in Figure 20.

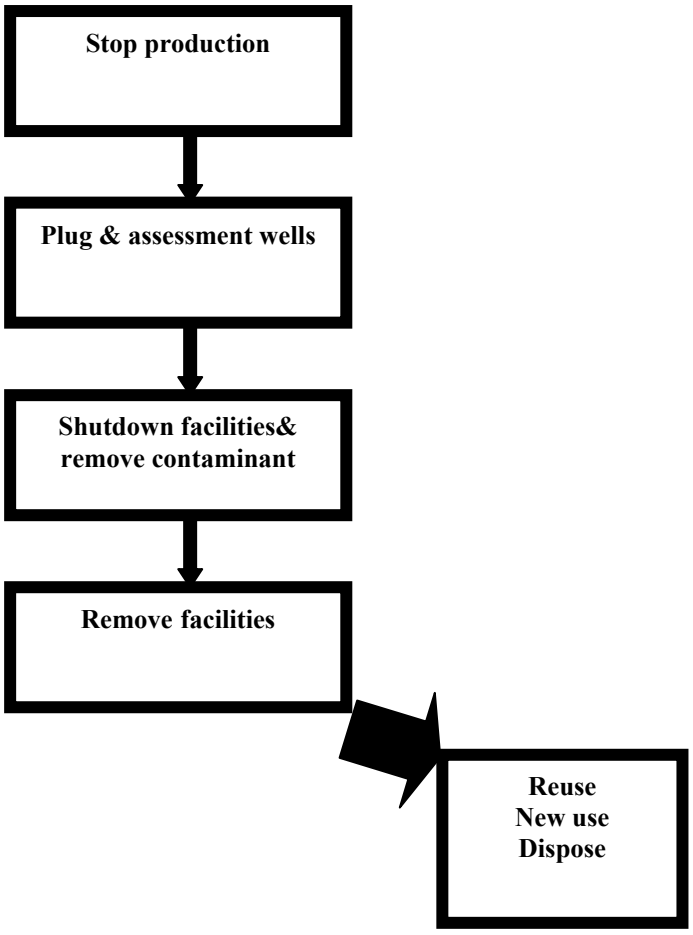

Figure (20) The decommissioning process
Source: [66]

3.2 Classification of the exploration and production wastes

All industries regardless of their functions generate some forms of waste. The exploration and production of oil and natural gas results in substantial volumes of wastes. Wastes from the exploration and production (E&P) segment of the oil and gas industry fall into the following four primary categories[67]: produced water, drilling waste, associated wastes and industrial wastes.

3.2.1 Produced water

Produced water is the largest waste-stream source in the entire exploration and production process. Over the economic life of a producing field, the volume of produced water can be more than 10 times the volume of hydrocarbon produced [68]. However, the volumes of produced water vary considerably both with the type of oil or gas production and throughout the lifetime of field. Thus, a cost effective and environmentally acceptable disposal of these waters is critical to the continued economic production of petroleum [126]. Produced water contains impurities including:

- Dissolved solids, the most common is salt and heavy metals,
- Suspended and dissolved organic materials,
- Formation solids,
- Hydrogen sulphide,
- Carbon dioxide,
- Oxygen depletion [68].

Produced water may also contain low levels of Naturally Occurring Radioactive Materials (NORM) and contamination of NORM can be expected at nearly every petroleum facility. Some NORM can be sufficiently severe that maintenance and other personnel may be exposed to hazardous concentrations [69]. In addition to naturally occurring impurities, chemical additives like coagulants, corrosion inhibitors, emulsion breakers, biocides, paraffin control agents and scale inhibitors are often added to alter the chemistry of produced water. A variety of those chemicals are often added to the produced water to avoid problems such as corrosion, microbial growth, suspended particles, foams, scale, and dirty equipment[75]. However, most of the water produced could it treated mechanically, chemically and biologically and subsequently re-injected to the subsurface either for disposal or for secondary recovery operation.

3.2.2 Drilling waste

Drilling waste is a result of the drilling fluid. An oil or gas well simply cannot be drilled without a continuous circulation of the drilling fluid to facilitate the drilling of the hole. Water based drilling fluids may contain viscosity control agent, density control agents (e.g., barium sulfate), deflocculants, (e.g., chrome – lignosulfonate or lignite), (sodium hydroxide), lost circulation materials and formation compatibility agents. Oil based drilling fluids also contain a base hydrocarbon and chemicals to maintain its water in oil emulsion [63], [70]. The drilling waste stream principally includes drilling cutting, excess or spent drilling

fluid, rig wash, precipitation that enters the reserve pit, water from such rig activities as pump lubrication, and wastes from cementing operations [125]. Both the U.S. Environmental Protection Agency (EPA) and the American Petroleum Institute (API) studied the drilling waste stream extensively and identified arsenic, benzene, sodium, cadmium, chromium, boron, and chloride as the constituents that pose the greatest human health and environmental risks [85].

3.2.3 Associated wastes

A variety of small volume waste streams that encompasses all other types of wastes are associated with oil and gas production. Associated wastes include the oily wastes, emulsions, and workover fluids, solids which are collected in surface equipment and tank bottoms, pit waste, scrubber wastes[x], stimulation wastes from fracturing and acidizing, wastes from dehydration and sweetening of natural gas[z], transportation wastes, and contaminated soil from accidental spills and release [119],[71].

3.2.4 Industrial wastes

These wastes are not uniquely associated with oil and gas production but they are nonetheless generated at well sites:

- Paint,
- Spent solvents,
- Used lube oil,
- Packaging material.

3.3 The potential environmental impacts

Petroleum exploration and production have the potential for a variety of impacts on the environment. These ‘impacts’ depend upon the stage of the process, the size and complexity of the project, the nature and sensitivity of the surrounding environment and the effectiveness of planning, pollution prevention, and mitigation and control techniques. The phases of upstream operations described in Table 5, are aerial survey, seismic survey, exploration drilling, production and development, and decommissioning and rehabilitation [57]. However, Oil and gas activities occupying large areas involve emissions and discharges of

[x] Scrubber waste is the gases that are emitted from the combustion process. Fore ample: fly ash is a potential chemical scrubber for acidic waste.
[z] Sweetening of natural gas is the technology of obtaining natural gas containing little or no H_2S.

pollutants in all phase from the first seismic surveys until fields are shut down and installations are removed [75]. In the stage of exploration, noise from surveying aircraft, helicopters and seismic explosions may cause animals to flee from the area. The seismic crew also may contribute to erosion. Improper disposal of waste from base camps can lead to contamination of local water and food supplies and environmental degradation [72]. In the stage of drilling and production, in cases of improper handling, discharge of waste and toxic substances during drilling can pose a threat to the surrounding environment and communities. Ground water is particularly sensitive to contamination, leading to profound health impacts on wildlife and local people. The most significant source of water pollution during drilling is inappropriate disposal of formation water that is extracted along with oil from the well and contains oil, high levels of chlorides and heavy metals [76]. This resulting contamination of ground and surface water can lead to serious impacts on local people, animals and vegetation [74], [118]. In the stage of the decommissioning and rehabilitation improper controls can result in soil and water contamination.

There are several types of potential impacts, which including human, socio-economic and cultural impact, atmospheric, aquatic, and terrestrial impact. Table 6 provides an overview of potential impacts in relation to the environmental component affected and the source and operational activity under consideration.

Table (6) Overview of potential impacts related to exploration and production activities

Activity in onshore	Source	Potential impact/aspect	Component affected
Aerial	Aircraft	Noise	At/B
Seismic operations (Onshore)	Seismic equipment	Noise	At/B
	Base camps	Noise/light	At/B
		Access/footprint	At/B/Aq/T
	Line cutting	Access/footprint	B/Aq/T
Exploration and appraisal drilling (Onshore)	Roads	Access	At/B/Aq/T
	Site preparation	Footprint	At/B/Aq/T
	Camp and operations	Discharges emissions waste	At/B/Aq/T
	Decommissioning and aftercare	Footprint	B/Aq/T
Development and production (Onshore)	Roads	Access	B/Aq/T
	Site preparation	Footprint	B/Aq/T/At
	Operations	Discharges wastes emissions	B/Aq/T/At
Decommissioning and rehabilitation (Onshore)	Remove and restoration	Footprint	
Seismic operations (Offshore)	Seismic equipment	Noise	B
	Vessel operations	Emissions and discharges	Aq/T/At
Exploration and appraisal drilling (Offshore)	Site selection	Interactions	B/Aq
	Operations	Discharges emissions waste	B/Aq/T/At
	Decommissioning	Footprint	B/Aq
Development and production (Offshore)	Site selection	Interactions	B/Aq
	Operations	Discharges wastes emissions	B/Aq/T/At
Decommissioning and rehabilitation (Offshore)	Remove and restoration	Footprint	B/Aq

Source: [57]
T= Terrestrial; Aq=Aquatic; Atmospheric; B= Biosphere

3.3.1 Aquatic impacts

The principal aqueous waste streams resulting from upstream operations are; first, produced water, second, drilling fluids, cuttings and well treatment chemicals, third, process, wash and drainage water, forth, sewerage, sanitary and domestic wastes, fifth, spills and leakage. The volumes of the waste produced depend on the stage of the exploration and production process. During seismic operations, waste volumes are minimal and relate mainly to camp or vessel activities. In exploratory drilling, the main aqueous effluents are drilling fluids and cuttings, whilst in production operations, after the development wells are completed, the primary effluent is produced water.

The E&P Forum waste management Guidelines[T] summarise waste streams, source and possible environmentally significant constituents, as well as disposal methods. Water-based drilling fluids have been demonstrated to have only limited effect on the environment. The major components are clay and bentonite that are chemically inert and non-toxic. Some other components are biodegradable, whilst others are slightly toxic after dilution [105]. Oil- based drilling fluids and oily cuttings, have an increased effect due to toxicity and redox potential. The oil content of the discharge is probably the main factor governing these effects.

Ocean discharges of water-based mud and cuttings have been shown to affect benthic organisms through smothering to a distance of 25 meters from the discharge and to affect species diversity to 100 meters from the discharge. Oil-based muds and cuttings affect benthic organisms through elevated hydrocarbon levels to up 800 meters from the discharge. The physical effects of water-based mud and cuttings the threshold criteria for gross effects on community structure has been suggested at a sediment base oil concentration of 1000 parts per million (ppm), although individual species showed effects between 150 ppm and 1000 ppm [128]. The pH and salt content of certain drilling fluids and cuttings poses a potential impact to fresh-water sources.

The environmental impact of produced waters disposed to other receiving waters other than the open ocean is highly dependent on the quantity, the components, the receiving environment and its dispersion characteristics. However, discharge to small streams and enclosed water bodies is likely to require special care. Other aqueous waste streams such as leakage and discharge of drainage waters may result in pollution of ground and surface water. Impacts may result particularly where ground and surface waters are utilized for household purposes or where fisheries or ecologically important areas are affected.

3.3.2 Atmospheric impact

Atmospheric issues are attracting increasing interest from both industry and government authorities worldwide. In order to examine the potential impacts arising from exploration and production it is important to understand the sources and nature of the emissions and their relative contribution to atmospheric impacts, both local and those related to global issues such as stratospheric ozone depletion and climate change. The primary sources of atmospheric emissions from oil and gas operations arise from: firstly, flaring, venting and purging gases, secondly: combustion processes such as diesel engines and gas

[T] These guidelines summarise waste streams, sources and possible environmentally significant constituents, as well as disposal methods. See Exploration & Production (E&P) Waste Management Guidelines. Sept. 1993.

turbines, third, fugitive gases from loading operations and tank age and losses from process equipment, forth, airborne particulates from soil disturbance during construction and from vehicle traffic, fifth, particulates from other burning sources, such as well test.

The volumes of atmospheric emissions and their potential impact depend upon the nature of the process under consideration. The potential for emissions from exploration activities to cause atmospheric impacts is generally considered to be low. However, during production, with more intensive activity, increased levels of emissions occur in the immediate vicinity of the operations. For instance: flaring of produced gas is the most significant source of air emissions, particularly where there is no infrastructure or market available for the gas. However, where viable, gas is processed and distributed as an important commodity. Thus, through integrated development and providing markets for all products, the need for flaring will be greatly reduced [57]. In 2003 the World Bank estimates the annual volume of natural gas being flared and vented worldwide at about 110 billion cubic meters.

3.3.3 Impact of ecosystems

The areas that are affected by hydrocarbon releases, can recover after the hydrocarbon has been removed, although full recovery can take a number of years. One ecosystem that is chronically exposed to hydrocarbons from petroleum is the Gulf of Mexico [78].

Plant and animal communities may also be directly affected by changes in their environment through variations in water, air and soil/sediment quality and through disturbance by noise, extraneous light and changes in vegetation cover. Such changes may directly affect the ecology. For example, habitat, food and nutrient supplies, breeding areas, migration routes or changes in herbivore grazing patterns, may then have a secondary effect on predators. Soil disturbance and removal of vegetation and secondary effects such as erosion and siltation may have an impact on ecological integrity, and may lead to indirect effects by upsetting nutrient balances and microbial activity in the soil.

If not properly controlled, a potential long-term effect is loss of habitat that affects both fauna and flora, and induces changes in species composition and primary production cycles. If controls are not managed effectively, ecological impacts may also arise from other direct anthropogenic such as fires, increased hunting and fishing and possibly poaching. In addition to changing plants and habitat, it is important to consider how changes in the biological environment also affect local people and indigenous population [57], [123].

3.3.4 Oil impacts on terrestrial environment

Soil contamination from petroleum hydrocarbons has an important human and environmental health issue in the world [122]. This contamination has probably occurred since the use of petroleum became widespread during the early part of the twenth century.

The potential exists for humans to be exposed to petroleum constituents in soils through various pathways. Potential pathways of exposure to petroleum hydrocarbons in soil at site depend on the type of soil, and petroleum constituents present [123]. Potential impacts to soil arise from three basic sources: physical disturbance as result of construction, contamination resulting from spillage and leakage or solid waste disposal, and indirect impact arising from opening access and social change. Potential impacts, which may result from poor design and construction, include soil erosion due to soil structure slope. Native vegetation is removed and soil is exposed, soil erosion may result. Alterations to soils conditions may result in widespread secondary impacts such as changes in surface hydrology and drainage patterns, increased habitat damage, reducing the capacity of the environment to support vegetation and wildlife. Soil contamination may arise from spills and leakage of chemicals and oil, causing possible impact to both flora and fauna [57].

3.4 Testing for toxicity

The toxicity of a substance is a test of how it impairs the life and health of living organisms following exposure to the substance. Toxicity is determined through a test protocol (bioassay) by exposing laboratory animals to different amounts of the substance. Bioassays measure the acute toxicity (lethality) on a test population of organisms [75].

Two types of toxicity measurements are commonly used: dose and concentration. The dose is the amount of substance that has been absorbed into the tissue of test species, while the concentration is a measure of the amount of a substance per unit of volume or weight in the environment that the species lives in, which also includes a time interval. The dose is the mass of the substance in the animal tissue (mg) when a particular effect has been observed. A dose that is lethal to 50 percent of the animals is called $LD_{50,}$ while the lowest dose that is lethal, i.e., the dose resulting in the first death, is called LDLO. The dose level required for any particular effect also depends on how the toxic substance is exposed by injection, ingestion, or inhalation [124]. The concentration is the fraction of the substance in soil that causes a particular effect when the target species is placed in that environment. It is a mass fraction in parts per million (ppm) or as mass per unit volume (mg/l). A lethal concentration

that kills 50 percent of the animals within a given period is called $LC_{50,}$ while the lowest lethal concentration for period of time is called LCLO [75], [119].

3.4.1 Toxicity of hydrocarbons

Natural petroleum deposits are composed of organic chemicals. When the chemical mixture is composed of small molecules, it is a gas at normal temperatures and pressures. When the mixture contains larger molecules, it is a liquid at normal temperature and pressure. On the basis of their structure, hydrocarbons are divided into two main classes, aliphatic and aromatic. Aliphatic hydrocarbons are further divided into families: Alkanes, alkynes, and their cyclic analogs. These families are distinguished primarily by how the carbon atoms are bonded to each other and by the presence of elements other than carbon and hydrogen. The relationships between some of these classes and families of hydrocarbons are shown in Figure 21. More details on families of hydrocarbons are given in Table 7. Crude oil contains significant quantities of other elements too, for example, sulphur, nitrogen, oxygen, and heavy metals that makes its characterization further complicated. Crude oil is typically composed of between 50 percent and 98 percent hydrocarbons. Other important components can be sulphur (0-10 percent), nitrogen (0-1percent) and oxygen (0 –5percent). Heavy metals can be found in the parts per million level [78].

The toxicity of hydrocarbons has been found to vary considerably and generalizations cannot be easily made. A factor that affects toxicity is molecular weight. For mixtures of hydrocarbons, such as crude oil, the toxicity also depends on the history of the exposure. For hydrocarbons of the families shown in Table 8, the toxicity tends to increase with decreasing molecular weight. However, light crude oils and refined products tend to be more toxic than those of heavy crude oils. As heavy crude oils have a higher average molecular weight. The toxicity of hydrocarbon families generally decreases as one goes down along the families shown in Table 7. The hydrocarbon families are the low-boiling-point aromatics, particularly benzene, toluene and xylene. The most toxic hydrocarbons also tend to have a high solubility in water. A high solubility makes a molecule more accessible for uptake by plants and animals. The toxicity of a given hydrocarbon varies considerably with the organism exposed. Factors that also affect the toxicity to a particular organism include the general health of the organism and whether the organism is already stressed. Stress factors include water salinity, temperature, and food abundance. The toxicity of crude oil to some fish can be twice as high in seawater as in fresh water. The toxicity of a particular hydrocarbon also appears to increase with temperature [111].

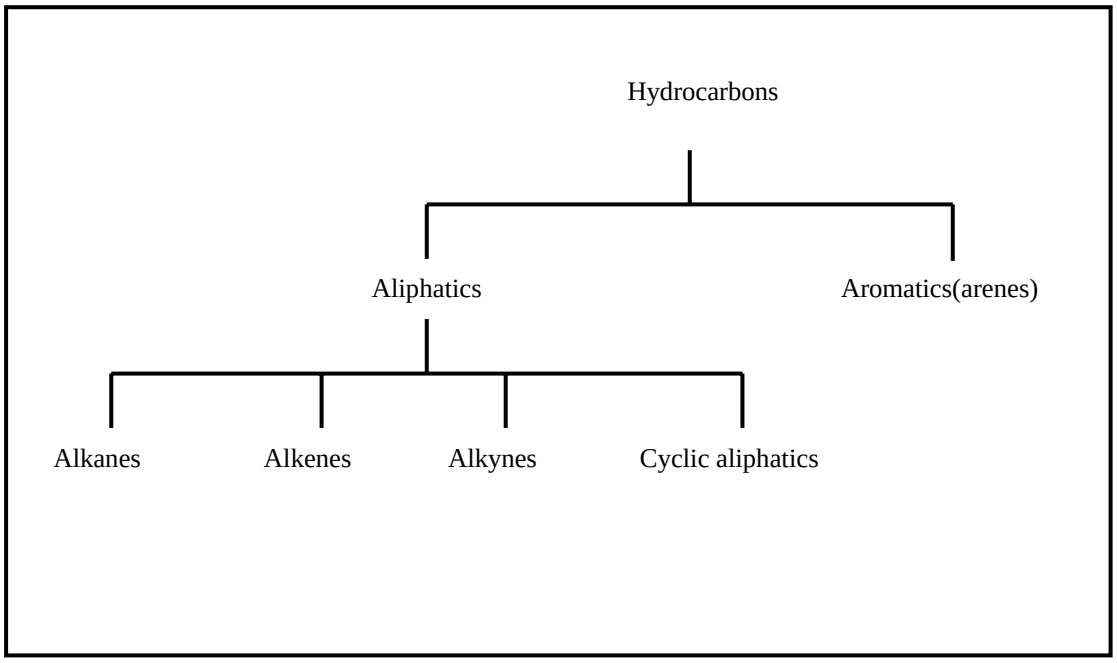

Figure (21) Classes and homologous series of hydrocarbons
Source: [111]

Table (7) Families of hydrocarbons

Family	Example	Formula
Alkanes	Methane Ethane Propane	CH_4 C_2H_6 C_3H_8
Alkenes	Methene Propene	C_2H_4 C_3H_6
Alkynes	Ethyne Propyne	C_2H_2 C_3H_4
Cylic Alkanes	Cyclopropane Cyclobutane	C_3H_6 C_4H_8
Aromatics	Benzene Toluene	C_6H_6 C_6H_5CH

Source: [111]

3.4.2 Drilling fluid toxicity

Drilling fluids, like many industrial chemicals, can be hazardous to humans if not used properly and with appropriate protective equipment. Hydrocarbons, chlorides and heavy metals are the principal sources of toxicity in drilling fluids. These contaminants also occur naturally and are sometimes incorporated into the mud during the drilling operation. Examples include crude oil found in productive formations, salt from massive salt formations, and trace metals contained in organically rich shale's that are drilled out [79]. The toxicity of drilling fluid is determined through bioassays by exposing laboratory animals to different amounts of substance in question. The resulting effects on the health of the animals are observed. Mysid shrimp is the species specified by the US Environmental Protection Agency

for use in drilling–fluid toxicity tests [80]. The shrimps are exposed for 96 hr to a variety of concentrations of the suspended particulate phase of the effluent.

The heavy metals encountered in drilling and production activities may cause a variety of environmental concerns, depending on the metal and its concentration. The concentrations of the various heavy metals in produced water often are higher than those occurring naturally in seawater [68] moreover, very low concentrations, some metals are essential to healthy cellular activity. Essential metals include chromium, cobalt, copper, iodine, iron, manganese, molybdenum, nickel, selenium, silicon, vanadium and zinc [81]

The environmental impact of heavy metals is manifested primarily through their interaction with enzymes in animal cells. General effects include damage to the liver, kidney, or reproductive system, blood forming or nervous system.

The toxicities of many metals found in the upstream petroleum industry have been summarised by the American Conference of Governmental Industrial Hygienists (ACGIH)[x] and are given in Table 8. The Table lists the concentration limits for heavy metals in the form of threshold limit values (TLV). Thus, the concentration of any metal that is higher than this value will be toxic to flora and fauna.

Table (8) Concentration limits for heavy metals

Metal	TLV (mg/m^3)
Aluminum	2.0
Arsenic	0.2
Barium (soluble compounds)	0.5
Barium (barium sulfate)	10
Cadmium	0.05
Chromium (trivalent)	0.5
Chromium (hexaxvalent)	0.05
Lead	0.15
Mercury	0.05
Nickel (soluble inorganic compounds)	0.1
Vanadium (as vanadium pentoxide)	0.05
Zinic (as zinc oxide)	5

Source: Proctor et al., 1989

[x] ACGIH: community of perfessionals advances health and safety through eduction and the development and dissemination of scientific and technical knowledge.

3.5 Summary

The activities of finding and producing petroleum can impact the environment and the greatest impact arises from release of wastes into the environment in concentrations that are not naturally found.

The exploration survey is the first stage of the search for crude oil bearing rock formations to identify major sedimentary basin. During the exploration phase in the search for petroleum, there are no major environmental problems apart form wastes resulting for explosives, cutting of trees during line cutting, and waste resulting for temporary camps.

During the drilling phase in which a hole is made in the ground to allow subsurface hydrocarbons to flow to the surface also results in rock cuttings, fluids and various materials added to the fluid to lift these cutting to the surface.

Production is the process by which hydrocarbons flow to the surface to be treated and used. Water is often produced with hydrocarbons and contains a variety of contaminants.

Poor environmental practices such as unsafe disposal of toxic drilling wastes and gas flaring, generally pose a greater threat to the environment.

In order to reduce the impacts resulting from the activities of the oil and gas industry, governments and the industry itself through their own voluntary initiatives sets some minimum laws. The next chapter will deal with an environmental agreements and guidelines to control environmental impact of the petroleum industry.

CHAPTER FOUR
ENVIRONMENTAL AGREEMENTS AND GUIDELINES TO CONTROL ENVIRONMENTAL IMPACT OF THE PETROLEUM INDUSTRY

It is important for the oil industries to coexist with a regulatory infrastructure that requires a strict adherence to regulations, a basic understanding of the laws, regulations, and methods of operation must be understood not only by the officers of the oil companies, but for every workers even remotely involved with operations.

There are many aspects of oil and gas industry activities that are covered by voluntary initiatives and Multilateral Environmental Agreements (MEAs). Voluntary initiatives are one among a set of instruments, ranging from international agreements and programmes, to national policy, legislation and regulation, to financial sector lending and investment requirements, which can serve the purpose of improving sustainable development practices and the performance of industrial activities. Their effectiveness lies in their capacity to reach beyond government regulations and to get industry to commit of its own free will to goals of improved environmental performance. A MEA is an agreement by several parties to take certain steps to increase protection of the world's natural resources or promote environmental quality. MEAs include international and regional conventions and protocols[87]. Therefore, the chapter will review some of the voluntary initiatives and multilateral agreements that are used to manage and regulate environmental impacts associated with the oil industry[86].

4.1 Voluntary initiatives

A voluntary initiative establishes common principles and statements of intent across subscribing organizations. Such principles are often, providing common policy direction and a broad framework for action. They can be generic, such as the Global Compact or they can be specific sector such as the guidelines and standards of the International Association of Oil and Gas Producers (OGP – formerly the Oil Industry International Exploration and Production Forum) and the American Petroleum Institute (API) The Global Compact is a voluntary international corporate citizenship network initiated to support the participation of both the private sector and other social actors to advance responsible corporate citizenship and universal social and environmental principles to meet the challenges of globalisation.

The compact asks participating companies to embrace ten principles[k] in the areas of human rights, labor standards, environment and anti-corruption.

The OGP represents oil and gas companies from around the world, and the API, through the history of the dominance of US oil companies in the international oil industry has a strong influence in the oil industry. The OGP has prepared several guidelines regarding onshore oil operations, on its own and in conjunction with InterGovernmental Organizations (IGOs) and Non-Governmental Organizations (NGOs) such as United Nations Environment Programme (UNEP), which represent "internationally acceptable operating practices" and "internationally acceptable goals and guidance on environmental protection during oil and gas exploration and production operations", including guidelines addressing: oil operations in tropical rainforests; exploration and production operations in mangrove areas. oil exploration in arctic and subarctic onshore region waste management and decommissioning for onshore exploration and production sites[94] [138] [139] [140] [141].

The US petroleum industry's commitment to protect the environment is embodied in the API's Environmental Stewardship Programme, which is based on 11 Principles[p] contained in the American Petroleum Institute Environmental and Safety Mission and Guiding Principles [90]. These Guiding Principles became part of API's in 1990, therefore the acceptance of the principles is a condition of membership of the API. The API has also produced guidelines for environmental practices including the 1995 guideline on onshore oil and gas production practices for protection of the environment [93].

Other environmental policies, codes, and guidelines for protection of the environment adopted by national and regional oil industry associations include;

- The Australian Petroleum Production and Exploration Association (APPEA) Environmental Policy 1997 and Code of Environmental Practice for companies operating in Australia;
- The United Kingdom Offshore Operators' Association's (UKOOA) Environmental Principles [95];
- World Conservation Union (IUCN) in conjunction with the OGP concerning the formulation of Guidelines for Environmental Protection for oil exploration in the tropics [98].

k The global compact's ten principles., June 24, 2004. See reference [26].

p These principles use sound science to prioritise risks and to implement cost-effective management practices. See reference [90].

4.2 Multilateral environmental agreements

Most environmental problems have a transboundary nature and often a global scope, and they can only be addressed effectively through international co-operation. As aformentioned MEA's are agreements by several parties to take certain steps to increase protection of the world's natural resources or promote environmental quality. They are classified into international and regional conventions and protocols; where a convention provides a general framework for action and protocols outline steps to address specific problems. There are numerous MEA's agreements adopted by the world community, however, this work focuses on conventions related to marine pollutions, since these are the major province of oil occurrences, the Montreal and Kyoto protocols and some major other regional agreements related to oil production [87].

4.2.1 Convention on the prevention of marine pollution by dumping wastes and other matter (London convention 1972; International maritime organisation)

The Convention on the Prevention of Marine Pollution by Dumping Wastes and other Matter, known as the London Dumping Convention (LDC) is a major global instrument that seeks to address the problem of marine pollution, by regulating the disposal of waste at sea from ships, aircraft and man-made structures. The LDC was opened for signature in November 1972. The LDC prohibits the dumping of certain hazardous materials, requires a prior special permit for the dumping of a number of other identified materials and a prior general permit for other wastes or matter. The disposal of wastes or other matter directly arising from, or related to the exploration, exploitation and associated offshore processing of seabed mineral resources are, however, excluded from the provisions of the LDC. In response to the increasing international concern over the issue of offshore abandonment of petroleum installations and facilities, especial meeting of the contracting parties to the LDC adopted a new protocol on november 1996 to clarity position on the issue in question. The definition of "dumping" in the convention was updated and expanded to include explicitly of dumping. Under the LDC Convention, dumping is defined as the following[89]:

- Any deliberate disposal at sea of wastes or other matter from (vessels, aircraft)[r], platforms or other man–made structures at sea;
- Any deliberate disposal at sea of vessels, aircraft, platforms or other man-made structure at sea;

[r] Vessels and aircraft" means waterborne or airborne craft of any type whatsoever. This expression includes air-cushioned craft and floating craft, whether self-propelled or not.

- Any storage of wastes or other matter in the seabed and the subsoil thereof from vessels, aircraft, platforms or other man-made structures at sea;
- Any abandonment or toppling at site of platforms or other man-made structures at sea, for the sole purpose of deliberate disposal.

The convention seeks to control and prevent marine pollution caused by dumping at the sea wastes and other matter from vessels, aircraft, platforms and decommission and abandonment. This means petroleum companies need other options for disposal such as underground or treatment of the waste before disposal. Hence, the LDC is likely to have impact on the profits of oil companies. This reducion in the companies profit may lead to reduction in the exploration which finally will result in lower production.

4.2.2 International convention for the prevention of pollution from ships

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively and updated by amendments through the years. MARPOL is aimed at the shipping industry but it has direct implications for the offshore petroleum operations[97]. The Convention covers pollution by oil, chemicals, and harmful substances in packaged form, sewage and garbage**.** The Convention also includes regulations aimed at preventing and minimizing pollution from ships both accidental pollution and that from routine operations and currently, includes six technical Annexes[r][96]:

- Annex I on regulations for the prevention of pollution by oil
- Annex II on regulations for the control of pollution by noxious Liquid substances in bulk
- Annex III on prevention of pollution by harmful substances carried by sea in packaged Form
- Annex IV on prevention of pollution by sewage from ships
- Annex V on prevention of pollution by garbage from ships
- Annex VI on prevention of air pollution from ships

The MARPOL annex I is covering operational oil pollution, while other annexes covered chemicals, harmful substances carried in packaged form, sewage and garbage.

[r] The Parties must accept Annexes I and II, but the other Annexes are voluntary.

MARPOL and its Annex I goes on to provide that fixed and floating rigs, when engaged in the exploration and exploitation of seabed resources, must apply the rules applicable to ship of 400 tonnes and above[h]. The effect of application of these rules is the prohibition of the discharging of oil and oily mixtures into the marine environment.

MARPOL has similar impacts as that of the LDC in the sense that both focuses on the control of waste dumping from ships into the ocean.

4.2.3 United Nations convention on the law of the sea

The United Nations Convention on Law of the Sea (UNCLOS), also called the Law of the Sea or LOS), was adopted on 10 December 1982 and came into force on 16 November 1996. The Convention establishes a comprehensive legal regime covering all aspects of the seas and oceans. The LOS is designed to consolidate all relevant rules and principle, both customary and conventional, into a single framework convention. The LOS provides a detail on marine environmental protection, which specifies in a comprehensive manner that the states parties to the LOS Convention must take measures to prevent, reduce, control the pollution of the marine environment. As far as offshore operations are concerned, it calls upon member states to take measures to prevent, reduce and control pollution of the marine environment and, in particular:

- Pollution from installations and devices used in exploration or exploitation of the natural resources of the seabed and subsoil, in particular measures for preventing accidents and dealing with emergencies, ensuring the safety of operations at sea, and regulation the design, construction, equipment, operation and manning of such installations[133].

The LOS provides that states shall adopt laws and regulations, which are no less effective than international rules, standards and recommended practices and procedures, to deal with pollution from or in connection with offshore activities; and shall cooperate in the protection of the marine environment on a global and regional basis.

The convention aims to control direct or indirect pollution of the marine environment from installations and equipments used in the petroleum industry. The LOS sets effective rules for the petroleum company to avoid short and long term environmental impacts. The impacts of the convention on the oil industry may be through, strict liability laws create the

[h] Ibid., Regulation 21 of MARPOL Annex

specter of unlimited financial exposure for companies, especially when natural resources damage compensation is involved

4.2.4 United Nations framework convention on climate change

In response to scientific predictions of man-made global warming, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 at the Rio Earth Summit. With 26 Articles, consisting of objectives, principles, commitments and recommendations, the UNFCCC became a blueprint for precautionary action against the threat of global climate change. The ultimate objective of the UNFCCC is to achieve the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. To achieve this objective, parties or countries to the convention that have committed themselves to the UNFCCC, are guided by the following of principles. [134]:

- The global climate should be protected for the benefit of present and future generations;
- Developed nations should take a leading role in combating climate change, in view of the fact that most of the greenhouse gas emissions are from developed nations;
- The needs and special circumstances of developing countries, particularly those vulnerable to climate change, should be given full consideration;
- A precautionary approach to mitigating or preventing the effects of global warming should be adopted, even when full scientific certainty is unavailable, to ensure the greatest possible global benefits at the lowest possible costs.

By adopting the UNFCCC, its objectives and principles, each party is committed to a number of obligations, including the reporting of national greenhouse gas emissions, the development of greenhouse gas emission reduction programmes, the protection of greenhouse gas sinks such as forests, and the provision of education, training and public awareness concerning global warming.

The international community to implement the treaty obligations will have to adopt more specific measures. The actual application of them will unavoidably have an impact on petroleum exploration, production and consumption. In this case, production and consumption

companies need to reduce outputs and inputs respectively in the short-run and implement new technologies in the long-run. This reduction in output and input will lead to reduction in exploration activities.

4.3 Protocols

4.3.1 Montreal protocol of the Vienna convention

The protocol is an international agreement to drastically reduce Chlorofluorocarbons (CFC) production and it was adopted in Montreal. Global cooperation for the protection of the stratospheric ozone layer began with the negotiation of the Vienna convention for the protection of the Ozone Layer, which concluded in 1985. The details of the international agreement were defined in the Montreal protocol on substances that deplete the Ozone Layer. The Montreal Protocol was signed in 1987 and became effective in 1989. The Montreal Protocol contains provisions for regular review of the adequacy of control measures that are based on assessments of evolving scientific, environmental, technical, and economic information. During the evolution of its implementation, as a result of changing conditions and increased information, additional requirements have been added to the Montreal protocol through amendments adopted in London 1990, Copenhagen 1992. The parties to the Montreal protocol agreed to a phase out of controlled substances by the end of 1995.Controlled substances include Chlorofluorocarbons CFCs, halons, carbon tetrachloride, methyl chloroform, and methyl bromide. On September 2002, 183 countries have ratified the Montreal Protocol which sets out the time schedule to "freeze" and reduce consumption of ozone depleting substances (ODS). The Montreal protocol requires all parties to ban exports and imports of controlled substances to and from non-Parties[136].

The impact of air toxics is a significant environmental issue. These are gaseous, aerosol or particulate pollutants which are present in the air in low concentrations but which may be a hazard to human, plant or animal life.they are emitted from a wide range of sources, including petroleum upstream operation and combstion process.The Montreal protocol of the Vienna convention is likely to have an effect on petroleum operations since those reduction requires intensive investment in the new technologies that may in effect reduce the industry’s income.

4.3.2 The Kyoto protocol to the United Nations framework convention on climate change

The Kyoto protocol is a legally binding international agreement to reduce the greenhouse gas emissions causing climate change, which was initially negotiated in Kyoto, Japan in 1997. The agreement came into force on February 16, 2005. The Kyoto protocol is an amendment to the United Nations Framework Convention on Climate Change, an international treaty on global warming. Countries which ratify this protocol, commit to reduce their emissions of greenhouse gases or engage in emissions trading if they maintain or increase emissions of these gases. A total of 141 countries have ratified the agreement. Notable exceptions include the United States and Australia.

The agreement specifies that all parties to the protocol must follow a number of steps including:

- Design and implementation of climate change mitigation and adaptation programmes,
- Preparation of a national inventory of emissions removals by carbon sinks,
- Promotion of climate friendly technology transfer,
- Fostering partnerships in research and observation of climate science, impacts and response strategies.

The emissions targets for the developed countries must be achieved on average over the commitment period 2008 to 2012. The greenhouse gases covered by the protocol are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The aggregate target is based on the carbon dioxide equivalent of each of the greenhouse gases. Each Annex I country (i.e., industrialized countries) has agreed to limit emissions to the levels described in the protocol [137].

Considering the aimed of Kyoto protocol which is limitation and/or reduction of green house gases emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy. The convention imposes identifiable obligations and expectations on governments that could translate into major impacts on these industries, such as through imposition of taxes and other measures designed to reduce development and/or use of fossil fuels. This protocol will have impact on the exploration and production activities in the sense that the protocol aims in reducing green house gases. This means there will be the need to for alternative sources of fuels preferably renewables. The substitute to renewable energy will lead to the reduction in exploration and production activities because there will be reduction in the fossil fuels market.

4.4 Regional agreements

4.4.1 Convention for the protection of the marine environment of the North-East Atlantic (OSPAR Convention)

OSPAR is the name given to the Oslo and Paris Conventions which have the objective of protecting the Northeast Atlantic against pollution. The conventions are managed by a Commission which acts as the forum through which the contracting parties cooperate. The commission normally meets once a year, and been hosted by one of the contracting parties.

The objective of the commission is to administer conventions to regulate and control the dumping at sea of industrial wastes, sewage sludge and dredged material and the incineration at sea. OSPAR administered the Oslo and Paris Convention for the protection of the Marine Environment of the North-East Atlantic (the 'OSPAR Convention') which was adopted in 1992, replacing the earlier Oslo and Paris Conventions adopted in the 1970s that had concentrated on pollution issues affecting the marine environment.

The OSPAR Convention aims to protect the marine environment through the monitoring and control of a wide range of human activities. Over the years, the OSPAR Commission has adopted numerous binding measures (Decision and Recommendation) to carry this work forward, including agreements carried over from the former Oslo and Paris Conventions.

In 1998, the OSPAR Commission released a strategy on hazardous substances. Its objective was to immediately restrict the pollution of the North-East Atlantic by chemicals, to a level that is harmless for human beings and for the environment. The long-term 2020 objective of the strategy is to achieve near zero concentrations of anthropogenic pollutants, and concentrations near to natural background levels for pollutants that also occur naturally. OSPAR is geared to achieving these goals. Substances that are regarded as hazardous in the sense of the OSPAR are put on a dynamic working list. Substances that are particularly toxic and persistent, and are inclined to bio-accumulate are dealt with as priorities[135].

The Oslo and Paris Conventions are the regulatory agreements for the prevention of pollution in the maritime area of the North East Atlantic arising respectively from disposal from ships and aircraft and discharges from land including atmospheric emissions. The impact of the OSPAR on the oil industry is not different from LDC.

4.4.2 Energy charter treaty

The Energy Charter Treaty (ECT) is a unique instrument for the promotion of international cooperation in the energy sector. Following its entry into force on 16 April 1998, the treaty provides an important legal basis for the creation of an open international energy market. The ECT is the first one of its kind to limit its scope specifically to the energy sector[91]. The ECT is a super-regional treaty in the sense that its scope covers the whole of Europe and the members of Commonwealth of Independent States (CIS), plus Japan and Australia. The ECT also includes a separate article (article 19) to address the environmental aspects of investment and trade in energy. The environmental article contains a number of vague provisions:

- It spells out three general principles of sustainable development, prevention and "polluter pays" for parties to observe in implementing their environmental obligations,
- It sets forth a general environmental obligation on contracting parties to strive to minimize harmful environmental impacts from all operations within the energy cycle,
- it provides for eleven actions points for state parties to comply with, which include[133]:
    - Environmental integration in energy policy,
    - Reflection of environmental costs in energy price,
    - Harmonization of environmental standards,
    - Energy efficiency and renewable energy sources,
    - Promoting cooperation and development of environmental sound technologies, etc.

The environmental provisions of the ECT employ quite a few permissive rather than formative terminologies such as take account of, promote, encourage, and upon request. These provisions, therefore, do not create enforceable commitments but function rather as indicators of good practice.

The impact of this treaty can turn adverse on the oil industry. For example, it can on the one hand, enhance the development of renewable energy technologies, and on the other hand, it can discourage the use of fossil fuels. In the case of discourge of use of fossil fuels can result in the reduction of exploration and production activities.

4.5 Summary

The future facing companies in the international oil and gas arena promises expanded and diverse environmental legal challenges. These will generate new and increased legal risks and liabilities for the companies.

The oil and gas industry seems to be covered by numerous voluntary initiatives and Multilateral Environmental Agreements (MEA's) aiming at avoiding environmental problems. The effectiveness of these agreements is in the capacity that they reach beyond government regulations and to get industry to commit of its own free will to achieve goals of improved environmental performance. However, it can be seen that these voluntary initiatives do not results in clean environment at no cost to the oil industry. The conventions basically results in some impacts on both production and the consumption from the industry.

The conventions will have impact on the exploration and production activities in the sense that the objectives of the conventions are to prevent or reduce pollution. This prevention or reduction in pollution will result in reduction in the exploration and production operations.

The next chapter will be dealing with the petroleum industry in Libya. The chapter presents an overview of Libya, the benefits of the petroleum industry to the economy, the petroleum and gas reserves and finally of the environmental laws applicable to the petroleum industry.

CHAPTER FIVE
THE PETROLEUM INDUSTRY AND ENVIRONMENTAL LAWS IN LIBYA

5.1 General information

The earliest days of Al-Qadhafi rule following his 1969 military coup, Col. Muammar Abu Minyar al- Qadhafi has espoused his own political system, the Third Universal Theory. The system is a combination of socialism and Islam derived in part from tribal practices and is supposed to be implemented by the Libyan people themselves in a unique form of "direct democracy". Figure 22 and Table 9 provide general information about Libya.

Figure (22) Libyan map
Source: [108]

Table (9)General information about Libya

Capital	Tripoli
Population	5.45 million
Area	1,759.54 km^2
Coastline	1,770 km
Land use	Arable land: 1.03 percent
Permanent corps	0.17 percent
Other	98.8 percent
Border Countries	Algeria 982 km, Chad 1, 055 km, Egypt 1,115 km, Niger 354 km, Sudan 383 km, and Tunisia 459 km.
Natural resources	Crude oil, natural gas and gypsum.
Currency	1 Libyan dinar = 1,000 dirhams
Language	Arabic
Continent	Africa

Source: : [108]

5.1.2 Overview of the Libyan oil industry: Libya's National Oil Corporation and subsidiaries

Libya's oil industry is run by the state-owned National Oil Corporation (NOC), along with subsidiary companies, which, all taken together, account for around half of the country's oil output. NOC was established on 12th November 1970, under Law No: 24/1970, to assume the responsibility of the oil sector operations [129]. NOC carries out exploration and production operations through its own affiliated companies. NOC also participates with other companies under service contracts or any other kind of petroleum investment agreements.

Of NOC's subsidiaries, the largest oil producers are the Arabian Gulf Oil Company (AGOCO) and Waha Oil Company (WOC). AGOCO oil production is coming mainly from the Sarir, Nafoora, and Messla fields. AGOCO's production was estimated by NOC at around 430,000 bbl/y in 2003. WOC was created in 1986 to take over operations from Oasis Oil Company, a joint venture of NOC 59.16 percent, Conoco 16.33 percent, Marathon 16.33 percent, and Amerada Hess 8.16 percent. WOC is among the Libyan companies that were affected by the US embargo. This is due to the fact that its oilfields are equipped mainly with old US equipment, for which WOC cannot acquire needed spare parts. As a result, production at WOC has fallen sharply, from about 1 million bbl/d at its peak in the late 1980s to around 300,000 bbl/d in 2002[108].

Two other large NOC subsidiaries are the Zueitina Oil Company (ZOC), which operates the five Intisar fields in the Sirte Basin, and the Sirte Oil Company (SOC), created in 1981 to take over Exxon's holdings in Libya. SOC operates the Raguba field in the central part of the Sirte Basin. SOC is also in charge of two other gas fields (Attahadi and Assumud) plus the Marsa el-Brega liquefied natural gas (LNG) plant.

NOC owns refineries and oil and gas processing companies. They own operating refineries such as Zawia and Ras Lanuf refineries, and also ammonia, urea, methanol, Ras Lanuf petrochemical complex and the gas processing plants.

5.1.3 Economic importance

Libya is one of the major oil producers in Africa. The country is also the biggest oil supplier to Europe among other oil supplies from North Africa.[104].

Libya has proven reserves of 39 billion barrels of oil and a production capacity of 1.4 million barrels per day. Italy, Germany, Spain and France account to 74 percent of Libya's export. Libya's economy is based on oil revenue, which accounts for 95 percent of Libya's hard currency. These earnings were hurt severely by the dramatic decline in oil prices during 1998, as well as by reduced oil production in part as a result of UN sanctions. With higher oil

prices since 1999, however, Libyan oil export revenues have increased sharply, to 13.4 billion in 2003, up from $ 5.9 billion in 1998. Due to higher oil export revenues, Libya experienced strong economic growth during 2003 and 2004, with real gross domestic product (GDP) estimated to have grown by about 9.8 percent and 7.7 percent respectively.

Despite Libya's relatively strong recent economic growth, unemployment remains high as the country's population grows rapidly and new jobs are not created rapidly enough. In addition, Libya's relatively poor infrastructure, a bloated public sector (as much as 60 percent of government spending goes towards paying public sector employees' salaries), and huge public work programmes (i.e., the "Great Man Made River" project)[h], have posed impediments to foreign investment and to economic growth [108].

In 2003, the economy has undergone a gradual process of liberalisation by the government. This came in the form of the issuance of regulations for the privatisation of certain government–owned enterprises and private businesses are allowed to operate in the country. In addition, the Libyan government also pledged to bring Libya into the world Trade Organization (WTO). Foreign involvement in Libya was severely reduced as a result of the sanctions and embargoes emplaced upon it especially between the years of 1992 and 1999. Since the UN sanctions were lifted in 1999, the government of Libya has tried to make the country attractive to foreign investors including a recent relaxation of foreign exchange controls. Libya is hoping to reduce its dependency on oil as the country's sole source of income, and to increase investment in agriculture, tourism, fisheries, mining, and natural gas. Libya also is attempting to position itself as a key economic intermediary between Europe and Africa. It has become more involved in the Euro-Mediterranean process and has pushed for a new Africa Union. The foreign relations of the country might see some developments as Libya continues efforts to establish an African Union with other countries in the region. The economic outlook for Libya is uncertain although this should not be immediately interpreted in a negative light. The recent developments in this arena look encouraging. For instance, the efforts of the government to attract a foreign investment which shows a commitment on their part to provide a safe environment for those wishing to invest in the country's oil business.

[h] The "Great Man Made River" project an enormous, long-term undertaking to supply the country's needs by drawing water from aquifers beneath the Sahara and conveying it along a network of huge underground pipes.

5.1.4 Oil production

The oil and gas industry had its beginning in 1859 in the state of Pennsylvania in the United States. It was 100 years later when the oil fields were discovered (at Amal and Zelten, now known as Nasser) in Libya [102]. In Libya oil exploration began in 1955, with the key national Petroleum Law No. 25 enacted in April of that year. Libya's first oil fields were discovered in 1959 and oil exports began in 1961.

Figure 23 illustrates the trend in Libyan oil production from 1970 to 2010. Libyan peak oil production was 3.3 million bbl/d in 1970, with a marked decline to 1.5 million bbl/d due to government production restrictions during the period 1970 to 1974, before rising again to 2.1 million bbl/d in 1979. During the 1980's, Libyan oil production averaged approximately 1.2 million bbl/d, rising to approximately 1.4 million bbl/d in 1990's. Between the years of 1992 and 1999, Libyan oil production was hardly reduced as a result of the sanctions emplaced upon it. With the full lifting of sanctions, Libya is looking for foreign companies to increase the country's oil production capacity from 1.5 million bbl/d in 2003 to 2 million bbl/d by 2010[24]. During 2004, Libyan oil production was estimated at nearly 1.6 million bbl/d, with consumption 237,000 bbl/d and net export 1.34 million bbl/d. Libya is considered a highly attractive oil exploration due to its low cost of oil recovery [108].

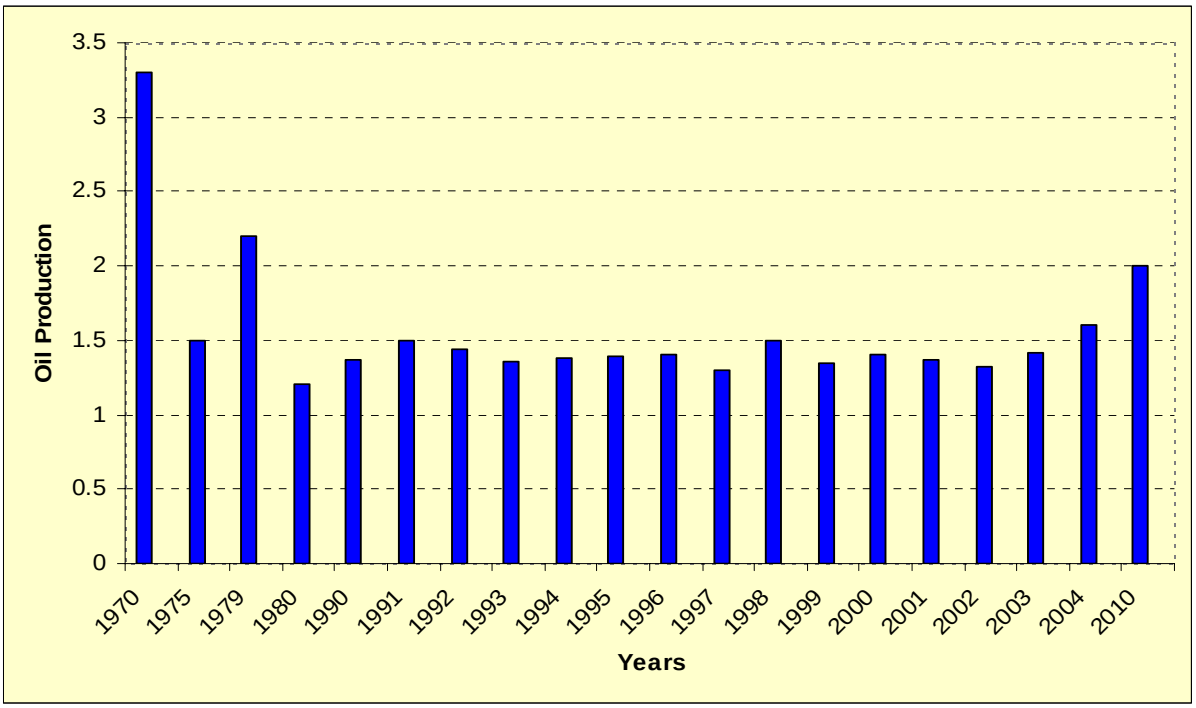

Figure (23) Libya's oil production from 1970 to 2010
Source: adopted from NOC

5.1.5 Gas production

Natural gas production remains a high priority for Libya for two main reasons. Firstly, Libya has aimed to use natural gas instead of oil domestically, freeing up more oil for export. Secondly, Libya has vast natural gas reserves. Natural gas production rose in line with oil production and peaked in 1979 at a rate of 2.2 billion cubic feet per day [103]. By 1994 production had fallen to 1.2 billion cubic feet per day. Approximately one-third of the total production is for industrial use or reinjected. In 1970, Libya became the second country in the world (after Algeria in 1964) to export liquefied natural gas (LNG). Since then, Libya‘s LNG exports have generally languished largely due to technical limitations, which do not allow Libya to extract Liquefied Petroleum Gas (LPG) from the LNG, thereby forcing the buyer to do so. At present, Libyan gas exports to Europe are increasing rapidly with the Western Libyan Gas Project (WLGP) and $ 6.6 billion “Greenstream” underwater gas pipeline coming online. Previously, the only customer for Libyan gas was Spain’s Enagas. The WLGP joint venture between Eni and NOC has expanded these exports to Italy. The supply is starting in 2005 at around 280 billion cubic feet (Bcf) per year of natural gas [108].

Libya is looking to increase its gas exports, particularly to Europe. To expand its gas production, marketing and distribution, Libya is looking to foreign participation and investment. The future of Libya’s gas production, thus, depends upon new investment and the use of up to date technological innovations [129].

5.1.6 Oil and gas reserves

The determination of petroleum reserves is a highly contentious issue. The official reserves claimed by the Libyan government in 1999 were 29.8 billion barrels. This is a significant increase over the official government estimates of 22.8 billion barrels in 1986, which remained unchanged from 1986 to 1994[103]. In 2004, according to the Oil and Gas Journal, Libya has total proven oil reserves of 39 billion barrels [25]. However, according to the NOC, Libya remains highly unexplored, and it has an excellent potential for more oil discoveries. In addition, despite years of oil production, only approximately 25 percent of Libya’s area is covered by agreements with oil companies [129].

Historically, Libya's onshore oil production has been found mainly in three geological trends of the Sirte Basin. Firstly, the western fairway, which includes several large oil fields (Samah, Beida, Raguba, Dahra-Hofra, and Bahi). Secondly the northern (between north and center) of the country, which contains the giant Defa-Waha and Nasser fields, as well as the large Hateiba gas field. Thirdly, an eastern trend which has large fields like Sarir, Messla,

Gialo, Bu Attifel, Intisar, Nafoora-Augila, and Amal Overall, Sirte Basin contains approximately 80 percent of Libya's proven oil reserves and accounts for 90 percent of production [108]. Asides from Sirte, NOC priorities for new exploration include areas in the Ghadames and Murzuq basins plus barely explored areas such as Kufra basin and Cyrenaica-Batnan basin. Ghadames is Libya's second most explored basin, and is linked geologically with oil and gas structures in Algeria and Tunisia. Murzuq has been a successful area for oil and gas exploration in recent years, with new fields including the El Sharara and Elephant fields.

Continued expansion of natural gas production remains a high priority for Libya, as Libya has vast gas reserves. In January 2005, Libya's natural gas reserves were estimated by the oil and gas Journal at 52 trillion cubic feet (Tcf) although its reserves are largely unexploited and unexplored and could be as much as 70-100 Tcf [25]. Major producing fields include Attahadi, Defa – Waha, Hatiba, Zelten, Sahl. One of Libya's priorities is the expansion of natural gas sector[129].

5.2 Stresses on the environment

The rapid increase in the awareness of environmental impact of petroleum operations by both governmental and non-governmental organisations has led to efforts by the petroleum industry in minimizing the environmental impacts of its operations. It is clear that the effectiveness of EMS requires not only looking at the policies guiding them, but also all component attributes must be comprehensively reviewed, for example drilling operations with their corresponding environmental impacts, organizational requirements, legislation both international and national and political influences in the operating region. Society's need for oil and gas, and the political and industrial responses to these needs, all place a stress upon the environment. The life cycle of the oil industry is shown in Figure 24. The upstream industry covers the stages from exploration to the transport of oil to land terminals. Stresses on the environment in the upstream industry are caused primarily by routine discharge and accidental spillage of oil from platforms and ships and of chemicals used in production. The downstream industry covers the stages from refining to the disposal of used oil. Stresses include emissions from refineries, spillages of petroleum products from storage, release of air pollutants by combustion, and contamination from discarded oil [115].

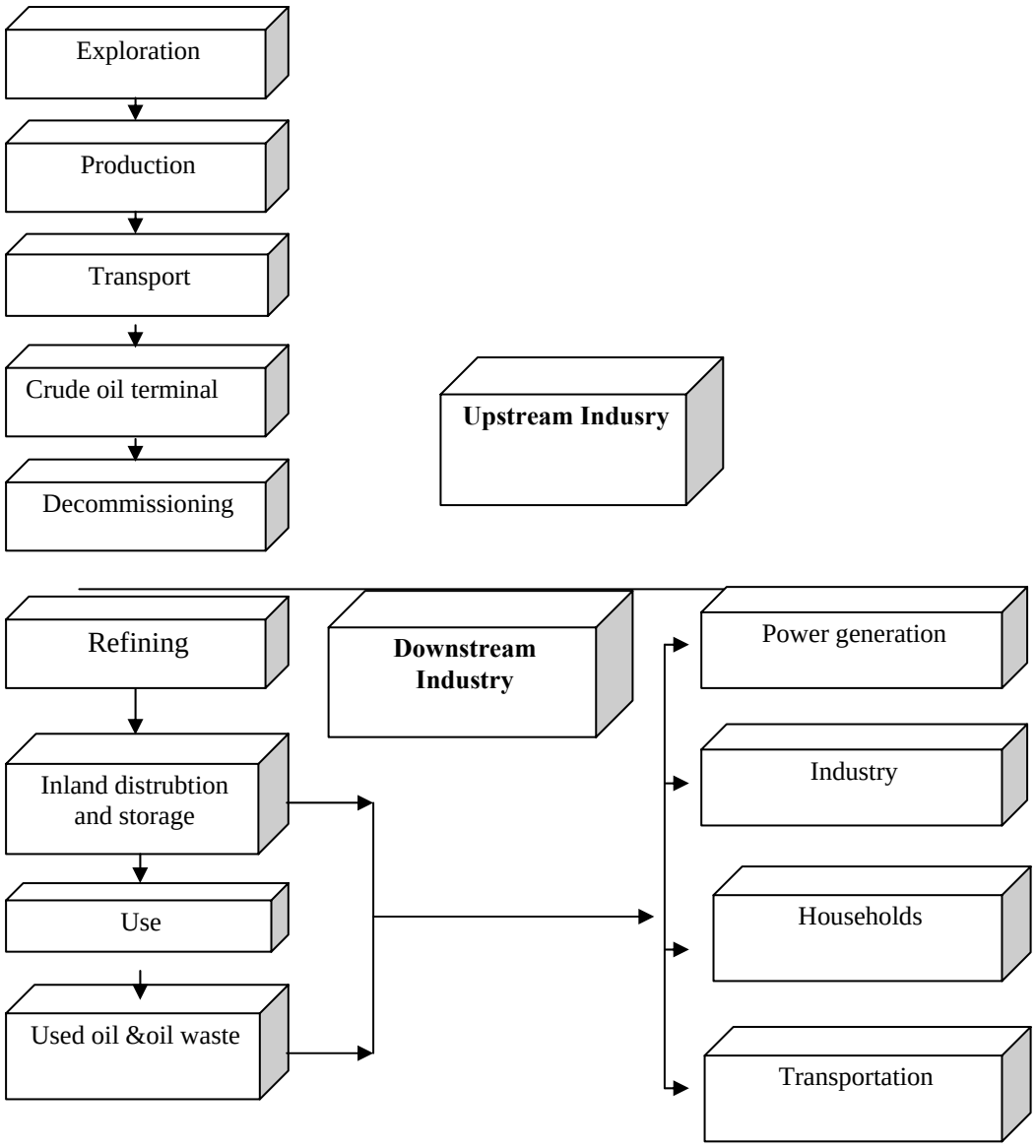

Figure (24) The life cycle of the oil industry
Source: environmental agency

5.3 Environmental laws in the Libya oil industry

In general, environmental protection was not influential in Libya over the past years, although a law on the environment exists (Law No 7/82). This might be due to the political problem that led to isolate Libya from the rest of world. The opening up of the economy of Libya to the rest of the world resulted in Libya an increased concern about environmental protection in priority of the government, which led to a new law on the environment in 2003 in the Libyan congress on the current environmental issues and created some awareness in the environmental issues [124]. This awareness also resulted in the issue of Libyan law on the environment (Law No 15/03) and the NOC HSE Work Programme. The Programme is overseen by the NOC which aims to promote national policies to protect health and the

environment and integrated approach to link economic,environmental and social policies. Therefore, companies are increasingly concerned to achieve and demonstrate sound environmental performance by controlling the impact of their activities, products or services on the environment. The actual implementation of strategies and methods requires minimizing environmental impacts of petroleum operations. It is apparently difficult to effectively implement an EMS without strong legislative backing from the government. However, for a company to strictly adhere to the legislation and policy of environmental issues requires examination and consideration of operational and legal requirements of the law. International agreements on environment have also played an active role as far as awareness on Libyan environmental awareness is concerned, as a result of Libya being party to convention on Biological diversity, the United Nations Framework Convention on Climate Change, the Convention on the International Trade in Endangered Species of Wild Flora and Fauna, the Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Convention of the prevention of Marine Pollution by Dumping Wastes and other Matter, the Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, and the Montreal Protocol on Substances that Deplete the Ozone Layer.

5.4 Summary

Libya’s oil production continued at moderate to low rates due to market conditions and OPEC Quota. However, Libyan oil industry remains to have a great potential to enhance its oil production capabilities by maximizing asset value through optimising production and recovery.

So far, environmental laws are not influential in Libya. However, an increased concern about environmental protection is now becoming priority of the government due to the opening up of the economy to the rest of the world. The opening up of the economy needs an adoption of international standards to be competitive in the global market place and as one of the main objective of the work, which aim at using AGOCO as a case study to integrate ISO 14001 EMS in Libya. Hence, the next chapter gives a brief introduction to this Arabian Gulf Oil Company (AGOCO). The chapter highlights the main oilfields of the company, the production and the potential environmental impacts of its operations.

CHAPTER SIX
ARABIAN GULF OIL COMPANY

AGOCO was the first oil company that is completely owned by NOC after the nationalization decisions[k]. It is one of the biggest oil companies in Libya and also stands as one of the largest oil companies in North Africa. AGOCO was established in 1971, as a result of nationalization of the British Petroleum Company (BP) shares, under law (115/71)[109].

AGOCO operates five major oil fields i.e., Sarir, Messla, Naffora, Beda and Hammada. The company also operates an oil terminal and a refinery in Tobruk and Sarir. Figure 25 shows six sedimentary basins in Libya and fields location of AGOCO[109].

The Sarir oil field which was discovered in 1961 and it is situated in the southeast part of Libya is one of the largest in Libya. The Messla field, which was also discovered in 1984, is situated five hundred kilometres south east of Benghazi and it is considered as one of the biggest fields in the Sirte basin.

The Nafoora field is situated in the northern east part of the Sirte basin the field was discovered in early 1965. The EL Beda and El Hamada fields were both discovered in the same year, 1959 but are situated eastern in Sirte basin and on the southern border of Grahames basin respectively.

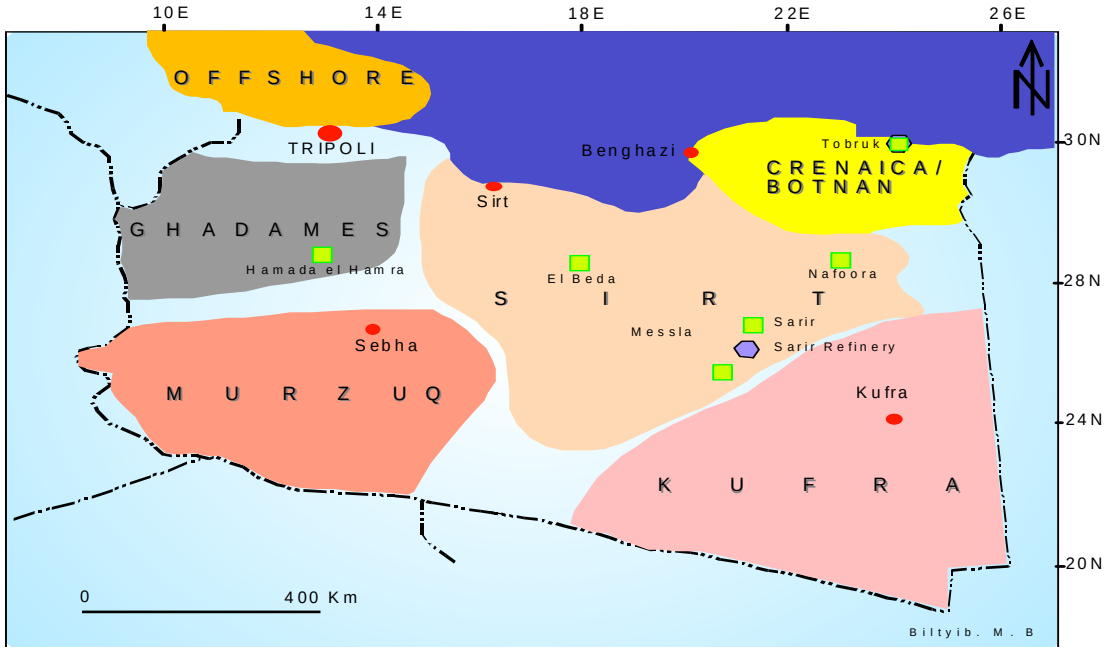

Figure (25) Sedimentary basin in Libya and AGOCO fields location
Source: Modified after NOC 2004

[k] The revolutionary council issues nationalization decisions on the 7th of December 1971 to nationalize the shares of foreign companies in Libya.

The Sarir refinery started operation in 1989 is designed to refine ten thousand barrels of oil per day. The fuel supply from the refinery meets the requirements of the Sarir agricultural project as well as for the area. The Tobruk refinery started in the early 1980's and by 1989 the refinery entered the production phase. In 1990, the refinery was affiliated to AGOCO after being run directly by the NOC. The refinery is designed to refine twenty thousand barrels of oil per day.

The Marsa El Hariega Terminal (Tobruk) is situated on the southern coast of Tobruk trade port. Construction of the terminal started by the end of 1964, and was completed two year later. Marsa El Hariega terminal was inaugurated by the export of the first load of crude from Sarir field in 1967. The crude from Sarir is pumped through 513 km of "34" pipeline, with an auxiliary pumping station between Sarir field and the terminal. The Marsa El Hariega terminal has become quite apparent from the bold achievements of AGOCO over the years that the company has extensively developed and improved from the outset of it's formation in 1971.

AGOCO‘s main business is the production of crude oil from its oil fields in the desert and pumping the crude oil through hundreds of kilometres of pipelines to the coast. Most of the oil is for export and the remainder is sent to the refineries.

AGOCO production amounts to approximately 40 percent of Libyan crude oil [109]. In Figure 26, AGOCO’s oil production in the year 2004 is shown. Oil in large volumes from AGOCO is produced from Sarir, Messla, and Nafoora respectively. The Bede and Hamad fields are old fields, but they are considered as “dead” fields unless new technology is implemented to enhance the recovery of oil that is difficult to extract.

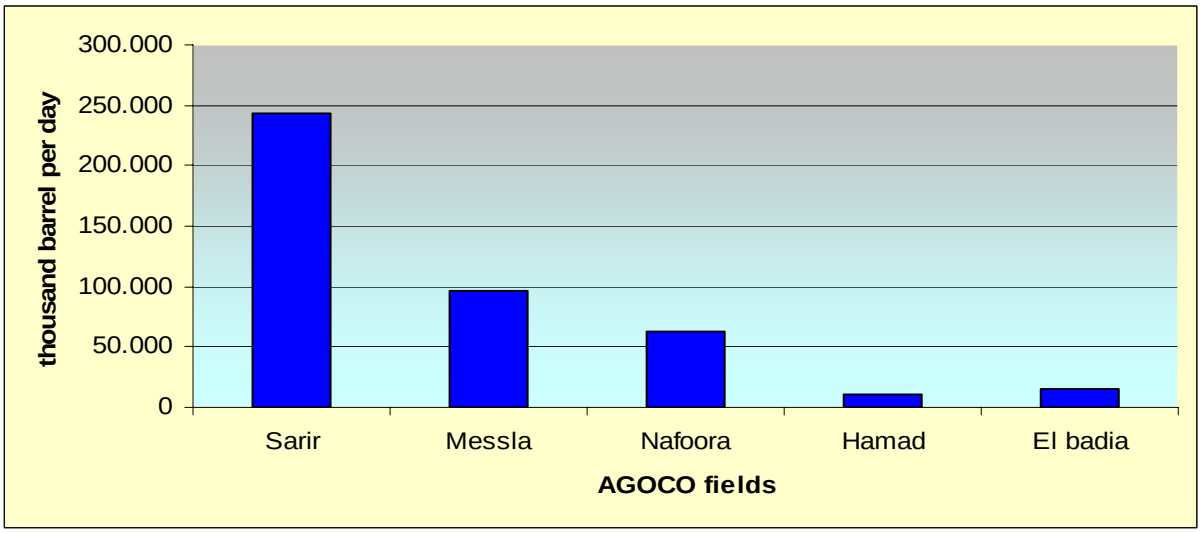

Figure (26) AGOCO oil production in 2004

Source: AGOCO2004

6.1 AGOCO operations and their potential environment impact[z]

6.1.1 Operation

6.1.1.1 Exploration survey by AGOCO

The exploration survey is the first stage of the search for hydrocarbon bearing rock formations. Geological maps are reviewed in desk studies to identify the major sedimentary basins. Since the beginning of the discovery in 1960, the Seismic Reflection Method (SRM-2D) applied by AGOCO. The seismic energy being generated by vibrosesis truck or use explosives as energy source in the area of deepest sedimentation. vibrosesis truck, vibrators the flat pad suspended under the middle of the truck. Once the truck reaches the specified point, this pad is used to raise the 20,000 kg truck entirely off the ground. The hydraulics then shakes the truck up and down on this central piston for a specified time and over a precisely controlled frequency band. Using explosives, the waves propagate through the earth and reflect when reaching a transition between rocks with different physical properties. The waves are reflected (bent) back to the earth's surface where the energy is detected by geophones and recorded by a computer. After that, an office analysis data include seismic processing and interpretation.

6.1.1.2. Exploration drilling by AGOCO

Drilling operations in AGOCO are similar to other oil companies in the world that push a drill bit against the rock and rotating it until the rock wears way. Before the drilling well is started, there is a step necessary that is known as well planning.

- **Well planning by AGOCO**

Proper planning of drilling an oil or gas well in AGOCO is the key to optimising drilling costs. The first step in planning a well is gathering of all available data on similar or nearby past drilled wells and analyses. For example, the information required for planning a well is depth determination, type of geological formations, and hole size.

- **Types of base mud used by AGOCO**

The main function of the drilling fluid is to replace the cuttings from the well during drilling and carry it to the surface. AGOCO uses water based mud for vertical drilling, the basic liquid can be saltwater, fresh water, or saturated water, depending on the availability of

[z] All information about AGOCO through personal communication with some staff at the company.

made up water and the necessary mud properties. Water based mud is composed of water plus highly colloidal clay such as Bentonite, Caustic Soda, Polymer, Defoamer, Shale Stabilizer, Calcium Carbonate, and Cellulose-R. The use additives are required throughout drilling operations in the event of lost circulation, stuck pipeline and other unexpected drilling problems. However, the drilling mud (additives) is the main source of the viscosity and the density of the drilling mud. AGOCO uses oil based mud for horizontal drilling, as oil base mud serves a wide range of applications. Oil based muds are used in order to avoid problems of hole enlargement when drilling through shale sections. Oil based muds is used whenever temperatures are too high for water base muds and corrosion is expected to be severe, e.g. when the formation contains hydrogen sulphide.

- **Types of drilling used by AGOCO**

AGOCO drills vertical and horizontal wells. Vertical wells are drilled in the early stage of the development of the fields. Horizontal wells are drilled to stimulate the production in the 'poor producer' wells to restore oil production by improving the formation permeability and increasing the inflow of the damaged wells especially in sand stone formations (e.g. Sarir oil field Messla oil fields). Figure 27 shows a typical horizontal well by AGOCO in the Sarir field Horizontal wells are costing more than vertical wells.

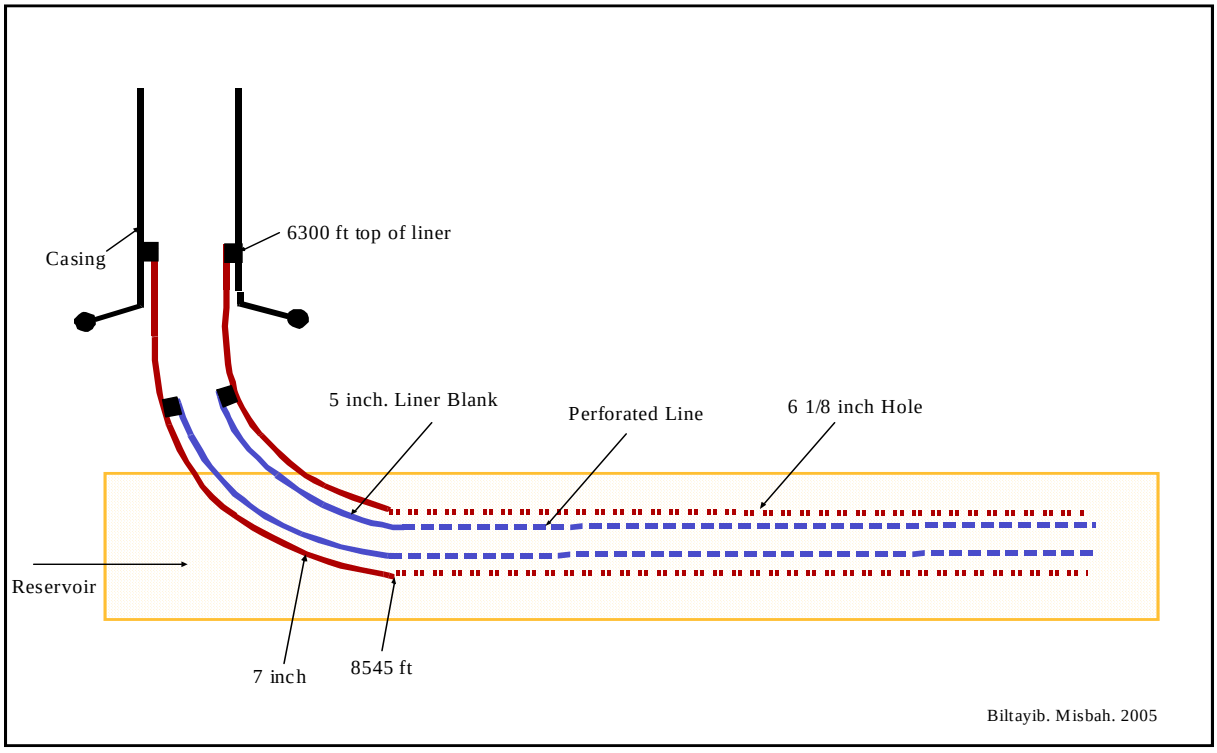

Figure (27) Horizontal well

6.1.1.3. Production and development by AGOCO

Production wells in an oil field recover petroleum through primary or enhanced recovery methods. Primary recovery uses natural reservoir pressure to move the oil to the main well shaft, where it can then be pumped to the surface. Normally, this pumping delivers no more than 25 percent or 20 percent of the total petroleum in the reservoir and hence the greater quantity of the valuable oil is left insitu.

In order to increase the recovery rate in Libya, the majority of the oil companies use some kind of artificial lifting mechanism to produce their liquid to the surface. The types of artificial lift mechanism used in Libya are gas lift, chemical, water, sucker rod pumps and electrical submersible pumps (ESP). In a typical gas lift system, compressed gas is injected through gas lift mandrels and valves into the 'production string[y]'. The injected gas lowers the hydrostatic pressure in the production string to re-establish the required pressure differential between the reservoir and well bore, thus causing the formation fluids to flow to the surface. Chemical solutions optimise the performance of production, refining, and other treatment requirements. Water is commonly used as a base fluid for hydraulic fracturing[z], because it is inexpensive and inflammable. Sucker rod pumps are used in the case of low productivity.

AGOCO fields use submersible pumping, because it is considered as an effective and economical means of lifting large volumes of fluids from great depths under a variety of well conditions. Submersible pumping equipment is used to produce as low as 200 b/d and as high as 60,000 b/d of fluid from depths up to 15,000 ft. The oil cut may also vary within very wide limits, from negligible amounts to 100 percent. The typical submersible pumping unit consist of an electric motor, seal section, intake section, multistage centrifugal pump, electric cable, surface installed switchboard, junction box, and transformers. Optional equipment may include a pressure sentry for sensing bottom hole temperature and pressure as well as check, and bleeder valves. The submersible pump is also used in producing high viscosity fluids, gassy wells, and high temperature wells.

It is well known that the gas lift method requires a large amount of gas to bring the oil to the surface. AGOCO field produces some associated gas with the oil, which is not enough for a gas lift technique.

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[y] The production string is typically assembled with tubing and completion components in a configuration that suits the wellbore conditions and the production method. An important function of the production string is to protect the primary wellbore tubulars, including the casing and liner, from corrosion or erosion by the reservoir fluid.

[z] Hydraulic fracturing increases the permeability around a well bore by creating a high permeability channel from the wellbore into the formation. During hydraulic fracturing, fluids are injected at a rate high enough.

6.1.2 Potential environmental impact by AGOCO operations

6.1.2.1. Potential impact of exploration survey by AGOCO

Oil operations can have profound impacts on the surrounding environment even if it never results in promising reservoirs of oil or leads to any drill activity. The source of the environment problem that accompanies an exploration survey of AGOCO are vibrosis truck, use explosives, equipment, and line cutting. The impact of vibrosesis truck is through the access to natural areas that may destroy vegetation and disturb wildlife. An explosive uses potential impacts, disturbance to human, birds and wildlife. Seismic activities and shot hole drilling causes disturbance to human, birds, fish and animal. Line cutting cause possible erosion, changes in drainage patterns and surface hydrology.

6.1.2.2 Potential impact of exploration drilling by AGOCO

The drilling of oil and gas well has the potential for adverse environmental impacts. The major impact in which drilling activities can impact the environment is through the drill cuttings and the drill fluid used to lift the cuttings from the well. The dill fluid, with suspended cuttings, then flows back to the surface in the annulus between the drill string and formation. At the surface, the cuttings are separated from the fluid; the cuttings, with some retained fluid are then placed in pits for later treatment and disposal. Secondary impacts can occur due to air emissions from the internal combustion engines used to power the drilling rig. For instance, methane and carbon dioxide are considered the main contributors to the enhanced greenhouse gas effect. The most common method for the disposal of drilling wastes by AGOCO wells are on site earthen pits. Most are unlined and many have received a wide variety of wastes during the drilling and production history of the facility.

Earthen pits, depending on the nature of the waste material and the type of underlying soil can lead to difficult and expensive reclamation problems, especially in sandy soils. Operators are encouraged to examine alternatives to the use of earthen pits and to take a proactive approach to the total restoration of existing pits. Priorities for the restoration should be placed on those pits with high environmental risk.

Most pits were constructed by excavating into native sands or subsoil and most do not have any form of additional lining to prevent leakage. Produced water, unburned fluids from the flare line and the residue from incineration is leached downward by the natural infiltration of rain and the pressure of the hydraulic head of the fluids in the pit. Sandy soils are permitting contaminants to easily migrate to the underlying soil and groundwater. Some of the

pits have received other forms of waste, so there is considerable potential for groundwater pollution from these sources.

There are several types of pits and ponds found in AGOCO:

- Oily flare pits (e.g., at oil batteries),
- Salt water pits (e.g., blow down of gas wells),
- Oily produced water retention and separation pits,
- Other earthen pits which collect process fluids and lubricating oils, and
- Buried pits and large surface or buried spills that have not been properly reclaimed [124].

Drilling operations by AGOCO can cause significant impact on the environment. According to AGOCO current practice of disposal waste to earthen pits. AGOCO disposal waste is unacceptable and causes unknown adverse environmental impacts.

6.1.2.3 Potential impact of production and development by AGOCO

In the production of oil, the production activities described above have the potential to release gases, vapours, and pollutants into the atmosphere and also have the potential to pollute both surface and underground waters, and leakage**.**

Ol and gas production facilities have potential to release gases, vapour and pollutants to the atmosphere. Emissions to the atmosphere from sources other than flare stacks, engine exhausts. Examples include leaking flanges, valves and packing glands, boilers, tank vents, deep hatches, vessel relief and other occasional sources. The gases, which escape, could include natural gas (methane). Volatile organic compounds (VOCs), are hydrogen sulphide or specific pollutants that causes health hazards,e.g., benzene.

Produced water is carried to the surface with the natural gas and the hydrocarbon liquids.

As produced water is the largest source of aqueous waste arising from AGOCO operations, it is important to understand potential impacts to the environment. Produced water from AGOCO's operations is contaminated with many types of substances such as, H2S, NORM, salts, lead, nickel, which are pumped up with the oil/water emulsion from the well. In addition, chemicals are added to the oil/water emulsion during the production and operating phase. These process chemicals may include biocides, de-emulsifiers, anti-corrosives, and glycols as contaminants in the water. The AGOCO practice of disposal-produced water is injected produced water to the surface (see Figure 28), or re-injection of produced waters into the reservoir. AGOCO's current practice of the disposal of produced waters to the desert is unacceptable and causes unknown adverse environment impacts.

The environmental impact of produced waters disposed to receiving waters and soils is highly by AGOCO. Release of produced waters resulted in contamination to the receiving environment and resulted in the pollution of soils, surface waters.

Figure (28) Disposal of produced waters to the desert in the AGOCO Sarir field
Source: Biltayib. Misbah (2004)

Oil leakages have significantly effect on the soil, ground and surface. The animals and birds most at risk are those that could come into contact with contaminated areas. The leakage of crude oil, oil products and chemicals in AGOCO caused by equipment failure (including corrosion) human error (storage overflow), and natural events, such as storms. The number of leakage accidents in AGOCO fields from 2000 to 2002 is shown in Figure 29. From the figure it can be seen that the leakage accident from 2000 to 2001 was almost constant. However, there was a significant change in leakage accident from 2001 to around 37,5 percent.

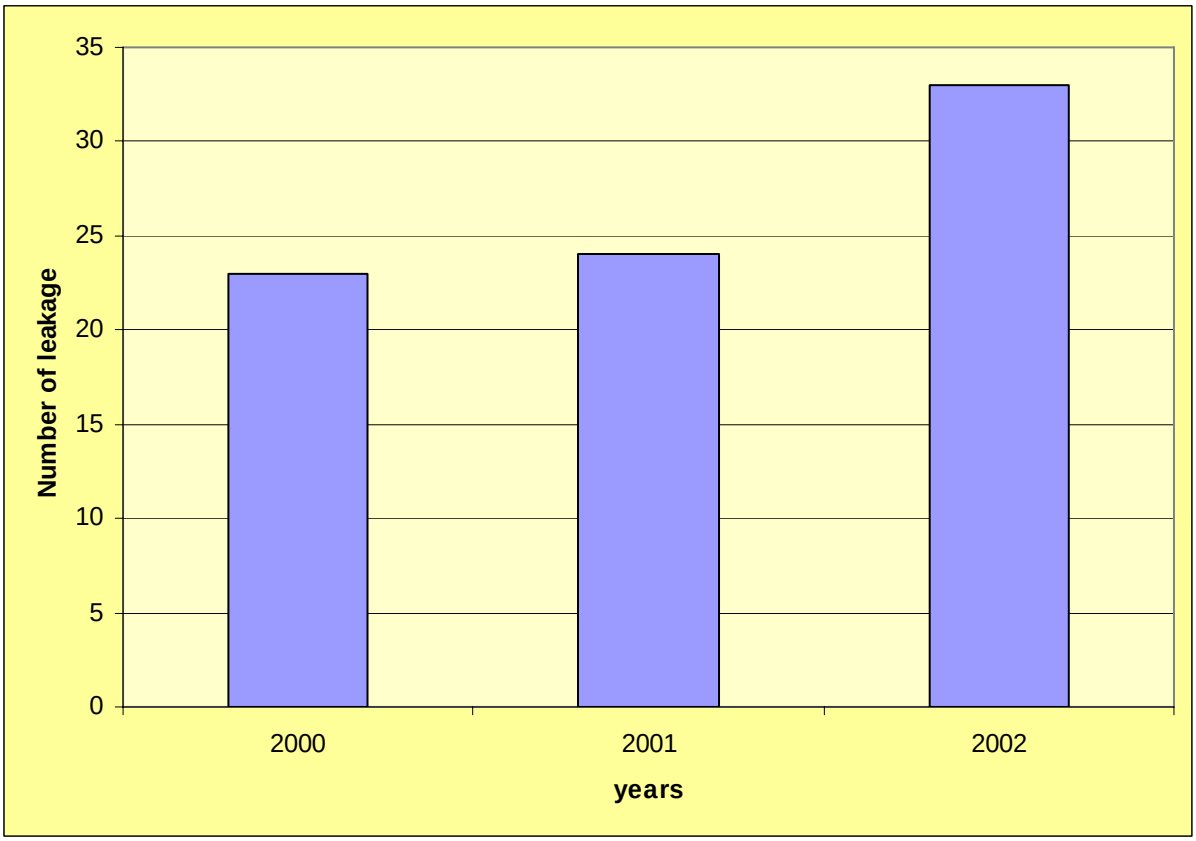

Figure (29) Leakage accident by AGOCO for 2000-2002
Source: [109]

6.2 Summary

AGOGO is one the major oil producing companies in Libya. The company is also an effective member of National Oil Corporation in Libya. The company's upstream operations could have significant impact on the environment if environmental problems are not well managed. Recently, it happened that the disposal of drilling waste to the earthen pits and the discharged water from the operations was not properly handled.

If the environmental problems are not properly managed by AGOCO, the operations can affect the health and pose risk to field personnel, the communities and the country as a whole. To be prevented or reduce the problems posed above there is the need to implement some basic environmental management tools, systems or procedure. Hence, the subsequent chapters will be focused on the basic steps to guide AGOCO to avoid or prevent these environmental problems. It starts with an introduction to Environmental Management Systems and further evaluate the current level of environmental management systems by AGOCO and later use this result as the basics to guide AGOCO to implement an internationally accepted environmental management system (ISO 14001).

CHAPTER SEVEN
INTRODUCTION TO ENVIRONMENTAL MANAGEMENT SYSTEMS AND EVALUATION THE CURRENT LEVEL OF AGOCO'S ENVIRONMENTAL COMMITTMENT

7.1 Introduction

Rising environmental issues in Libya as result of petroleum production have encouraged the Libyan National Oil Corporation putting measures in place to avoid environmental impacts. A personal visit to the company and communication with some of the technical staffs revealed that the company is putting measures in place to control environmental problems associated with production.

AGOCO is one of the largest oil producers company in Libya, there is a need to put measures in place to control its environmental impacts, since more oil production result in environmental impacts. To achieve this environmental mission, it is recommended for AGOCO to go above local standard[k] and to focus internationally. Hence, ISO 14001, which is an internationally accepted standard, is recommended.

Setting up an EMS in accordance with ISO 14001 would result in a more competitive position of AGOCO in the international market. Besides being competitive in the international market, AGOCO can also reduce the environmental impacts of its operation and make an efficient of natural resources. Moreover, ISO 14001 can assist AGOCO in putting in place a more systematic approach in meeting environmental and business goals contributing to the following:

- Corporate image
- Less insurance payments
- Investment opportunity
- Improved worker health and safety
- Improved internal communication
- Enhance customer trust
- Improved company morale
- Reduced operation cost

[k] National oil company, health, safety and environment work programme- 2003 and Libyan environment ministry, environment law number 15, 2003.

As the main objective of the research is to guide AGOCO to implement EMS in accordance with ISO 14001, there is a need to review the current management system to identify the strengths and weak areas in the system. This is because one cannot evaluate what is not measured. Hence, this section focuses on an initial review of AGOCO's current environment management system.

7.2 ISO 14001 Environmental Management System (EMS)

In the early 1990s, with rising concern over environmental barriers to trade and the growth of increasingly stringent environmental regulations at national levels, representatives from business, industry, and governments came together to craft a set of voluntary environmental management system standards (ISO14000). The International Organization for Standardization (ISO) proposed a set of environmental management system (EMS) guidelines that seek to constantly improve environmental management by industry [117]. ISO 14001 EMS specifies requirements for an environmental management system, to enable an organisation to formulate a policy and objectives taking into account legislative requirements and information about significant environmental impacts. Thus, to formulate an effective environmental policy, the organizations can incorporate all the requirements of the ISO 14001 into their own environmental management systems [110].

ISO 14001 has been written to be applicable to all types and sizes of organisations and to accommodate diverse geographical, cultural and social conditions.The basis of the approach is shown in Figure 30. The success of this system depends on commitment from all levels and functions, especially from top management. A system of this kind enables an organisation to establish, and assess the effectiveness of, procedures to set an environmental policy and objectives, achieve conformance with them, and demonstrate such conformance to others. The overall aim of the standard is to support environmental protection and prevention of pollution in balance with socio-economic needs[110].

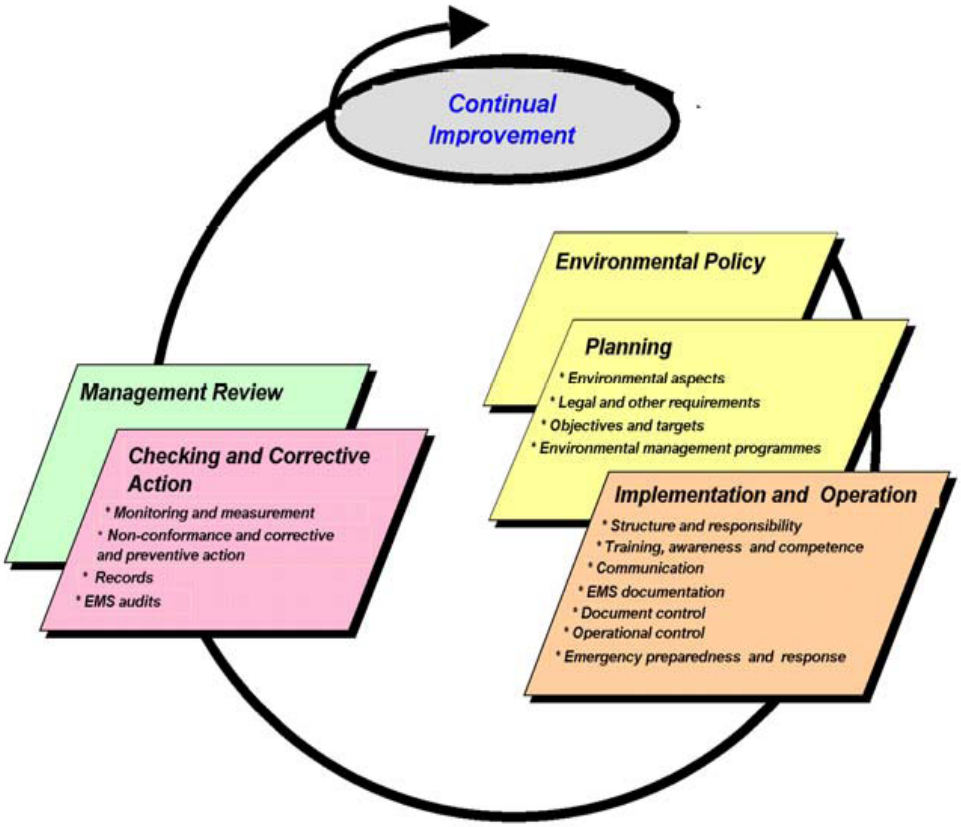

Figure (30) Environmental management system model for ISO 14001

Source: courtesy of ISO14001 international standrad

7.3 Initial environmental review

An environmental review is an intial comprehensive analysis of the environmental management system and the issues, impacts and performance of activities at a site. The purpose of this intial review is to asses the current position of the organisation with regard to the environmental management system and the impacts of a site's activities[77].

The initial environmental review assists the company to understand which of the 17 ISO 14001 elements are covered by the existing management system. At this stage, the current environmental management system in AGOCO was reviewed using the elements of the ISO 14001 standard as shown in Figure 30.

7.3.1. Policy

AGOCO drafted an environmental policy in April of 2004 which is shown in box 1

Box (1) AGOCO environmental policy

AGOCO's Environmental Policy

It is the policy of the Arabian Gulf Oil Company (AGOCO) to conduct all aspects of its business in compliance with all government laws and regulations. AGOCO is committed to conduct all operations in diligent manner designed to minimize adverse impacts on the environment, the health of its employees and the well being of the people in the communities in which AGOCO operates.

- AGOCO will assess the potential effects of all its projects and will integrate protective measures during the planning process to prevent or reduce impacts on the environment, public health and safety.
- AGOCO will endeavor to ensure its employees are supplied with proper training and equipment to enable them to efficiently carry out the intent of this policy.
- Despite all the best efforts of AGOCO, should environmental impairment occur, AGOCO will make all necessary efforts to correct the damage in a timely and efficient manner.
- It is the responsibility of all AGOCO employees and all contractors, to follow and support this policy through attention to proper training, appropriate equipment, policies, procedures and emergency response plans.
- It is the responsibility of all supervising levels of each division of AGOCO to maintain and enforce this environmental policy and environmental procedures in accordance with the company's existing loss prevention policy, regulations and procedures.

The environmental policy statement required under ISO 14001 is the keystone upon which the entire environmental management system is constructed [143]. The environmental policy is the central focus of the environmental management system. The policy must contain and clearly communicate the following for the organization:

- appropriate to the organization's environmental impacts
- provides a framework for setting environmental objectives and targets
- commitment to continual improvement
- commitment to prevention of pollution
- commitment to comply with environmental laws and regulations, and other requirements to which the organization subscribes
- communicate it to all employees
- commitment to communicate the environmental policy to the public[110].

For the environmentally policy of AGOCO to be conformance with ISO 14001, the policy must address the above requirements under environmental policy in accordance with ISO 14001.

From box 1, it can be concluded that the environmental policy is very comprehensive in the sense that it addresses various important issues such as: compliance with applicable laws and regulations, identification of environmental aspects in order to reduce impacts, safety, training and emergency situations. However, the policy is not sufficient to address all the requirements as far as international standard are concerned. The policy is silent on the requirement of continual improvement and the requirement about external communications as contained in ISO 14001.

7.3.2 Planning

Planning starts with identifying the environmental aspects of activities the organization controls (i.e., the components of those activities that are likely to interact with the environment) and understanding how those aspects impacts the environment. Management then sets objectives and targets for reducing identified impacts and develops managerial programmes for achieving them, including a mechanism for identifying applicable legal and other requirements [112].

7.3.2.1 Environmental aspects

From the company's environmental response procedures manual[p], it can be seen that AGOCO has identified a general list of environmental aspects related to drilling and production operations and oil and gas pipelines. A description of associated environmental issues is shown in appendix A.

Considering environmental aspects in appendix A, one sees that AGOCO has a general definition of the environmental aspects of drilling, production and pipeline operations but that of seismic activities were left undefined. Moreover, there is no procedure to identify environmental aspects of the activities to enable significant aspects to be idenitified as required by ISO 14001 EMS.

[p] Environmental response procedures manual is environmental procedures Manual for AGOCO, (June 2004) contained, environmental policy, and general environmental consideration for planning and environmental operating codes of practice. Benghazi, Libya. See appendix (C).

7.3.2.2 Legal and other requirements

An interview with some of the technical personnel in the company revealed that the laws enacted by the Libyan environmental administration have been submitted to the NOC, which in turn sends them through post to the oil companies. All new laws and regulations are received through similar procedures through the appropriate AGOCO representative(s). The Libyan oil companies are subjected to the Libyan governmental laws and regulations in Table 10. However, no procedure exists to ensure that the company will identify and access all new and modified legal or other requirements applicable to activities, products and services as far as ISO 14001 is concerned.

Table (10) Libyan environmental laws and regulations

Year	Number	Focuses
1982	7	On the environment
2003	15	On the environment
2003	N/A	HSE

Source:AGOCO 2004

7.3.2.3 Objectives and targets

From a personal visit to the company's offices and some interviews with some of the technical personnel in the company, it could be seen that AGOCO has objectives, such as minimizing spills at all facilities, but AGOCO has no specific target as far environmental performance. For example, setting target to reduce oil spill by 10 percent by January 2008. There is also no procedure to ensure that these objectives are reviewed and maintained regularly as far as ISO 14001 is concerned.

7.3.2.4 Environmental management programme(s)

From the company's environmental response procedures manual and a personal visit to the company's offices. AGOCO has environmental programme to achieve its objectives. The deficiencies in the environmental programme, as far as ISO 14001 is concerned, are the means and time-frame by which these objectives are to be achieved.

7.3.3 Implementation and operation

Implementation and operation encompasses defining roles and responsibilities, developing programmes for training and awareness, establishing avenues for communication inside and out side the organization, maintaining documentation, and planning for operational control and emergency response.

7.3.3.1 Structure and responsibility

Figure 31 shows the management structure of AGOCO. This structure is focused entirely on exploration, production and supply rather than integration environmental issues into the entire objectives of the company. This structure will not be effective, considering the entire objectives and the comprehensive nature of environmental issues.

From the company environmental manual AGOCO has five main divisions which environmental issues managed. These are chairman, division general managers, senior management environmental committee, manager/superintendents and field supervisors or coordination and on- site representatives. The composition and functions are described below the management structure .

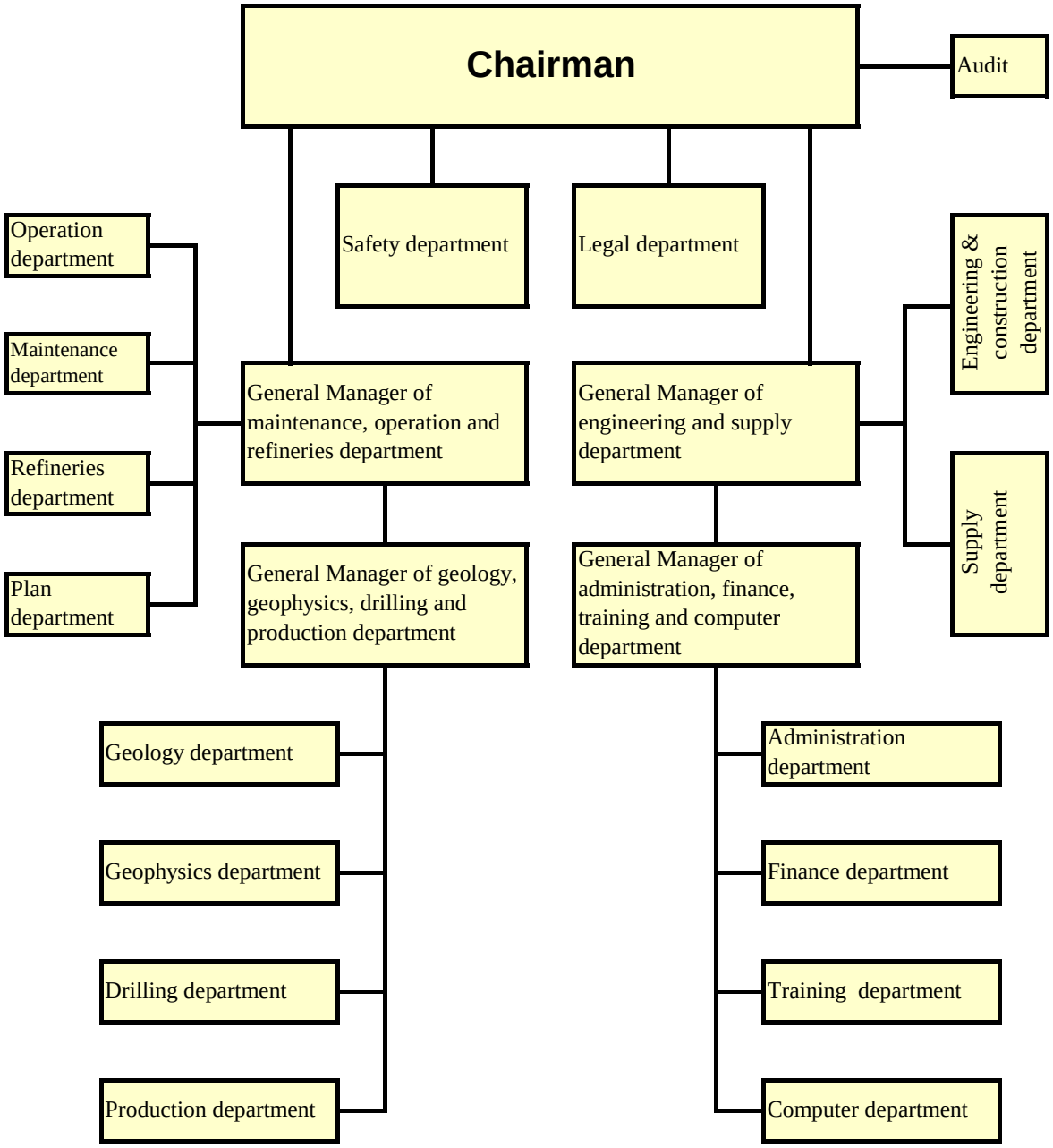

Figure (31) AGOCO management structure

Source: [109]

Chairman

- The chairman reviews and signs the environmental policy
- Provides leadership and direction to the health/ safety and environment programmes.
- Plays a leading role with the Division General Managers in the Senior Management Environmental Committee.
- The chairman ensures that operating and business plans reflect and are consistent with AGOCO stated environmental policy .

Division general managers

- The General Managers ensure that their operations and facilities are designed, operated and maintained in compliance with AGOCO requirements and provide the required directions in support of the environmental policy.
- The Division General Managers (or their designates) ensure that all environmental reports required by the officers of the company are prepared and forwarded to the chairman in a timely fashion.
- The Division General Managers (or designates) ensure that an external review of environmental management practices is conducted, and that the results of the review (environmental Audit) are forwarded together, and which are implemented through the field operations personnel.

Senior management environmental committee (SMEC)

- Consists of the chairman, meneral managers and the loss prevention manager, who sets out the environmental policy and provides executive direction to the environmental programme.
- Receives regular reports on environmental issues and incidents.
- Reviews significant environmental issues and approve recommended actions. However, it can be seen from the manual (appendix C) that there are no procedures in identifying significant environmental aspects. In this case one can only assume that the SMEC has documented procedures not yet put in to practice.

Managers/superintendents

- The managers and superintendents (or their designates) ensure that all employees and/or contractors are properly trained.
- The managers and superintendents (or their designates) initiate audits and inspections through the loss prevention department, and follow up with action plans for the implementation of the recommendations.
- The managers and superintendents (or their designates) ensure that all applicable permits, licenses and public consultation are in place for all projects.
- The managers and superintendents (or their designates) ensure that compliance with Environmental regulations is measured on an individual basis, and used as one of the

criteria for consideration during annual performance reviews of employees and contractors.

- The managers and superintendents (or their designates) ensure that environmental management programmes such as abandonment, decommissioning and recovery are undertaken as required that the results of abandonment be appropriately addressed, and that environmental enhancement initiatives are fully supported, i.e. drum and filter disposal programmes.
- The managers and superintendents (or their designates) encourage all employees and/or contractors to report any environmental concerns directly to AGOCO.
- The managers and superintendents (or their designates) ensure that all employees and/or contractors are aware of their rights of protection from any negative actions, should they report any environmental concerns to the company.
- The managers and superintendents (or their designates) ensure that employees and/or contractors are aware of their joint responsibilities for environmental protection.

Field supervisors or coordinators and on–site representatives

Senior field personnel must be aware of the requirements for drilling and operations and shall be responsible for providing information on environmental issues. In addition, they must:

- Know company policies and procedures set in the loss prevention manual, and use them at all times when supervising work in the field, organizing work to be done, training personnel in operating procedures, or in orienting new employees to the company.
- Be alert to any potential environmental hazards, and take steps to reduce or eliminate those hazards. This person shall take further corrective action in conjunction with the managers or superintendents, should it be necessary in the event of a spill or release of potentially harmful agents.
- Always set a good example in the area of environmental awareness, and ensure that all actions are consistent with company requirements. This person shall further actively support any environmental initiatives, as defined by the AGOCO management.
- Ensure that conducting regular inspections for environmental performance and housekeeping standards and supporting any external evaluations or audits that may be conducted comply with company requirements and legislation.

Interviews with some members of the technical personnel in the company and inspecting the company's environmental response manual (which shows the various divisions and responsibilities) revealed that the company has defined, documented, and communicated the general roles, responsibilities and authority of personnel in great detail. However, for an effective EMS, ISO 14001 recommends two main positions and one team: an Environmental Management Representative (EMR), a coordinator and an environmental management team. The coordinator and the environmental management team assist the EMR in building upon the EMS in the development and the promotion of the EMS. There will also be the need for management to identify resources essential to the implementation and control of the environmental management system. Resources may include human resources, specialized skills, technology, equipment, and financial resources but specialized skills are lacking.

7.3.3.2 Training, awareness and competence

According to the AGOCO environmental response procedures manual, as defined by the environmental policy statement, all employees are supplied with proper training in order to enable them to efficiently carry out the intent of their policy. Nevertheless, AGOCO does not has any identified training needs nor established and maintained procedures to make its employees or members aware of the importance of conformance with the environmental policy and procedures and with the requirements of the environmental management system. ISO14001 requires a company to identify training needs and provide specific training to those associates whose work activities could cause an adverse environmental impact.

7. 3. 3.3 Communication

From inspecting the company's environmental response manual and during interviews with some of the technical personnels in the company, it was found that the company communicate and inform employees and other stakeholders with informations regarding environmental aspects. However, there is no written procedure for internal communication and receiving, documenting, and responding to relevant communications. As far as ISO 14001 is concerned, the organisation should establish and maintain procedures for internal communications between the various levels and functions of the organisation. The standard also requires an organisation to establish procedures and maintenance procedures of receiving, documenting and responding to relevant communications from external interested parties.

7.3.3.4 Environmental management system documentation

From a personal visit to the company's offices and inspecting the company's environmental response manual, it could be seen AGOCO has established and maintained information on the elements of the environmental management system in paper form. However, there were no description that demonstrate the interaction between the elements of the environmental management system. As fas as ISO 14001 is concerned, the organisation should establish and maintain information on EMS in paper or electronic form to describe the core elements of the management system and their interaction. The standard also requires direction to related documentation[143].

7.3.3.5 Document control

From inspecting the company's environmental response manual, it could be observed that AGOCO has a way to control their documents. However, there is no procedure describing controlling issues, access (to documentation) and revision of EMS documentation to ensure that each employee has up-to-date documents that are relevant to their activities as far as ISO14001 is concerned.

7.3.3.6 Operational control

From inspecting the company's environmental response manual, it became clear that AGOCO has operational control for the environmental aspects associated with their activities, which includes well sites, access roads, drilling waste management, tanks, and atmospheric emissions. However, there is a lack to communicate the procedures and operational criteria to suppliers of products and services that might interact with the established significant environmental aspects. As far as ISO 14001 is concerned, the organization should identify its operations and activities that are directly associated with the significant environmental aspects. Secondly, the organization should develop procedures and operational criteria, including maintenance, that address the specific operations and activities associated with the significant environmental aspects. Thirdly, the organization should communicate the procedures and operational criterias to suppliers of products and services that might interact with the established significant environmental aspects[143].

7.3.3.7 Emergency preparedness and response

From the company's environmental response procedures manual and a personal visit to the company's offices, it could be seen that the company has very good documentation on emergency response and procedures. These emergency response and procedures are classified into four main groups:

- Corporate emergency response plan,
- Facility emergency response plans,
- Spill prevention and response and,
- Incident notification and reporting.

The corporate level emergency plan includes plans to cover all operations. The principal focus is on the management level response to ensure that prompt and effective actions be taken for all emergency situations. All management personnel must be aware of this plan and familiar with their responsibilities in regards to this plan.

The facility emergency response plan describes which facilities require an emergency response plan. Generally, those facilities with a greater probability of having a serious environmental or social impact, are subjected to emergency plans should an accident occur. The facility emergency response plan has to take into consideration the worst possible sequence of events that may impact on the public, property or the environment and be prepared to deal with the consequences. Each facilities plan is prepared in order to be able to mobilize and deal with a series of facilities of the worst type.

The spill prevention and response describe how to respond promptly and effectively to spills of oil, chemicals and produced water in order to minimize personnel injuries, property loss, and adverse environmental effects and to reduce production losses. Employees must make a sincere effort to prevent spills and to be prepared to respond when a spill does occur. There are guidelines for spill prevention, which is minimizing the risk of spills at facilities. For example, corrosion monitoring and prevention practices are reviewed on a regular basis, all dead–end pipe or tubing that could leak fluids must be terminated with a bulb plug, blind flange, and loading or transferring of produced fluids should be properly supervised.

In respect of spill response, the first priority after discovering a spill is to protect the safety of employees and to minimise damage to the environment and control costs associated with the loss of product or equipment. The key actions to take immediately following a spill, for instance; assess the safety of the situation, remove the sources of ignition if it is safe to do so, find information regarding the hazards of all chemicals involved in the spill in the material

safety data sheets located in the area office, and notify the supervisor. The senior employee is responsible for initiating notification and response procedures.

The purpose of incident notification and reporting is to describe procedures for reporting incidents in order to ensure compliance with company requirements for incident notification. Spill reports are to be made immediately by telephone and must be followed by a written report within seven days. AGOCO requires that operations take immediate steps to contain and clean - up spills. AGOCO requires that all spills, regardless of size, be reported to the supervisor. All spills of significance (large than 2 cubic metres of produced fluids.

From the above emergency and response plans of AGOCO, it can be seen that the company has detailed definitions of all possible emergency incidents. However, there are a lack of key personnel responsible for such emergency situations and drill to test the effectiveness of these plans if any of the emergencies above are to occur.

7.3.4 Checking and corrective action

As far as checking and corrective action are concerned, an organization must measure its performance against its own targets and objectives, its operational controls, and its compliance with relevant laws and regulations. Specifically, the EMS must define how non-conformance with the ISO standard will be handled and how corrective measures will be taken.

7.3.4.1 Monitoring and measurement

From the company's environmental response procedures manual and a personal visit to the company's offices, it could be seen that AGOCO has monitoring and measurements such as corrosion monitoring, groundwater monitoring, and leak detections. A checklist is frequently used to ensure thoroughness and keep track of results. However, there is no established and maintained documented procedure for periodically evaluating compliance with relevant environmental legislation and regulations.

7.3.4.2 Non-conformance and corrective and preventive action

From the company's environmental response procedures manual, it can be concluded that AGOCO has corrective action plans to respond to identify non-conformances and describing how non-conformances will be corrected. These plans cover only spill corrective and preventive action. However, there are no documented procedures for defining responsibility and authority for handling and investigating non-conformances.

7.3.4.3 Records

From inspecting the company's environmental response manual, it could be seen that the company has records as far as environmental management is concerned. However, procedures for the identification, maintenance and disposition of environmental records were not spelt out in the environmental procedures manual. Moreover, retention (time of disposal of outdated information) was not always established.

7.3.4.4 Environmental management system audit

From the company's environmental response procedures manual, it could be seen that AGOCO has audits and inspections in the framework of a formal programme for environmental audits and inspections to promote environmental compliance, company policy and procedures and industry best practice. AGOCO's audit programme includes a commitment to undertake a formal environmental assessment of all major facilities every three years. AGOCO has retained the services of Environmental Specialists to oversee this programme. The specialists undertake these audits either independently or together with the operations staff. Another option is to request operations staff from another operating areas or departments of the company to assist in audit.

It is also important that audit results are thoroughly documented, recommended and that operations staff be appraised of observed deficiencies from the inspections and the audits. The facilities that are not large enough to justify a formal environmental audit are effectively reviewed using an inspection by local operations staff. The inspectors use a checklist which provides review of the facility and allows convenient documentation of observations.

From the environmental audits programme, it was found that this programme consists of:

- A commitment to conduct an environmental audit of each major facility every three years.
- A programme of planned inspections where operations staff complete an inspection, using a prepared checklist, of all of the facilities within their area at a minimum of at least once year.

The results of the entire audit programme, including corrective action plans are reported on a regular basis to top management. However, the scope of the audit, methodologies, as well as the responsibilities and requirements for conducting audits is not well defined. The scope of audits are not well defined in the sense that the procedure has no

specific information on the activities and areas to be considered during auditing, well defined procedures/methodologies and also the competence of staffs engaged in this audit.

7.3.5 Management review

AGOCO has a formal review in the form of an environmental audit to be conducted periodically. The results of audit are presented to the top management of AGOCO with clear recommendations related to the environmental measures. However, there is no procedure for top management review of the EMS as specified by ISO 14001.

7.4 Summary of the results of initial review of EMS elements

The summary of this initial review will be used as the basics to guide in the implementation of an Environmental Managements System for AGOCO in accordance with ISO 14001. The initial review was based on a cumulative assessment of the current environmental management manual from AGOCO, interviews with some of the company's personnel and telephone communications the employees of the company. It was found that AGOCO has no written procedures for most of the requirements of the EMS according to ISO 14001. Therefore, the current environmental management system in place is not up to the requirements specified by ISO14001. It was also found that the current environmental management system of AGOCO will only assist the company to achieve minimum standards and that it provides no encouragement to go beyond those minima. Table 11 shows a summary evaluation of AGOCO's environmental management system.

Table (11) Summary of the evaluation of AGOCO's environmental management system

EMS element	Key actions to be completed	Status of compliance with ISO 14001 EMS
Commitment and Policy	• The policy needs to be committed to the idea of continual improvement. • The policy need to be committed to the external communication	
Planning	• Procedure for significant environmental aspects determination needs to be well defined. • Procedure for identification and accessibility to all new and modified legal or other requirements applicable to company's activities, products and services need to be defined. • The company needs defined environmental targets. • Procedures to review objectives and targets should also be defined and maintained regularly. • Time frame to achieve environmental programmes needs to be defined.	
Implementation and Operation	• A specific management representative for EMS should be defined. • The resources essential to the implementation and control of the environmental management system should be identified. • The company needs to defined training needs. • Procedure for internal communication and receiving, documenting, and responding to relevant communications should be defined. • The company should develop EMS documentation and control. • The company should communicate relevant procedure to suppliers and contractor. • Procedures should be periodically reviewed. • Tests of the emergency response procedures should be regularly carry out. • Key personnel responsible for emergency situations should be defined.	
Checking and Corrective Action	The company needs: • A procedure to verify compliance with a relevant environmental legislation and regulations. • A documented procedure for defining responsibility and authority for handling and investigating non-conformances. • A procedure for the identification, maintenance and/or disposition of environmental records. • The scope of the audit, methodologies, as well as the responsibilities and requirements for conducting audits.	
Management Review	• The company should develop and implement procedure for top management review of the EMS.	
Overall system evaluation		

 Full conformance  Substantial conformance  Partial conformance  Nominal conformance  Non-conformance

The next section will be focused on implementation strategies to guide AGOCO in implementing an EMS in accordance ISO 14001.

CHAPTER EIGHT
GUIDING AGOCO FOR THE IMPLEMENTATION OF EMS ACCORDING TO ISO 14001

According to the findings from the initial review, AGOCO has some measures to control environmental issues resulting from its activities but, these measures are not up to the requirements specified by ISO14001. Therefore, this chapter will be focused on improvement of the weak elements in the environmental management system, and formulates procedures for AGOCO 's towards the implementation of the ISO14001 EMS.

8.1 Environmental policy

The aforementioned initial review shows that AGOCO has a written environmental policy that partly conforms to ISO14001. However, the policy is silent as far as continual improvement and external communications are concerned. AGOCO should upgrade its environmental policy to comply with ISO 14001. Comparing the old version of the policy with the requirements under the ISO 14001, a proposal have been made in Box 2 below to possibly upgrade the policy of AGOCO. The statements in red bold are posibly additions to upgrade the company's policy.

Box (2) Modified environmental policy for AGOCO

AGOCO's Environmental Policy

It is the policy of the Arabian Gulf Oil Company (AGOCO) to conduct all aspects of its business in compliance with all government laws and regulations. AGOCO is committed to conduct all operations in diligent manner designed to minimize adverse impacts on the environment, the health of its employees and the well-being of the people in the communities in which AGOCO operates.

- AGOCO will assess the potential effects of all its projects and will integrate protective measures during the planning process to prevent or reduce impacts on the environment, public health and safety.
- AGOCO will endeavor to ensure its employees are supplied with proper training and equipment to enable them to efficiently carry out the intent of this policy.
- **AGOCO will establish procedures to promote continuous improvement.**
- **It is the responsibility of the company to communicate its environmental commitment and performance to interested external stakeholders.**
- Despite all the best efforts of AGOCO, should environmental impairment occur, AGOCO will make all necessary efforts to correct the damage in a timely and efficient manner.
- It is the responsibility of all AGOCO employees and all contractors, to follow and support this policy through attention to proper training, appropriate equipment, policies, procedures and emergency response plans.
- It is the responsibility of all supervising levels of each division of AGOCO to maintain and enforce this environmental policy and environmental procedures in accordance with the company's existing loss prevention policy, regulations and procedures.

8.2 Planning

An identification of the environment aspects and legal requirements and a series of the objectives and targets should be defined to ensure that AGOCO meets the corporate policy goals as well as legal and environmental requirements.

8.2.1 Environmental aspects

1 Purpose

The purpose of the definition of environmental aspects is to provide guidance for the development and review of environmental aspects and impacts for AGOCO operations and for the determination of significant.

2 Scope

This procedure addresses the determination of significant environmental aspects applicable to the company operations.

3 Definitions

3.1 Environmental aspects are those elements of the company activities, product, services, or physical resources, which may have potentially beneficial or harmful effects on the environment. These may include discharges and emissions, energy use, noise, dust and visual pollution.

3.2 Significant environmental aspect is an environmental aspect that has or can has a significant environmental impact.

3.3 Environmental impact: Any change to the environment either positive or negative, wholly or partially resulting from the company's activities, products or services, for example including, pollution of air.

3.4 Frequency / Probability: The number of times an environmental aspect occurs (e.g. daily, weekly, monthly, or yearly) or the likelihood of the aspect occurring (often or not often).

3.5 Significance criteria: Company criteria to determine which aspects are "significant" and which aspects are not significant[145].

Identification of environmental aspects and impacts

There are many ways and method to design aprocedure for the identification of environmental aspects and impacts. The US National Centre for Environmental and Decision Making Research (located in Tennessee) has identified four steps for the determination of environmental aspects:

- Activities are first reviewed in process increments small enough to be examined for impacts, but large enough to get the identify the aspects in a reasonable time.
- All environmental aspects of the procedures or process are identified.
- All potential and actual environmental impacts from these aspects: positive impacts, negative impacts and potential impacts are identified and associated with an aspect.
- The aspects are judged for their significance. A measurement system (depending on the person doing the evaluation) is developed to separate those aspects that are significant (and thus will require "targets and objectives" and "operational control" under the ISO 14001 Standard) and those that are not. Since a registrar auditor must review the procedures for this step, it is suggested that it be written down and quantified [130].

The environmental aspects and significant impacts of the company's activities and products are going to be identified using similar method as above. From the company's activities and products, five main processes were identified, i.e. seismic, drilling, production, transportation and management. The aspects associated with each operation are clearly stated with their impacts on the ecosystem. Table 12 has been formulated to deal with every aspect of the environment as far as AGOCO's operations are concerned.

In the Table, the activities having highly significant environmental impacts are highlighted in red bold text. The determination of the significance of each environmental aspect was done with respect to the impact associated with each aspect through assigning a value from 0 to 5 (with 0 being no impact, 1 very low, 2 low, 3 middle, 4 being high and 5 meaning a major impact) to each aspect. The total environmental score value used to categorize the overall impact as low when the value was less than 20 or high when the value greater than or equal to 20, assuming a total maximum score of 40 (see Table 12). The calculation of the total environmental score value is the sum of the individual impacts with respect to its activity.

Table 12 shows the total environmental scores of all criteria for each aspect. The numbers indicates the relative priority of the aspect compared to other aspects and impacts in the same category. The total environmental scores are directly proportional to the impacts on the environment. The higher the total score, the higher priority should be considered as significant aspects. In the Table, the threshold value is fixed at 20. This means that, when the value is greater than or equal to 20, the activity in question is considered significant.

From the Table it can be seen that explosive materials, release of sour gas, chemical spill, drilling waste, produced water, nuclear radiation, oily sludge, exhaust emissions, energy use, and pipe leakage are having a total environmental score equal to or above 20 and hence these aspects are considered as significant aspects.

In order to cover most of the aspects close to the threshold and include them in setting environmental objectives and targets, the method considers a tolerance of 2 below the threshold. That means that each aspect with a score of 18 or 19 will also be considered as significant aspect. Hence, aspects like restoration and reclamation, usage of drilling mud, solid wastes, and tank drainage are considered as significant aspects. The tolerance factor of 2 will allow the company and, for that matter, any petroleum company intended to adapt this procedure for the identification of its aspects capture almost all the environmental impacts to enable an effective implementation of its EMS. Aspects that are considered to have a significant impact on the environment, emergency situations or abnormal operating conditions are specifically identified. The procedure follow Table 12 can be useful for the identification of environmental aspects and impacts.

Table (12) Identification of environmental aspects

Activities	Environmental aspects	Impact on air quality	Impact on water quality	Impact on human health	Acoustic Impact	Impact on plant life Growth	Impact on ozone	Impact on wildlife	Impact on soil	Total environmental score	Normal operation	Abnormal operation	Emergency
Seismic survey	Noise	0	0	4	4	0	0	4	0	12			
	Explosive material	**3**	**0**	**3**	**5**	**2**	**4**	**3**	**4**	**24**	√	√	√
	Access (line cutting)	0	2	1	0	5	0	5	4	17			
	Restoration and reclamation	**1**	**3**	**1**	**2**	**4**	**1**	**2**	**4**	**18**	√	√	
Drilling operation	**Release of sour gas**	**4**	**3**	**3**	**0**	**3**	**5**	**4**	**1**	**23**	√	√	
	Chemical spill	**1**	**4**	**4**	**0**	**3**	**1**	**3**	**4**	**20**			
	Usage of drilling mud	**1**	**3**	**4**	**0**	**4**	**0**	**4**	**3**	**19**	√	√	
	Drilling waste	**0**	**4**	**4**	**0**	**5**	**0**	**5**	**4**	**22**	√	√	
	Opening and land clearing	0	3	3	0	4	0	3	3	17			
	Surface disturbance	0	2	2	0	5	0	4	3	17			
	Noise	0	0	4	4	0	0	4	0	12			
	Restoration and reclamation	1	2	2	0	5	0	2	4	16			
	visibility	0	0	4	4	0	0	4	0	12			
Production operation	**Produced water**	**3**	**5**	**4**	**0**	**4**	**0**	**4**	**5**	**25**	√	√	
	Nuclear radiation	**4**	**1**	**4**	**0**	**1**	**5**	**4**	**1**	**20**	√	√	
	Chemical production	1	2	5	0	2	0	4	3	17			
	Sewage system	0	5	4	0	2	0	2	1	14			
	Oily sludge	**1**	**2**	**5**	**0**	**4**	**0**	**5**	**3**	**20**	√	√	
	Potential discharge of hazardous material	**3**	**3**	**4**	**0**	**4**	**4**	**4**	**5**	**27**	√	√	√
	Exhaust, gas emission	**5**	**1**	**4**	**0**	**3**	**5**	**2**	**0**	**20**	√	√	
	Solid wastes	**0**	**3**	**4**	**0**	**4**	**0**	**4**	**4**	**19**	√	√	
	Energy use	**5**	**3**	**3**	**0**	**2**	**5**	**2**	**0**	**20**	√	√	
	Tank drainage bottom and sludge	**0**	**4**	**2**	**0**	**4**	**0**	**4**	**4**	**19**	√	√	
Oil and gas transportation	**Pipe leakage**	**1**	**5**	**3**	**0**	**5**	**0**	**4**	**4**	**22**	√	√	√
	Surface disturbance	1	1	3	0	5	0	2	3	15			
	Road for access	0	0	2	0	4	0	1	4	11			
	Restoration and reclamation	1	1	3	2	5	0	1	3	16			
Administration management	Paper use	0	0	3	0	0	0	0	2	5			
	Consumption of electricity	0	0	3	0	0	0	0	0	3			

Source: complied by author

4 Procedure

- Department managers create baseline lists of AGOCO activities, products, and services that have the possibility of interacting with the environment, (e.g. process environment aspects) together with their environmental aspects.
- These environmental aspects are evaluated to determine the significance of the potential environmental impacts.
- The environmental management team must establish criteria for determining significance criteria based on the severity, frequency, probability and duration of potential impacts.
- Reviews of the environmental aspects associated with the operations of the company must considered existing or potential, air emission, solid waste, soil and land impacts, hazardous waste, and noise.
- Compare the potential impacts against the significance criteria to determine which aspects are defined as significant.
- Create a final list of all aspects that have been defined as significant, because they meet or surpass the significant criteria established for AGOCO.
- Aspects which could be considered to have a significant positive or negative impact on the environment in routine conditions, or negative impacts in reasonably foreseeable emergency situations or abnormal operating conditions is specifically identified.
- The final list of significant environmental aspects is distributed as controlled documents as necessary to support the development or update of annual objectives and targets.
- Whenever a new activity, product or service is initiated at AGOCO, the requirements of this procedure will be applied to it to determine if any new significant environmental aspects have been introduced.
- This procedure applies also to activities, products and services at AGOCO that originate from external sources (e.g., suppliers).

5 Responsibilities

- The training, safety, and environmental manager is responsible, along with the environmental management team, for developing and performing a periodic review and update of the significant aspects list that are associated with the company operations. The training, safety, and environmental manager is responsible for

ensuring such reviews are completed in time to support the generation or modification of objectives and targets.

- The environmental management team is responsible for compiling and revising the environmental survey and significance aspects criteria matrix.

8.2.2 Legal and other requirements

1 Purpose

Purpose here means to identify and obtain access to the legal and other requirements, which are applicable to the company activities, products and services.

2 Scope

The scope is to describe the procedure for identifying and providing access to legal and other requirements associated with the company activities, products, and services.

Identification and accesses to laws and regulations

There are only few sources for obtaining information about applicable laws or regulations in Libya. The main source of environmental information includes commercial services with updates offered in paper form, from the main environmental administration at the state level, or through consultants and other petroleum companies.

The main regulatory body in charge of the environment is the Libyan environmental administration. This administration is in charge of environmental laws and regulations and frequently conducts environmental monitoring to check and assist companies on issues pertaining to the environment[z]. The procedure follow can be useful for the identification and accesses to the laws and regulation.

3 Procedure

- The environmental management team identifies relevant environmental laws, regulations and industry standards AGOCO adheres to. These include international, national and local laws and regulations.
- Each department identifies legal and other requirements that are applicable to the department's significant environmental aspects.

[z] Information through personal communication with some staff at the company.

- The environmental management team identifies and maintains a list of all applicable legal and other requirements.
- The manager of each department maintains a list of legal and other requirements, including detailed summaries of the regulation themselves.
- The environmental management team reviews the legal and other requirements on a regular basis. When legal and/or other requirements change, the environmental department notifies, department managers, On-site Managers.
- A list of all environmental laws are posted on the company's web site and is kept updated as necessary.

4 Responsibilities

- Department managers and the environmental management team incharge of environmental isues are responsible for identifying and the analysis of environmental regulations and other legal requirements applicable to their activities, products and, services.
- It is the responsibility of all employees to comply with all regulations.

8.2.3 Objectives and targets

1. Purpose

The purpose of this procedure is to identify the environmental objectives and targets based on consideration of the company analysis of operational requirements, significant environmental impacts, regulatory standards and compliance, technological options, financial resources.

2 Scope

This procedure referees to the setting and tracking of the environmental management system objectives and targets applicable to the AGOCO environmental programme.

3 Definitions

3.1 Objectives: An objective is a goal, rising from the environmental policy and the list of significant environmental aspects that the company decides to accomplish[110]. For example, a

company like AGOCO can identify its significant aspects and consequently decide to take the reduction of produced water resulting from the company's activities as an objective.

3.2 Targets: These are measurable performance requirements that come out from an objective[110]. For example, during the implementation of the EMS, AGOCO could set as a target to reduce impact of produced water by 10 percent by January 2008.

Setting objectives and targets

The objectives are established to meet the company's environmental policy. These objectives are the overall goals for environmental performance identified in the environmental policy. When establishing objectives, the company should also take into account the identified environmental aspects and the associated environmental impacts. In reviewing and analysing this information, the company has to identify priorities (e.g. a situation of non-compliance which puts the whole operation at risk has to be addressed first) [114].

In setting objectives, first address the issues (significant aspects) with the highest priority.

Objectives may include commitments to:

- Reduce waste and the depletion of resources;
- Reduce or eliminate the release of pollutants into the environment;
- Design products to minimize their environmental impact in production, use and disposal;
- Control the environmental impact of raw material sourcing;
- Minimize any significant adverse environmental impact of new developments; and
- Promote environmental awareness among employees and the community [130].

Environmental targets are then set to achieve these objectives within a specified time-frame. Targets should be specific and measurable. For example, a already suggested above, AGOCO can set a target to reduce impact of produced water by 10 percent by January 2008.

To be able to achieve objectives and set targets, ISO 14001 recommends organisations to take into account preventive measures, legal and other requirements, significant environmental aspects, technological options, financial considerations, operational and business requirements, and the views of interested parties[145].

The results from chapter 7 (the initial review) and the aspects matrix (see Table 12) gives some ideas on the main activities and areas that have to be considered in guiding AGOCO to implement an EMS in conformance with the international standard. Based on the

significant environmental aspects identified in Table 12, 15 (when the sum of the value is greater than 20) aspects have been considered in setting objectives and targets at this stage.

Table 13 lists the objectives and targets. It has been divided into three columns. i.e., significant aspects, objectives and targets, respectively. The Table shows that each significant aspect identified has its corresponding objectives and targets. The objectives as described already are mostly alternatives (inputs) or procedures to stop these significant aspects from occurring reduce it respectively whilst the targets are also same as above, pollution quantities to be reduced with their respective time frames. The procedure below Table 13 can be useful for the setting objectives and targets.

Table (13) List of objectives and targets

Significant aspects	Objective	Targets
Explosive material	No use of explosive material/reduce the use of explosives	Substitute/reduce explosive material by the year 2008
Release of sour gas	Reduce air pollution	Reduce sulphur dioxide emission from the engine generator by 15 percent by the year 2008
Drilling waste	Reduce drilling waste	Reduce total drilling waste by 10 percent by the year 2009
Produced water	Reduce produced water impact	Reduce the impact of produced water 25 percent by the year 2008
Exhaust, gas emission	Reduce greenhouse gas emissions	Reduce greenhouse gas emissions by 20percent by the 2008
Potential discharge of hazardous material	Prevent the release of hazardous material within a list of hazardous material	Reduce the release of hazardous material by 10 percent by each year
Energy use	Reduce use of natural resources	Reduce electricity use by 10percent by January 2007 Reduce natural gas use by 15percent by January 2007
Pipe and tanks leak	Reduce pipe and tanks leak	Reduce 25 percent occurrence of leaks based on the year 2002
Restoration and reclamation	Ensure environmentally acceptable and sustainable working environment	Investigate effectiveness of additional best management practices by January 2008
Chemical spill	Reduce occurrence of spills	Reduce spill occurrence by 10 percent by January 2007.
Usage of drilling mud	Reduce use of toxic chemicals	Reduce use of toxic chemical by 10 percent each year
Nuclear radiation	Reduce radioactive discharges	Improve storm water collection and filtration system by year 2007.
Oily sludge	reduce oily sludge	Reduce oily sludge by 10 percent by the year 2009.
Solid wastes	Reduce paint waste	Reduce paint waste by 15 by January 2007.
Tank drainage bottom and sludge	Reduce tank drainage	Reduce tank drainage by 10 percent by the year 2008.

Source: complied by author

4 Procedure

- The environmental management team evaluates the list of the significant environmental aspects and establishes objectives and targets for each significant environment aspects.

- The EMS coordinator reviews all environmental objectives to determine if additional objectives need to be established. The objectives and targets should be consistent with environmental policy.
- Each department manager/field supervisor identifies the impacts of the objectives in a specified area, establishes targets to achieve the objectives and must develop appropriate measures to track progress toward meeting the specified objectives and targets.
- Each department manager/field supervisor is responsible for communicating objectives and targets and other means for achieving them.
- Objectives and targets may be amended during the year as a result of new or revised operations, services, products and regulations.
- The EMS coordinator is responsible for their maintenance and facilitating their report to the safety, training and environment manager.
- Progress toward the objectives and targets reviews on a regular basis at management meeting.
- Objectives and targets may be removed from the list by the AGOCO environmental management review, as circumstances surrounding the objectives and targets may change during the year**.** The documentation of objectives and targets should be providing as revision of the EMS.
- A list of objectives and targets of the company are fixed on company's website.

6 Responsibilities

- EMS coordinator, environmental mangament team, department managers and field supervisors.

8.2.4 Environmental management programme(s)

1 Purpose

The environmental management programme provides the framework for AGOCO and its employees to follow and to achieve the objectives and targets.

2 Scope

This procedure provides a road map for achieving the targets and identifies line responsibility and assigns accountability within the company for the success of the EMS.

Environmental management programme(s)

The translation of the policy into action takes the form of an environmental management programme. Within the general planning of activities, the company should establish a programme that addresses all of its environmental objectives. To be most effective, the environmental progamme should be integrated into the organization's strategic plan (actual business plan) [114]. An environmental programme addresses schedules, resources and responsibilities for achieving the company's environmental objectives and targets. Within the framework provided by an environmental management programme identifies specifications in order of their priority to the organization as far as the environmental objectives and targets are concerned. The creation and use of (a) programme(s) is a key element to the successful implementation of an environmental management system. The programme should describe how the organization's targets will be achieved, including time-scales and personnel responsible for implementing the organization's environmental policy.

In relation to AGOCO's significant environmental aspects identified and their respective objectives and targets, there is the need to set up an environmental management programme to be able to achieve these objectives and targets. Table 14 has been formulated taking all the objectives and targets into consideration with specific actions plans to achieve the objectives and targets. The Table also contains responsibilities and schedules as far as those objectives and targets are concerned. Hence, the Table is divided into five columns, objectives, targets, action plan responsibility and schedule. The environmental management programme in Table 14 is based on the objectives and targets identified in Table 13.

In order to achieve the set objectives and targets, the action plan (see Table 14) recommends either change in equipment, technology/methodology and in some cases reduction/change inputs. For instance, taking the case of drilling waste and produced water, the action plan recommends change in equipment (reduction in bit diameters) and (technology) improves wastewater treatment respectively. In cases where the aspects are related to input material, as in the case of explosives, the plan recommends reduction or an outright substitution of the input in question.

In the case of responsibility, the structure of the environmental management programme is such that the employee with the maximum influence or knowledge on the objective in question bears the responsibility. For example, to reduce drilling waste, the drilling engineer should be responsible with objectives concerning drilling waste reduction since he/she has the maximum influence or has enough information on this activity. Finally, the schedule, shown in column 5, contains the time table for starting and/or finishing

objectives and targets. The procedure follow Table 14 can be useful for the environment management programme.

Table (14) Environment management programme

Objective	Targets	action plan	Person in charge	Schedule	comment
No use of explosive material/reduce the use of explosives	Substitute/reduce explosive material by the year 2008	Substitute/reduce explosive material			
Reduce air pollution	Reduce sulphur dioxide emission from the engine generator 15 percent by the year 2008	Reduction in flare and ensure facilities are operating in compliance with regard to allowable emissions	Chemical and Safety engineering	2008	
Reduce drilling waste	Reduce total drilling waste 10 percent by the year 2009	Application of slim drill technique. Improve quality of treatment	Drilling Engineer	2009	
Reduce produced water impact	Reduce impact of produced water 25 percent by the year 2008	Recycle produced water	Production and process Engineering.	2008	
Reduce greenhouse gas emissions	Reduce greenhouse gas emissions by 20percent by the 2008	Through Life cycle cost effective measures		2008	
Prevent the release of hazard material within a list of hazardous material	Reduce the release of hazard material by 10 percent by each year	Technology improvement in discharge water treatment	Environmental and Safety engineering.		
Reduce use of natural resources	Reduce natural gas use 10 percent by January 2007	Use solar power		2007	
Reduce pipe and tanks leak	Reduce 25 percent occurrence of leaks based on the year 2002	Regularly monitoring and Substitute or prepare any tools may cause leak	Production Engineering.		
Ensure environmentally acceptable and sustainable working environment	Investigate effectiveness of additional best management practices by January 2008	Process optimisation			
Reduce occurrence of spills	Reduce spill occurrence 10 percent by January 2007.	Proper care and maintenance of fuel oil tank, lines, and furnace.	Production and Environmental Engineering	2007	
Reduce use of toxic chemical	Reduce use of toxic chemical by 10 percent each year	Using non toxic chemical	Chemical and Safety engineering		
Reduce radioactive discharges	Improve storm water collection and filtration system by year 2007.	Test any material before discharge			
reduce oily sludge	Reduce oily sludge 10 by the year 2009.	Collected in approved containers while awaiting recycling or proper disposal		2009	
Reduce paint waste	Reduce paint waste 15 percent by January 2007.	Paint mixing at point of use			
Reduce tank drainage	Reduce tank drainage 10 percent by the year 2008.	Impermeable bunds are required around tanks	Safety and production engineering	2008	

Source: complied by author

3 Procedure

- The environmental management programme includes the designation of responsibility for achieving the environmental objectives and targets, and the means and the time frame by which they are to be achieved.
- The environmental management team is responsible for creating action plan, assigning a person responsible, creating a schedule for implementation, identifying resources needed and costs associated with the actions.
- The EMS coordinator reviews and discuss the environmental management programmes with relevant department managers regularly to ensure that the progress is in the right track and the environmental objectives and targets will be achieved within the time frame.
- Environmental management programme progressing is primarily the responsibility of the The EMS coordinator. The coordinator will routinely report to the safety, training and environment manager the status of environmental programme .
- Progress toward the environmental management programme reviews on a regular basis at management meeting.
- The environmental managementprogramme is amended when there are projects that relate to new developments and modified operations, products or services to ensure that environmental management applies to such projects.

4 Responsibilities

- The environmental management team, and EMS coordinator.

8.3 Implementation and operation

8.3.1 Structure and responsibility

1 Purpose

The purpose is to make all employees of the company to have a clear understanding of their environmental roles and responsibilities, as well as understand the importance of the environmental targets and objectives that they can affect.

2 Scope

The scope is to define and documents the responsibilities, authorities and interrelationships of all key environmental personnel.

Structure and responsibility

The commitment of all employees to the successful implementation of an environmental management system should begin at the highest levels of management. For an EMS to be effective, individual roles and responsibilities should clearly be defined as they relate to the achievement of environmental objectives and targets, and the overall operation of the EMS. Top management must supply the necessary resources, both financial and staff, to ensure that the EMS is effectively implemented. For an effective EMS, ISO 14001 recommends top management to appoint an Environmental Management Representative (EMR). His tasks include:

a) Ensuring that environmental management system requirements are established, implemented and maintained in accordance with this international standard;

b) Reporting on the performance of the environmental management system to top management for review as a basis for improvement of the environmental management system [110].

It is, however, important at this stage for the EMR to form a team of expects that will assist him in building the EMS, hence there is the need for an EMS coordinator, and an Environmental Management Team (EMT), all of whom will play a role in developing and promoting the EMS.

- The EMS coordinator will be responsible for identifying, assigning, scheduling, providing the necessary support for, and ensuring completion of all tasks relating to the EMS. The EMS coordinator works closely with the EMR and the EMT. The EMS coordinator is also responsible for maintaining the EMS manual, under the leadership of the EMR.

- The EMT includes members of the activity who are responsible for representing their area or department in several sides of the EMS, such as identifying environmental aspects, objectives and targets [114].

In relation to AGOCO, there is the need for a modification of the management structure. Hence, Figure 31, which was shown in Chapter 7, is modified and the outcome is shown in Figure 32. Since the old structure focuses entirely on exploration, production and supply, it is important to integrate environmental issues into the overall objective of the company. This implies that the existing structure will not be effective in terms of meeting this overall objective which includes the comprehensive nature of environmental issues.

Figure 32 presents this new structure for AGOCO, for the implementation and operation in accordance with ISO 14001.

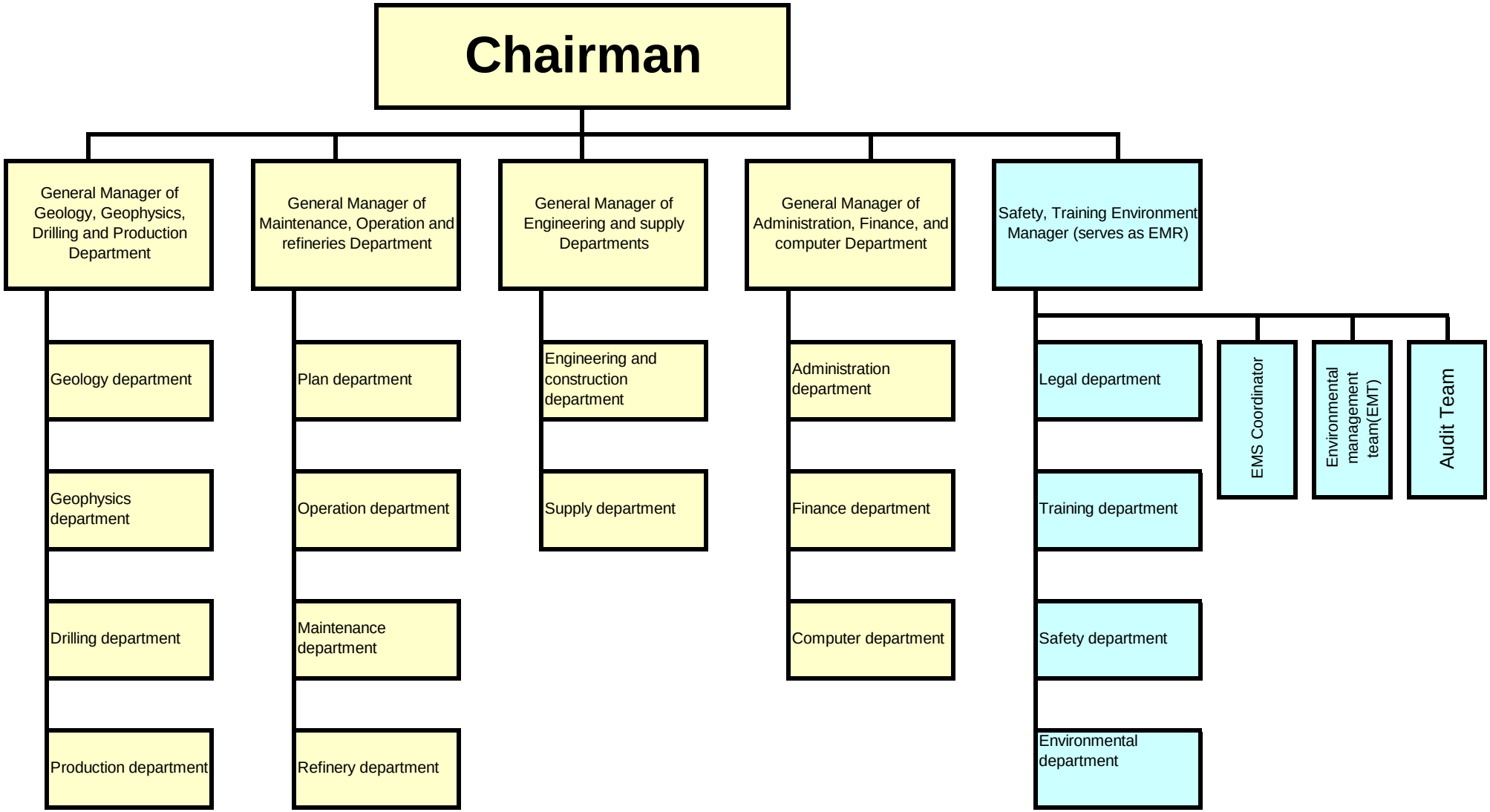

Figure (32) Suggestion for a new structure for AGOCO

Source: complied by author

This structure, as shown in the Figure, has a chairman and five general managers for operation, maintenance, engineering, administration and the environment, respectively. managers. The six (chairman plus the five general managers) 'top' managers will define the overall role, the responsibilities and the authorities for the EMS and ensuring that it works. The proposed organisational structure sets the environmental manager on the same level with other managers. This is very important in the sense that it gives the environment the same consideration as far as company bottom-line objectives (profits and production) are concerned.

The general managers of the operation, maintenance, engineering and administration departments are responsible for the allocation of responsibilities for the environmental aspects of their specific departments. For example, the drilling manager is in charge of assigning responsibilities as far as environmental objectives related to drilling are concerned.

The top managers are also responsible for the identification of significant environmental aspects, provide input to objectives and targets, participate in environmental management programmes, appoint and supervise internal auditors, and carry-out corrective and preventive actions. The safety, training environment manager will be responsible for appointing a full-time EMS coordinator to oversee that the environmental mission of the company is achieved. The EMS coordinator will be conducting routine checks to make sure that training programmes are conducted as planned and done by qualified personnel and focus on achieving the set objectives.

Table 15 gives a summary of the responsibilities and the level of involvements in order to make the EMS effective. This Table is divided into seven columns and it shows the tasks to be conducted under the EMS and various responsibilities. From the Table it can be seen that it is very important for the chairman to approve the company's environmental policy for the EMS to be effective. An approval of the policy is also a sign of commitment by top management as required by ISO 14001. It can also be seen that the EMT, line staff and the general managers are involved in all tasks related to the EMS. Making this group of people become involved in all tasks concerning the EMS is crucial, since it gives them the chance to explore the range of job functions and the various skills that make up the company. It can further be seen that the audit team also is involved in only few tasks concerning the EMS. This team assists in setting the general objectives towards good governance on the environment and check to make sure these objectives are met or even improved. Finally, one can observe that the field supervisors are also involved in some tasks since they are in charge

of the basic activities in the company and hence, have more influence on activities resulting in most environmental aspects of the company.

Table (15) Responsibilities and level of involvement in the activities

Tasks	Chairman	EMT	Audit Team	General Managers and Line staff	Field supervisors	Safety, Training environment Manager
Developing an environmental policy	Approval	Involved	Involved	Involved	Involved	Responsible
Conducting legal and other requirements		Involved	Involved	Involved		Responsible
Conducting and analysis of environmental aspects		Involved		Deeply Involved	Deeply Involve	Responsible
Setting objectives and targets		Involved		Involved	Involved	Responsible
Conducting training		Involved		Involved	Involved	Responsable
Internal & external communication		Involved	Involved	Involved		Responsible
Documentation system and control		Involved		Involved		Responsible
Measurement and Evaluation		Involved	Involved			Responsible
Coordinating emergency response efforts		Involved		Involved	Involved	Responsible
Maintenance of EMS records		Involved		Involved		Responsible
Conformance facility's EMS requirements		Involved	Involved	Involved		Responsible
Conducting Audits		Involved	Deeply involved			Responsible
Maintenance of equipment/tools to control environmental impact		Involved		Involved	Involved	Responsible

Source: complied by author

8.3.2 Training, awareness and competence

1 Purpose

To identify, provide, and track training that will help employees to minimize environmental impacts and the increase operation efficiencies.

2 Scope

To identify training needs and provide specific training to those employees whose work activities could cause adverse environmental impacts.

Training, awareness and competence

It is important for an organization to determine overall training needs required for competence with respect to the environmental management system. There is the need to approach this requirement “Training, Awareness and Competence” in two ways. First, the entire organization must receive training that provides a baseline understanding of the concepts underlying the environmental management system. This is very important in the sense that it makes every individual employee become aware of the organisation’s policy towards the environment and measures taken to control them. Secondly, there is the need to have specific training of individuals and units that have the potential to perform activities that could cause significant impact on the environment. These individuals may require specific technical and skill training related to those impacts in order to reduce their occurrence since they have greater influence on them [142].

Baseline training is focused on the importance of the EMS (environmental policy statement, objectives and targets), laws and regulations, the roles within the organization in achieving and maintaining the EMS, and the consequences of deviating from the EMS procedures[130].

The specific technical and skills training should be focused on two distinct areas. First, training should be provided for individuals and units that are responsible for activities or processes that may create significant environmental impacts. The scope and degree of training will depend upon the complexity of the process and the level of education and experience of the personnel involved. The organization must determine the necessary level of competence required. Second, the individuals and units responsible for emergency preparedness and response should be trained and competent to respond under the procedures developed to respond to those events if and when they occur [113].

In relation to AGOCO, it will be important for the company to go through both the baseline and specific training requirements. In this case, there is the need for a company wide training focused on the importance of the company's environmental policy statement, objectives and targets, laws and regulations, the roles within the organization in achieving and maintaining these objectives and the consequences of deviating from the EMS.

Specific training on the 15 identified significant aspects should be conducted periodically (bi-annually or annually) to be able to achieve the set objectives and targets.

Case study related to produced water

Produced water: Training, awareness and competence

a) Baseline training

I Purpose

The purpose here will be to undertake a company wide environmental training, awareness and competence as far as AGOCO's produce water is concerned. Hence, all departments will be involved and undertake this exercise.

Areas to be considered under this training will be:

- The general policy statement towards environmental commitment;
- Specific objectives and targets towards the reduction in produced water;
- Laws and regulations on produced water;
- General roles and regulations within AGOCO in maintaining objectives towards produced water; and
- The consequences of deviating from these objectives as far as produced waters are concerned.

II. Scope

Since this is going to be a general training the training, it will be just aimed at creating awareness.

b) Specific training

I Purpose

The purpose here will be to undertake a company wide specific training for employees whose activity results in produced water causing environmental problems. In this case, only the production engineers and chemists will be involved.

Areas to be considered will be:

- The general policy statement towards environmental commitment;
- Specific objectives and targets towards the reduction in produced water;
- Laws and regulations on produced water;
- General roles and regulations within AGOCO in maintaining objectives towards produced water; and
- The consequences of deviating from these objectives as far as produced waters are concerned.

Strategies/training to reduce impacts form produced water

This will be focused on practical training to achieve reduce the impacts of produced water. Since the production engineer seem to have no control of produced water, a treatment plant will have to be installed. Employees must be trained as soon as the plant is installed. The main areas that should be focused during training are:

- Compositions and characteristics
- Separation process of the plant
- Handling of produced water,
- How final products should be disposed
- Options available for produced water management
- New and emerging surface treatment technologies
- Environment risk assessment and monitoring
- Techniques for blocking water from entering the well (e.g. mechanical blocking devices and water shut-off chemicals) and methods for preventing water from coming up to the surface (e.g. downhole oil/water separators)**.**

3 Procedure

- **Identification of training needs**

The knowledge and skills of employees necessary for the department to achieve environmental objectives must be identified. Continuing development of employee skills must be accomplished through internal and external training and education programmes [130]. AGOCO environmental mangament team and the safety, training and the environmental manager are responsible for identification of training needs.

- **Conducting environmental training**

Training appropriate to the achievement of environmental policy, objectives, and targets must provided to all personnel within the department. Employees should have an appropriate knowledge base that includes training in the methods and skills required to achieve their tasks in an efficient and competent fashion [130]. Managers of each department and the safety, training and the environmental manager are responsible for conducting training of all employees.

Training elements

Departmental environmental training programmes should have to following elements:

- Identification of employee training needs to accomplish job assignment,
- Development of a training plan to address defined need,
- Documentation of training received,
- Evaluation of training received.

Areas to be considered for environmental training for AGOCO:

- Training on the handling of produced water,
- Training on the handling and operation of dangerous and hazardous wastes and emergency preparedness and response,
- Training on the handling prevention, emergency preparedness and response for the managers responsible for the security and safety of processes,
- Training on the oil spill prevention and emergency preparedness and response for technical personnel,
- Training to enhance the skill of employees, particularly those whose responsibility could impact the environment.

- Training shall cover class lessons, seminars, videos, awareness programmes and field practices with the objective to educate employees in the execution their tasks.
- The safety, training and environment manager confirms that all trained personnel must sign the ‘sign in sheet’, to document their training and understanding of the procedures, for example appendix B.
- The department managers must compare training received with the training plan to ensure policy goal are met.
- The EMS coordinator and department managers responsible for keeping all training records (e.g. staff attendance records) and a copy of each training manual for reference. All staff training records shall be kept at least three years.

4 Responsibilities

- Department managers, the EMS coordinator and the safety, training and the environmental manager are responsible for conducting training of all employees.

5 Accompanying documents: Appendix: B

8.3.3 Communication

1 Purpose

The purpose of this procedure is to establish and maintain internal communication procedures for the company.

2 Scope

Communication includes establishing processes to report internally and, where desired, externally on the environmental activities and information of the company.

Communication

Internal and external communications provide input for formulation as well as dissemination of information relevant to the EMS. Good communications are essential for coordinating the smooth execution of procedures and programmes to fulfil the environmental policy and to achieve the objectives and targets.

Internal communication must explain the environmental policy and address the EMS roles and responsibilities delegated to employees as well as progress toward specific objectives and targets.

Internal EMS communication should reach all employees within a company departments. The departments should be part of the EMS effort and be solicited for input and advice where appropriate, specifically departments are critical where their activities are sources of environmental aspects, for example, produced water from production process[116]. Departments that work with chemical products containing hazardous constituents can be valuable advisors regarding the environmental aspects and impact of the products used and the handling, storage, and disposal regulations that apply to waste material.

A company may rely on employees to gather information about operations and processes linked to EMS objectives and targets [116]. Communications require top-to-bottom as well as bottom-to-top flow of information.

Communication with external parties is also important for the comprehensive management of a company's environmental aspects. Communication with interested parties, such as regulators, insurers, contractors and local community interested in the environmental impacts of the company should be addressed and documented. By maintaining a meaningful dialogue and a proactive approach with external parties, a company can fulfil its environmental policy and realize EMS objectives [130].

In the case of AGOCO, the main system for internal communications by the company should be employee meetings, notice boards and the company's intranet. The company's environmental policy, environmental aspects, objectives and targets should be announced to all employees at a meeting, fixed on all notice boards and finally on the company's intranet.

External communications of the policy, environmental aspects, objectives and targets should be included in the company's annual reports, any popular paper and on the internet. In any case both internal and external communications should include company's performance on environmental issues after some time of EMS implementation. The following procedure can be useful for the communications.

3 Internal communication

3.1 Procedure

- **Identify communication methods**

  Identify internal communications for operations, products, services, EMS status, environmental status and issues, and employee feedback. The EMS coordinator is responsible for identifing communication methods. Communication may include the following types:

  - Posted notices on bulletin boards,
  - Verbal communication, either via telephone, in-person, or through routine meetings,
  - E-mail or internal electronic memos,
  - Brief status updates on objectives and targets at employee/safety meetings,
  - Company newsletter,
  - Employee suggestion box and surveys.

- **EMS communication**

Communication on the status of the EMS objectives, targets and compliance is the responsibility of the EMS coordinator. Other forms of communication for environmental aspects, operation, products, and services will be the responsibility of the existing department.

- Responsibility for ensuring the smooth and sufficient flow of internal EMS communications rests with the EMS coordinator, who may work through others to effect this end.
- The EMS coordinator will establish lines of communications to gather pertinent data on a periodic basis to monitor the EMS effectiveness.
- The EMS coordinator ensures the distribution and communication of the environmental policy to all AGOCO employees.
- The EMS coordinator will arrange for environmental awareness training of all employees and competence training for employees whose work may involve a significant environmental aspect.
- Internal communication methods are reviewed and updated annually, or upon the addition of new environmental or legal requirements and process change
- The EMS coordinator is responsible for maintaining a list of internal communication and procedure on file.

4 External communication

1 purpose

The purpose of this procedure is to establish a reliable and consistent process for receiving, documenting and responding to relevant information, communication or requests from external parties.

2 Scope

At AGOCO all external input regarding environmental performance will be considered as being from external parties.

3 Procedure

- **Identify communication methods**

Identify external communications for operations, products, services, EMS status, environmental status and issues, and external parties' feedback. The EMS coordinator is responsible for identifying communication methods. The following types of communication are included:

  - Company internet web site,
  - E-mail,
  - Telephone,
  - Letters receive

- The safety, training environment manager addresses environmental activities of the company, externally through press release, advertisement, conferences and seminars.
- The EMS coordinator is responsible for receiving, documenting and responding to suggestions, inquiries or complaints about environmental affairs by external parties. The EMS coordinator also keeps all correspondence.
- Environmental related complaints from neighbours, customers or the general public are forwarded to the safety, training environment manager who will acknowledge receipt of the complaint and initiate any investigation and corrective action required.
- Views from other external stakeholders are considered by the EMS coordinator during review of objectives and targets in other to implement any changes to the EMS if necessary.
- The EMS coordinator records consideration of external communications and any decisions taken with respect to them and documentation or copies of responses to external communications.

4 Responsibilities

- The safety, training and environment manager and EMS coordinator are responsible for EMS communication.

8.3.4 Environmental management system documentation

1 Purpose

The purpose is to show how AGOCO establishes and maintains information either in paper or electronic form to describe the core elements of the management system and their interactions and also to provide direction to related documentations.

2 Scope

The scope of the EMS documentation is to provide a standardized structure for organizing the company policies, procedures and work instructions, and records.

Environmental management system documentation

The EMS documentation is a road map to all associated documents. The EMS documentation describes what the EMS consists of, where other related documents, such as EMS procedures, standard operating procedures and environmental management programmes are located, and where records of performance can be found [130]. The documentation provides an overview of the EMS. It is not the purpose of the EMS documentation to fully document all of the environmental controls in the EMS. The purpose of the EMS documentation is to describe briefly the basic components of the EMS and to provide direction to the relevant documentation [130].

The documentation should be clear enough that someone unfamiliar with the EMS (such as new staff, or an auditor) can readily navigate and understand the system. EMS documentation typically includes:

- The environmental policy
- The EMS system procedures;
- Key records such as register of environmental aspects and impacts and the register of Legal and other requirements.
- Work Instructions
- Records such as training , audit and monitoring records.
- The EMS documentation should provide cross-references to other related documentation and records[144]..

The documentation shall either contain these policies, procedures, and delegations of authority within its text or provide direction to users as to where they are contained[144]. The EMS documentation should consists of several types of documents and records that are

categorized into various levels [145] (the levels has been explained futher under procedure of documentation).

In relation to AGOCO, there is a comprehensive company environmental response manual and established information on environmental management in paper form. However, there are no information as far as the direction to related documentation, description of the core elements of the management system and their interactions are concerned. To ensure direction of the related documentation, description of the core elements of the management system and their interaction, there is the need to have a standard documentation required by ISO 14001. This ensures the EMS is well understood and operating as designed. This EMS documentation will provide a direction for employees of the company on the application of EMS. There may also be external parties who will be interested in understanding how AGOCO's EMS is designed and implemented, such as customers, regulators, lending institutions, registrars and the public. The procedure follows can be useful for the establishing environment management system documentation.

3 Procedure

The EMS documentation consists of several types of documents and records that are categorized into four levels as follows.

Level 1 - Consists of EMS manual describing conformance with the ISO 14001 EMS standard and include environmental policy.

Level 2 - Consists of supporting regulation-based planning documents, and other supporting plans, documents, and/or information systems that may be required to fully implement the requirements of the ISO 14001 standard.

Level 3 - Consists of section-specific work instructions and standard operating procedures which identify approaches to managing task-oriented activities that relate to environmental impacts.

Level 4 - Consists of records and forms relating to Level 2 and 3 documentation, internal staff memos, reference lists or documents, reports, and other supporting documents developed in compliance with regulatory requirements or other EMS requirements.

8.3.5 Document control

1 Purpose

The purpose is to define a procedure or a mechanism for the controlling of the EMS documents. It is aimed is to ensure that personnels requiring access to EMS documents have the most up-to-date versions and are aware of the document control process.

2 Scope

The procedure encompasses all documents necessary to establish and maintained to be in conformance with the EMS at the company.

Document control

The document control system should be designed to confirm that employees has access to appropriate EMS documentation. It is important within an organisation to ensure that employees have the 'right' copy of the 'right' document at the 'right' time. Document control procedures should be implemented to ensure that personnels have access to appropriate EMS documentation and that out-dated documents are replaced and only current versions are used[116]. One of the easiest ways to control EMS documentation may be electronically, either on an intranet site, or a network directory. Password-protected access prevents unauthorised changing or moving of files [29]. Document control will ensure that EMS documents can be:

- Easily located;
- Periodically reviewed; updated as necessary and approved for adequacy by authorized personnel; and
- Available at all locations where operations are essential to the effective functioning of the environmental management system;
- Removed when obsolete or retained for legal and /or knowledge preservation purposes are suitable identified [110].

It is important that the EMS and supporting documentation can be found at one or more locations in the company. AGOCO has a way to control the company's documents, however, there is no procedure describing controlling issues, access and revision of EMS documentation to ensure that each employee has up-to-date documents that are relevant to the employee's activities as far as ISO14001 is concerned. To ensure that everyone is working with the proper EMS documents, the company needs a procedure that describes how the

documents should be controlled. When employees can easily locate working documents that are periodically reviewed, the company can be sure that employees are working with the right information. With the current suggested structure of AGOCO, the procedure below can be very useful for the control of the EMS documentation.

3 Procedure

- **Location**

In the case of AGOCO, EMS documents could be located with reference to Figure 32 that shows the management structure of the company. From this Figure it can be seen that there are five sub-departments: operation, maintenance, engineering, administration and environmental departments. Documents related to the EMS will be specific as far as individual departments are concerned. In this case each, departments will be supplied with the documents related to the department's objectives and targets within the EMS to allow easy access to the respective line and other staff members in the each department.

After every revision of the EMS, all doucments within these departments will be updated and obsolete ones withdrawn from points of usage. However, the safety, training and environmental department will have copies of all documents related to the EMS for back ups and for training purposes.

The safety, training and environmental manager is responsible for the EMS documents and communicate their locations to all staff. The managers of the various departments (see Figure 32) must be responsible and make sure the requirements specified are in place and functioning, as they should:

- **Availability**

Current versions of all documentation should be available to the person (s) using them. Hence, for example, the general manager (geology, geophysics, drilling, and production) is responsible for environmental documents concerning the exploration and production operations.

- **Periodic review**

The safety, training and environmental manager is responsible for the EMS documentation and its periodical revision. A master list of environmental records is

maintained at the field operation and in the company environmental department. For the EMS documents, a numbering system is used which shows the frequency of revision.

Controlled documents should have a date in addition to a revision number or version number.

Supporting documentation should have revision numbers assigned to them when they are revised after the issuance of the policy. The EMS supporting documentation is assigned document numbers (e.g., AG procedure No. 100).

- **Disposition of outdated copies**

Obsolete or outdated EMS documentation are removed from all locations and are not available for unintended use.

Copies of obsolete or outdated documents are retained for legal or knowledge preservation purposes. However, these are clearly marked as being obsolete and are not intended for use. The EMS coordinator keeps a copy of each outdated/obsolete document for one year for reference.

4 Responsibility

- The safety, training and environmental manager is responsible for the EMS document control system.

8.3.6 Operational control

1 Purpose

The purpose of this procedure is to provide guidance for establishing the operational controls that are to apply to AGOCO's activities, products, and service that exhibit significant environmental aspect to fulfil the requirements of the ISO 14001 Standard.

2 Scope

This procedure is used to establish the operation controls that are applicable to all activities, products, and services, which are associated with significant environmental aspects of the company. These operational controls provide clear work procedures for the staff to perform their tasks and duties properly and effectively.

Operational control

Operational controls are broadly defined to include technological (e.g., shut-off valves) and administrative (e.,operator intervention, standard procedures) controls.

The environmental mangament team follows a process to identify aspects that may lead to significant impacts and uses these to establish objectives and targets, which are addressed in the environmental management programme(s). Environmental management programmes are then used to develop specific operational control procedure [113].

Operational controls ensure that activities associated with significant environmental aspects are in line with the environmental policy and progress toward fulfilling its objectives and targets. An organisation may use various methods to provide operational control for processes and their potential environmental impacts.

With reference to ISO 14001, it is required that companies establish operational control over all activities significantly affecting the environment. This means that operational methods and procedures should be available for all activities causing environmental impact. This provides consistency when staff changes occur, and clearly identifies to staff members what their job responsibilities are.

Specific documented instructions should be developed for those activities where absence of instructions might result in a non-conformance or a high risk of environmental impact. In those cases, written instructions should be clearly and succinctly provide operating procedures, performance verification criteria and any corrective activities required in the event of a non-conformance [130].

It is important to know what needs to be done, who will do that, how it should be done and when it should be done.

AGOCO has operational controls for the environmental aspects associated with some of their activities, which includes well sites, access roads, drilling waste management, tanks, and atmospheric emissions. However, these controls do not cover all significant environmental impacts and also there is a lack of communicating relevant procedures to suppliers and contractors. Moreover, these procedures are not periodically reviewed as far as is ISO14001 concerned. It will, however, be very useful if the company can develop specific documented instruction to cover all the significant environmental aspects and periodically reviewing these set of instructions.

The set of steps can be used to develop effective operational controls for significant impacts. Produced water has been used as an example to demonstrate how this procedure can be applied (see box 3).

Box (3) Operational controls procedure for produced water for AGOCO

Department: production

Operation: produced water result of oil production stage

Procedure

Step I

Sampling responsibility: production operator

Step II

Sample frequency: every hour

Step III

Treatment:

Criteria/indicators

PH,

Non-halogenated organic content,

Halogenated organic content,

PCB Content.

DWD ← treatment ← 4.5>PH > 4.5-12.5 → Deep Well Disposal (DWD)

DWD ← treatment ← 10%< NH<10% → DWD

DWD ← treatment ← 1,000 mg/kg < H< 1,000 mg/kg → (DWD)

DWD ← treatment ← 50 mg/kg < PCB content< 50 mg/kg → (DWD)

A. The department manager is in charge of the revision the operational control procedure annually at least to ensure that the procedures are implemented and performing as planned.
B. The department manager, with the assistance of the EMS coordinator and the safety, training and environment manager, is also in charge of communication as far as the operational control procedures and requirements to suppliers and contractors are concerned when practicable.
C. In case of environmental incident, the operational controls procedures are however reviewed and revised. Any changes in the procedure are recorded.
D. The department manager is responsible as far as the responsibilities related to sample collections and testing are concerned.
E. Authorised and signed by: confirmed by:

1.The safety, training and environment manager **2. Department manager**

…….. **……**

Date: Drafted…….Revision……

Source: compiled by author

3. Procedure: proposal for the operational controls

Operational controls are needed to ensure that AGOCO activities, product, and services maintain stability within specified criteria. The following steps are taken to identify operational controls associated with the activities, products or services of each significant environmental aspect.

- Department managers in consultation with staff in their department/sections establish appropriate operational control procedures for controlling environmental aspects that are evaluated as significant in Table 12.
- Each department specifies their operating criteria, their maintenance plans, and the actions to be taken when they may be interrupted. Any documentation associated with operation controls should be kept current and accessible.
- Each department manager revises the operational control procedures in accordance with the practical situation of AGOCO, in order to ensure that the operational control procedure can be implemented effectively.
- Department managers, with the assistance of the EMS coordinator and the safety, training and environment manager, communicate relevant operational control procedures and requirements to suppliers and contractors (e.g. responsible person for contract-out services) wherever practicable.
- The operational control procedures are reviewed and revised based on corrective actions recommendation as a result of environmental incidents (such as leakage, spill or release) to the environment.
- The department managers are responsible for approving department-operating procedure where the absence of operating procedure could lead to significant environmental impact.
- The safety, training and environmental manager is responsible for ensuring the operational controls are implemented for those activities, products and services that have significant environmental aspects associated with them.
- All operational control procedures are authorised and signed by the safety, training and environment manager and confirmed by the general managers.

4. Responsibilities

- General managers and the safety, training and environment manager are responsible to establish and develop operational controls procedures.

8.3.7 Emergency preparedness and response

1 Purpose

The purpose is planning and preparing for a potential environmental emergency situation that may pose an immediate and significant threat to the environment and responding to such a situation in the event that such an event is imminent or occurs.

2 Scope

The scope is to encompass all activities at the company. The procedure applies to the actions of all employees at the company, as well as the services and products provided by vendors and contractors while operating on site.

Emergency preparedness and response

Emergency preparedness and response plans identify the potential for and response to environmental accidents and emergency situations. These plans also address the prevention and mitigation of the environmental impacts of accidents that do occur [113].

Despite a facility's best efforts, accidents and other emergency situations can occur. Effective emergency preparation and response should reduce injuries, prevent or minimize environmental impacts, protect employees and neighbours, reduce asset losses, and minimize downtime [142].

Emergency preparation and procedure should be established to respond to unplanned events. Procedure should define control mechanisms, operational requirements and other controls during these events. Emergencies, as defined by an EMS, include releases to the environment of all types, natural disasters that might lead to releases, and process hazards that might become emergencies. Emergency preparations for most facilities are usually based upon human health considerations [130].

An effective emergency preparedness and response programme should include provisions for assessing the potential for accidents and emergencies, preventing incidents and their associated environmental impacts, responding to incidents (emergency plans and procedures), testing of emergency plans and procedures periodically, and mitigating impacts associated with accidents and emergencies. Consistent with the focus on continual improvement, it is important to review emergency response performance after an incident has occurred so that can correct deficiencies in the procedure.

Two planning components that many facilities overlook are how they identify the potential for accidents and emergencies and how they prevent these occurrences or mitigate

their impact. A Cross Functional Team (CFT) (made up of representatives from engineering, maintenance, and environmental health & safety, for example) can identify most potential emergencies by asking a series of “what if ” questions related to hazardous materials, activities, and processes employed at the site. In addition to normal operations, the CFT should consider start up and shutdown of process equipment and other abnormal operating conditions. When developing emergency procedures, it is important to ensure that everyone (including new employees) knows what to do in an emergency (for example, how would contractors or site visitors know what to do in an emergency situation). In developing emergencies preparedness and response plans (steps to be undertaken in cases of emergencies) there is the need to:

- Conduct mock drills (mock drill test involves training on non-real situations, (e.g. leakage, and/or spill, and fire) to make employees more efficient carrying out the emergency.
- Reinforce training and get feedback on the effectiveness of the company’s plans/procedures.
- Paste copies of the company’s emergency preparedness and response plans and procedures (or at least critical contact names and phone numbers) around the company and especially in areas where high hazards exist.
- Include phone numbers for the company’s on-site emergency coordinator, local fire department, local police, hospital, rescue squad, and others as appropriate.
- Revise and improve plans as the company learns from mock drills, training, or actual emergencies [142].

It is important to ensure that the company emergency preparedness and response procedure describes the following:

1. Potential emergency situations (such as fires, explosions, spills or releases of hazardous materials, and natural disasters);
2. Hazardous materials used on-site and their locations;
3. Key organizational responsibilities, including emergency coordinator;
4. Arrangements with local emergency support providers;
5. Emergency response procedures, including emergency communication procedures;
6. Locations and types of emergency response equipment;
7. Maintenance of emergency response equipment;
8. Training/testing of personnel, including the on-site emergency response team if applicable;

9. Testing of alarm/public address systems;
10. Evacuation routes and exits (map); and
11. Assembly points [142].

From the review it appears that AGOCO has a very good procedure for emergency and response plans. However, there is a lack of key personnel responsible for such emergency situations and drilling to test the effectiveness of these plans if any of the emergencies occur. It is will be important for AGOCO to upgrade their procedure to meet ISO14001 requirements. To fill up the gap between the required procedures for emergency plans and that of AGOCO's emergency plans, the guidelines below apply:

- Duties of department managers, field supervisors, the safety, training, and environment manager;
  - Identify potential emergency to facilities and processes,
  - Identify and implement best management practice where necessary,
  - Maintain, test and inspect equipments, and
  - Review and update hazard assessments procedure at least 3 or 4 years or as a result and change.
- The department managers and the safety, training, and environment manager should carry out inventory operations and asses the availability of resources to handle potential emergencies.
- In case of a problem any employee has to phone his supervisor and the safety manager by short message, for example in case of fire (tell him/her the place and state, "fire, fire, fire"). Electronic alarms can also be installed for emergency situations.
- Phone numbers and contacts should be documented for emergency plans and should be included at least for, e.g. the department manager, field supervisor, and the safety ,training and environment manager.
- The safety, training and environment manager and department manager should hold a meeting to discuss the results of the emergency tests and write their recommendations.

3 Responsibilities

- The safety, training and environment manager is responsible for ensuring that an emergency preparedness and response procedure is implemented and for approving the emergency plans.
- Department managers and field supervisors are responsible for planned development, and planned implementation.

8.4 Checking and corrective action

8.4.1 Monitoring and measurement

1 Purpose

This procedure describes the process for the scheduled monitoring and measurement of key characteristics of the company's environmental management system activities.

2 Scope

The scope is to addresses collection of environmental data associated with operations and activities that have the potential to have a significant environmental impact.

Monitoring and measurement

Without effective monitoring and measurement procedures the company cannot ensure that the targets and objectives are being met. Monitoring and measurement helps the company to: measure environmental performance; analyse root causes of problems; and assess compliance with legal requirements.

The EMS requires an established and maintenance of documented procedures to monitor and measure, on a regular basis, the key characteristics of operations and activities that can have a significant impact on the environment (including the recording of information to track performance, relevant operational controls and conformance with environmental objectives and targets). Monitoring and measuring equipment must be calibrated and maintained and records of this process must also be maintained according to the procedures [113].

Most effective environmental monitoring and measurement systems use a combination of process and outcome measures. Outcome measures look at results of a process or activity, such as the amount of waste generated or the number of spills that took place. Process measures look at "upstream"factors, such as the number of employees trained on a topic[142].

The main idea is to figure out the operations and activities that can have significant environmental impacts, the key characteristics of these operations and activities and how these characteristics can be measured to know the performance of the company's environmental commitment.

Table 16 shows examples of EMS performance indicators that can be used to track performance:

Table (16) EMS performance indicators

Activity	Indicator/s
Planing	Number of significant aspects included in project plan
Review	Number of objectives and targets met
Production	Pounds of harzardous waste generated per unit of production
Training	Percentage of employees completing environmental training
Checking and corrective action	Average time for resolving corrective action
Resources	Energy or water use per unit of production; Resources used per unit of product or service
Recycling	Percentage of solid waste recycled/reused; Number of products that have a recycling programme
Social	Number of complaints from community and/or number of responses to complaints
Employees participation	Number of pollution prevention ideas generated by employees
Emissions	Pollution (by type) generated per unit of product or service
Regulation	Number of instances of non-compliance

Source: adopted from [142]

The results from environmental performance indicators will always become the basis for the company's plans for subsequent years and for documenting continuous improvement.

The response procedures in the manual of AGOCO show that the company seems to have monitoring and measurements such as corrosion monitoring, groundwater monitoring, and leakage detectors. There is also a checklist that is used frequently to ensure uniformity and keep track of results. However, there are no established and maintained documented procedures for periodically evaluating performance and compliance with relevant environmental legislation and regulations. It will, therefore, be very important for AGOCO to carefully evaluate the company's operations and activities that can have significant environmental impacts, the key characteristics of these operations and activities and how these characteristics can be measured to know the performance of the company's environmental commitment. The procedure that follows can be a useful guide for AGOCO for an effective monitoring and measurement.

3 Procedure

- Monthly progress report

A monthly report is established for department managers to submit monitoring and measuring information about performance of the EMS. This monthly progress report then forwarded to AGOCO's top management to review the information for assess the

effectiveness and adequacy of the management system. The report is structured having at least the following information.

- Provide the status of the environmental management programme designed to fulfill environmental objectives and targets,
- Provide the status of performance indicators as related to targeted timeframes,
- Provide compliance status of environmental operating[145].

- Supervisors are responsible for providing an oral presentation regarding the status in their area. The EMS coordinator will be responsible for reporting on the status of EMS activities
- Each monitoring and measurement procedures includes the monitoring and measuring frequency, method and equipment used, responsibilities, and records or reports that are kept. The monitoring and measurement plan integrates to the operational control procedures of relevant departments.
- Each department ensures that environmental monitoring equipment is upgraded and maintained at a frequency consistent with manufacturers recommendation. Each department is maintained calibration and maintenance records as necessary to prove conformance with this procedure.
- The monitoring and measurement plans are reviewed and revised annually by relevant department managers according to changes in legislative requirements and the practical situation of AGOCO. Appropriate adjustments are made to monitoring and measurement plans as a result of continual improvement of environmental performance and changes in preventive and corrective actions.
- Each applicable area and department maintains a list of EMS equipment requiring calibration and the corresponding calibration frequency.
- All operational monitoring and calibration to support and assure regulatory compliance are done in accordance with the applicable regulation permit at either national or international level.
- The safety, training and environment manager issues periodic updates of environmental issues via e-mail, memo, and bulletin board regarding updates to the EMS level documentation, EMS training, and status of audits.

4 Responsibilities

- The EMS coordinator is responsible for submitting a monthly progress operating report that provide the status of the environmental management programme designed to fulfill environmental objectives and targets, the status of performance indicators as related to targeted timeframes, and compliance status of environmental operating.
- The safety, training and environmental manager reviews the monthly operating reports to assure continuing suitability and effectiveness of the EMS.

8.4.2 Non- conformance and corrective and preventive action

1 Purpose

The aim of this procedure is to outline the activities involved in the identification and investigation of non-conforma nces and the mitigation of associated impacts and the determination of corrective and preventive action

2 Scope

The scope is to describe the control process for initiating corrective and preventive action in response to internally or externally reported non-conformance.

Non- conformance and corrective and preventive action

A non-conformance is a situation where the actual condition is not in accordance with planned conditions. Employees not following a procedure, a regulatory compliance, or an incident constitute examples of possible system non-conformances. Non-conformances can be identified through audits, monitoring and measurement, communications, and other systemic reviews and can also be registered directly. The intent is to correct the system defect by addressing root causes. The ISO 14001 standard requires that trends in corrective actions be evaluated to see if deeper-rooted preventive actions can be implemented [28].

The procedure needs to make sure that non-conformances are not only addressed to mitigate environmental impacts, but rather, further investigation is undertaken to determine their root cause, and action taken to avoid the non-conformances from happening again. Preventive actions would then be those actions resulting from an evaluation as to why non-conformities are occurring. The standard states that the corrective action should be appropriate to the magnitude of the problem and the impacts encountered, to avoid either over-compensating or under-compensating for a problem [28].

Procedures for non-conformance and corrective and preventive action should define responsibility and authority for handling and investigating occurrences of non-conformance with the requirements of the EMS. This procedures includes taking action to mitigate significant environmental impacts, and initiating and completing corrective and preventive action. Any changes in procedures resulting from corrective and preventive actions are implemented and recorded [113].

An organisation will need to establish a method to determine the causes of failing to conform. In some cases, the cause may be obvious, and in others, obscure. EMS non-conformance typically include:

- Poor communication;
- Faulty or missing procedures;
- Equipment malfunction or lack of maintenance;
- Lack of training;
- Lack of understanding of requirements;
- Failure to enforce rules; and
- Corrective actions fail to address root causes of problems [142] .

The AGOCO environmental response procedures manual shows that the company has corrective action plans to respond to non-conformance, identifying deficiencies in the management system and describing how deficiencies in the management system will be corrected. These plans, however, only cover oil spills and have no documented procedures for defining responsibilities and authorities for handling and investigating non-conformance. This means that AGOCO's policy on non-conformance is focused only on emergency situations, which would naturally result in deficiencies with respect to various provisions of the EMS. It would therefore be very important for AGOCO to elaborate non-conformance and preventive measures to cover all the objectives and targets of the EMS and also all environmental laws and regulations with the appropriate defined responsibilities. In order for AGOCO to be in conformance with the provisions of ISO 14001, the following procedure would assist in identifying the root causes of problems of non-conformance, responsibilities, reporting and corrective actions can be adopted.

3. Procedure

Where non-conformance or non-compliance are identified during internal or external audits process, the affected area or department managers, audit team member or EMS coordinator is responsible for:

- Identifying the root cause(s) of non-conformance or non-compliances
- Identifying appropriate corrective and preventive actions (including modifying or creating environmental procedures and work practice)
- Planning and implementing corrective and preventive actions
- Verifying the close-out and effectiveness of corrective and preventive actions.

- Any corrective/ preventive action reports should include the following;
  - List of personnel who identitied the problem,
  - Description of the problem,
  - Provide a root cause analysis, which identifies the source of the problem,
  - Describe corrective/preventive action, if unable to determine what corrective or preventative action must be taken to resolve the problem, skip the section, and the supervisor or personnel in charge must contact the appropriate personnel to immediately resolve the problem, and if able to determine the corrective or preventative action must be taken to resolve the problem.
- Some (technical) employees are empowered to create a corrective/ preventive action reports following incidents or a near miss or at any another time the employee wishes to make recommendations for changes to existing procedures or policies and/or to identify the need for additional policies and/or procedures.
- Department managers and field supervisors discuss (environmental management team) the non-conformance condition and roots causes, and jointly develop suitable measures, which can be taken to correct the non-conformance.
- A report will be submitted to the safety, training and environmental manager is responsibilty of the EMS coordinator on a regular basis, reviewing all non-conformances and their respective corrective and preventative actions. The report will include the following:
  - Review of non-conformance reports
  - Review of preventive actions
  - Review of corrective actions
  - Review of environmental complaints

- The safety, training and environmental manager, determines if the corrective action has been sufficiently adopted, and if not sufficient, the designee should assign a new or revise corrective action.

- Changes in the documented procedures resulting from corrective and preventive action are implemented and recorded.

4 Responsibilities

- The EMS coordinator is responsible for establishing and maintaining a non-conformances report.
- The safety, training and environmental manager is responsible for approving and monitoring the corrective and preventive actions on the non-conformance items, which, stated in the EMS non-conformance report.
- Department managers are responsible for identifying, handling and investigating non-conformances of AGOCO's EMS, establishing and implementing appropriate corrective and preventive actions to mitigate the environmental impact, and minimize the recurrence of the problem and the potential for nonconformance.
- All employees are responsible for helping their department managers in identifying non-conformances of AGOCO's EMS.

8.4.3 Records

1 Purpose

The purpose of this procedure is to define steps that AGOCO should follows to ensure that the EMS records are identified, indexed and filed for ready access.

2 Scope

The scope is that the records demonstrate conformance with the company EMS according to ISO 14001.

Records

Records exist to serve as verification of the system operating and the organization's conformance to the standard and its own EMS requirements. Procedures in this element (records) are required for the maintenance of records, and specifically require that records should be identifiable, retrievable, safely stored, and legible, retained as appropriate and traceable [28]. Record and document retention should also specify in the procedure.

Records include details of non-conformance and corrective actions, training records and corrective actions, incident reports and follow ups, complaints and responses, supplier

and contractor information, inspection and maintenance records, and monitoring data. Records management under an ISO 14001 EMS should be able to prove that the organization is actually doing what it committed [130]. Good records will primarily benefit the company team while they develop, implement, review, and revise the EMS. Occasionally, it may be necessary to prove the effectiveness of the EMS to people outside the company including community organizations, environmental groups, or a "registrar" that has been asked to certify the EMS as conformant to an environmental standard such as ISO 14000[116]. In short, keeping records is the only way the company can show explicitly that there EMS in place, been monitored and performing as planned.

The AGOCO environmental response manual shows that the company has records as far as environmental management is concerned. However, procedures for the identification, maintenance and disposition of environmental records were not spelt out in the environmental procedures manual. Moreover, retention (time of disposal of outdated information) was not always established. In this case there is the need for AGOCO to extend the recording system to cover all areas like: nonconformance and corrective actions, training records and corrective actions, complaints and responses, supplier and contractor information. The procedure that follows can be very useful guide for the identification, maintenance and the disposition of environmental records.

3. Procedure

- **Maintenance of environmental records**

All environmental records should be completed by the representative of the document control department, and verified or approved by authorised personnel. The environmental records should be established and maintained according to the environmental management system documents/procedures. Records arise from environmental management system documents/procedures of each department should be located at the corresponding department [130].

The EMS coordinator ensures that environmental records that belong to controlled EMS documents (e.g. register of significant environmental aspects and register of legal and other requirements) are periodically reviewed by the representative of the document control department according to the EMS procedure. The EMS coordinator also ensures that revisions are authorised by the safety, training environment manager, and distributed to relevant personnel whenever updated versions are available.

- **Storage and retrieval of environmental records**

The representative/s of the document control stores all environmental records in a systematic way, with record title and other useful information clearly shown so which they can be retrieved easilyand protected against damage or loss.

Environmental records are legible, identifiable and traceable to the corresponding operation or product involved.

- **Retention and disposition of environmental records**

The EMS coordinator is responsible for ensuring which the retention times and the responsibilities of maintaining environmental records are defined on EMS procedures. The representative of the document control department normally keeps environmental records for at least two years.

- **Management of obsolete environmental records**

The EMS coordinator and the safety, training environment manager, normally dispose obsolete records. Records that are kept for reference purpose must be isolated from useful records and clearly labelled.

4 Responsibilities

- The EMS coordinator is responsible for identifying and managing environmental records that are necessary for the implementation of the EMS.

8.4.4 Environment management system audit

1 Purpose

The purpose is to define the process for conducting periodic audits of the EMS. This procedure defines the process for scheduling, conducting, and reporting of EMS audits.

2 Scope

The scope of this procedure is to provide management with information on the success of the implementation of the EMS.

Environmental Management System Audit

After any EMS implementation there is the need to conduct periodic system audits to ensure that the environmental management system has been properly implemented and maintained. Periodic audits are very important in the sense that they help the company to determine whether or not the environmental management system conforms to planned arrangements for environmental management including the requirements of the ISO 14001 International Standard; and also to know whether the EMS has been properly implemented and maintained[110].

Firstly,during audits, it is important for the organization to develop a programme and related procedures that define an audit plan of the environmental management system. In addition, the programme should define frequency of the audit process. Secondly, the procedures must specify the methodology of the audit process, including the qualifications of the auditors. Thirdly, the audit reports should be submitted to the safety, training and environmental manager. Finally, the audit reports should provide recommendations directed at correcting any reported non-conformance that was discovered in the audit process [143].

The results of these audits should be communicated to senior to management for inclusion in the management review. Audits should be performed according to a schedule, which is based on the environmental importance of an activity, the results of previous audits and the audit schedule.

The audit procedure should cover the audit scope, frequency, methodologies applied and the responsibilities and requirements for conducting audits and reporting results. All auditors should be properly trained, and the audit records are kept with audit programme leader for use in the management review process [113]. ISO 14001 standard is silent on the frequency of audits however, generally accepted practice with EMS is a total audit of the system at least once a year.

The auditors or audit team must have knowledge of the field of activity in which they will carry out their audit, as well as knowledge of environmental management, technology, the environment in general and the environmental requirements which apply to the area in question [143].

From the AGOCO environmental audits programme it was found that this programme consists of:

- A commitment to conduct an environmental audit of each major facility every three years.

- A programme of planned inspections where operations staff completes an inspection, using a prepared checklist, of all of the facilities within their area at a minimum of at least once year.

The results of the entire audit programme, including corrective action plans are reported on a regular basis to the safety, training and environmental manager. However, the scope of the audit, methodologies, as well as the responsibilities and requirements for conducting audits is not well defined. Moreover, the procedure of the audits has no specific information on the activities and areas to be considered during auditing, well defined procedures/methodologies and also the competence of staffs engaged in this audit. Hence during audits, it is important for AGOCO to develop a programme and related procedures that define an audit plan of the company's environmental management system. There is also the need for the company to increase the frequency of auditing to at least a year instead of three years and clearly specifying the methodologies of the auditing process itself. Finally, there is the need for the audit process to provide recommendations directing corrective actions and of non-conformances. The procedure that follows can be useful to enable AGOCO to have a comprehensive auditing process that capture all of the above to enable the company be in conformance.

3 Procedure

- Internal audits will be scheduled on the basis of need, as reflected by the importance of activities or the results of pervious audits, but not less than annually in order to verify that the system is implemented and functioning as expected.
- The EMS audit team composes; representative from the following areas of the company; seismic, drilling, and production operations, and maintenance, and purchasing department.
    - Audit team selection is based on consideration of the particular areas of emphasis for the audit and the qualification and capabilities of the prospective team members.
- All internal EMS auditors are received formal training in the ISO 14001 and the EMS auditing procedure from a qualified a company.
- Audit team must prepare and complete the audit checklist by identifying the objective evidence that must be assessed for conformance with all requirements that fall within scope of the audit. The audit team identifies on the checklist any pervious corrective actions that need to be assessed.

- The EMS coordinator notifies department managers of the audit at least two weeks prior to the audit date. The notification should set the date, time, and location and discuss what will be covered in the audit.
    - No auditor conducts an audit on his own working area and at least two members of the audit team conducts each audit.
- The audit team conduct the audit. An opening session holds to explain the audit process to the EMS coordinator and other relevant employees.
- The EMS audit team is responsible for assisting in the audit preparation, conducting the audit investigations, and reporting of results in compliance with this procedure, under direction of the EMS coordinator.
- The audit report consists of a narrative of the state of each section in the EMS for the audited area and a listing of the findings and the observations.
    - Finding instances of non-conformance with ISO 14001 standards.
    - Observations of weaknesses in the programme that are not in conformance with the standard.
- At the completion of the audit, while still on site, the EMS audit team holds a closing session with an area supervisor to discuss the audit findings and answer any questions that the auditors may have at that time.
- The audit team documents corrective actions. Responsibility for corrective actions will reside with management in the area where the findings occurred. If a corrective action relates to the EMS itself, the EMS coordinator has primary responsibility for making the correction.
- The Audit team completes the audit report and makes it available to the safety, training and environment manager and the EMS coordinator.
- The EMS audit is closed when the audit team establishes that the corrective and preventive action plans have been developed and are likely to be effective.
- The internal EMS audit report and actions taken to address findings will be used during the management review.

4 Responsibility

- The EMS coordinator and audit team are responsible for creating and managing the audit programme.

8.5 Management review

1 Purpose

To provide guidelines for top management review of the AGOCO's EMS to ensure that the EMS continues to be effective, suitable and adequate and to make any decisions or take any actions necessary for its continual improvement.

2 Scope

The review should cover all elements of the EMS and should include sufficient information for management to make informed decisions on whether the EMS continues to be suitable, adequate and effective for its intended purpose.

Management review

Management review is an essential portion of the continual improvement of the organization's EMS. The improvement process does not end with the establishment of an initial policy, realization of initial objectives, or certification of the EMS to a standard. Management review is the essential element for systems improvement, along with preventive and corrective action.

A management review of the EMS should be of a scope to include all environmental potentialities for organizational activities, products, and services. This may include the financial impacts of these environmental potentialities and how the environmental concerns of the firm might relate to business opportunity [130].

The EMS review process includes a senior management review of all elements of the EMS. Management reviews should be conducted annually to ensure suitability, adequacy and effectiveness [113]. The management review should address the possible need for changes to policy, objectives, and other elements of the environmental management system, in the light of environmental management system audit results, changing circumstances and the commitment to continual improvement [130].

AGOCO has a formal review in the form of an environmental audit to be conducted periodically. The results of audit are presented to the top management of AGOCO with clear recommendations related to the environmental measures. However, there is no system for top management review of the EMS as far as ISO 14001 standard is concerned.

Hence there is the need for AGOCO top management to define the frequency of review (say yearly after every audit) to ensure continuing suitability, adequacy and effectiveness of the EMS. There is also the need for the process to ensure all necessary

information is collected for management to carry out the necessary evaluations. Finally, it will be important for AGOCO to carefully evaluate this information to see if there is the need for changes in company's policy, objectives and other elements of the environmental management system in light of environmental management system audit results, changing circumstances and the commitment to continual improvement."

To be able to achieve an effective management review, the procedures below can be adapted as guide.

3 Procedure

- The AGOCO top management conducts a review of the EMS at least once each year, unless circumstance warrants a more frequent review.
- The company top management reviews all applicable components of AGOCO EMS. The EMS coordinator is prepare the necessary input to be considered in the review, include the follows:
  - EMS audit results,
  - Results of monitoring and measurement of environmental indicators
  - Progress of the objectives and target programmes,
  - Legal and other requirements,
  - Corrective and preventive actions,
  - Any other relevant information on the EMS,
- The company top management reviews, discuss the agenda items and assess the effectiveness, sustainability, and adequacy of the environmental management system.
- The result of the management review is recorded in management review form.
- All employees is aware of the board's findings by the The EMS coordinator through methods outlined in communication procedure.

4 Responsibility

- Top management

CHAPTER NINE
CONCLUSION

In general, the environmental protection was not influential in Libya over past years, although law on the environment exists. Some of the reasons attributed to this were political and international sanctions. These predicaments put both the companies and the government under a very tight consideration to embrace most of the internationally agreed environmental protection policies.

Environmental issues can be effectively managed whilst identifying and exploiting the numerous opportunities proper environmental management can bring. Hence, the company needs to adopt an environmental management system which will give the company greater flexibility over how it achieves better environmental performance, but within a framework designed to “make company think” about its environmental challenges and to establish systematic solutions.

Libya's oil industry is run by the state-owned National Oil Corporation (NOC), along with subsidiary companies, which combined account for around half of the country's oil output. AGOCO, which is one of the biggest subsidiaries with such a performance, can cause serious environmental problems if measures are not taken to reduce environmental problems resulting from petroleum production.

Concern for the protection of the environment has become now an issue worldwide and for that matter Libya. This put the oil industry under increasing pressure to improve environmental performance and compliance focused on effective environmental management systems. Effective environmental management systems if adopted by the oil industry will drive the industry towards improved environmental performance.

This study reveals that there is not enough concrete information or documentation on EMS implementation in the oil industry in Libya. However, the first move by AGOCO in 2004 towards environmental management system was just a starting point that requires a lot of improvements. It is found that AGOCO has no written procedures for most of the Environmental Management System (EMS) requirements according to ISO 14001. Nevertheless, it was found that there exist some strength in some of the requirements especially in the areas of emergency preparedness and response by AGOCO. In the environmental response manual of AGOCO, this requirement seems to be well documented and implemented. The reason of this may be because petroleum industry in many cases

associated with accident such as spill, fire and well organised labour organisations with focus on human and economic well being.

The review of the environmental management system of AGOCO reveals the management system in place can assist the company to achieve minimum standards and provides no encouragement to go beyond those minima. This means as far as environmental management is concerned, the company is focused on the traditional active type of management not on the pro-active procedures required by ISO. This can be due to the fact that the industry in Libya used the prescriptive approach, which means, telling the companies exactly what measures must be taken and requiring little interpretation on the company side.

For effective implementation, the company should develop the capabilities and support mechanisms needed to achieve its environmental policy, objectives, and targets. When beginning the process, would be better to go through the whole process again, however, the priority must be given to elements listed below:

a) Identification of environmental aspects
b) Objectives and targets
c) Structure and responsibility
d) Training, awareness and competence,
e) Communications,
f) EMS documentation,
g) records
h) Operational control

Although most of these subjects are self–explanatory, the specification requires that organizations define, document and communicate the roles, responsibilities and authorities of all personnel, from the highest level to the lowest. This specification requires that the organization makes available the human, physical (e.g. equipment) and financial resources to ensure that the EMS is effective.

The initial review of AGOCO provided enough information that resulted in the various procedures to assist the company to be in conformance with the ISO 14001 EMS if well implemented. Effective implementation of these procedures can have not only a positive effect on AGOCO’s environmental performance alone but also the entire Libyan oil industry as whole. This is because other companies can use AGOCO’s procedures as benchmark in achieving environmental performance leading to total environmental improvement in the oil industry.

It is important for the Libyan environmental administration to formulate local EMS to be adopted by all sectors as a primary step towards an integration of the ISO 14001 EMS. Hence, the local or domestic EMS must contain elements of the ISO 14001 EMS. It is also an essential action for the environmental administration to enforce (time limit say 18 months after introduction) and support the industries to implement a local EMS. The implementation of any EMS requires an intensive training programme to make people awareness of the environment and prepare them for the implementation of the EMS.

The EMS of AGOCO company has been analyzed and discussed as a model for the other companies operating in the oil and gas sector in Libya. Based on this suggested analysis, guidelines for the evaluation of EMS of any company can be easily developed in an explicit form. It is opinioned that a suitable questionnaire could be developed at a later stage which could then be sent to the company concerned. In the light of their response, guidelines for the evaluation and hence implementation of EMS would be developed in form of documents at a later stage by the Libyan government In the presence of such documents any EMS system in the country would be easily evaluated.

Glossary

Abandoned well: A well that is no longer in use, either because it was drilled as a dry hole, or has ceased to produce or for some other reason is incapable of being operated.

Agenda 21: A 500-page document of new initiatives identified during the 1992 United Nations Conference on the Environment and Development (UNCED) held at Rio de Janeiro, Brazil.

Appraisal well: A well drilled into a formation shown to be potentially productive of oil or gas by an earlier well for the purpose of obtaining more information about the reservoir.

Associated gas: Natural gas found in oil reservoirs; the composition of this variable

Bentonite: The mineral montmorillonite, a magnesium aluminum silicate. Used as a treating agent, also, as a component of drilling mud, and in grease

Biodiversity: An acronym for biological diversity and refers to the variety of living organisms that inhabit the earth.

Blowout: The uncontrolled of oil and gas, oil or other well fluids into the atmosphere, which occurs when formation pressure exceeds the pressure, applied to it by the column of drilling fluids.

Casing: Steel tube that is cemented into an oil well to prevent the collapse of the well, the flow of fluids between formations, possible contamination of groundwater.

Cost effective: This means to achieve a benefit objective at the lowest cost or to achieve the greatest benefit at a given cost.

Cuttings: The fragments of rock dislodged by the bit and brought to the surface in the drilling mud.

Circulation of mud: The return to the surface of a portion of the drilling mud used in the drilling of a well

Decommissioning: The process of deciding how best to shut down operations at the end of a field's life, then closing the well's cleaning, making the installation safe, removing some or all of the facilities and disposing or reusing them.

Development well: Well drilled in a formation for the purpose of producing oil and gas. Also called a production well.

Drilling rig: The complete machinery and structures needed for drilling a well.

Drill site: This is the area comprising the useful area and pits or tanks for disposal of cuttings, treatment of drilling fluids and production testing, areas covered with vegetation, storage for vegetal matter and other areas required in accordance with the topography of the terrain.

Dry hole: A well drilled without finding gas or oil in commercial quantities.

Exploration: The search for reservoirs of oil and gas that includes aerial and geophysical surveys, geological studies, core testing, and drilling wells.

Exploration drilling: Drilling carried out to determine whether hydrocarbons are present in a particular area or geological structure or to learn more about subsurface structure.

Field: Geographical area in which a number of oil or gas wells produce from a continuous reservoir**.**

Flaring: Controlled disposal of surplus combustible vapor by igniting them in the atmosphere.

Flow line: The surface pipe through which oil travels from the well to processing equipment or to storage.

Formation: Deposit composed throughout of substantially the same type of rock; lithological unit; each different formation is a given name.

Geophones: The detectors used in seismic survey to pick up acoustic waves reflected from subsurface strata.

Injection well: A well used to inject gas or water into an oil/gas reservoir rock to maintain reservoir pressure during the secondary recovery process. Also a well used to inject treated wastes into selected formations for disposal.

Interested party: An individual, organization, or group interested in concerned with environmental performance.

Jack-up drilling rig: An offshore drilling structure with tubular or derrick legs which support the deck and hull. When positioned over the drilling site, the bottoms of the legs rest on the sea floor. The rig is towed to location with its legs up, on arrival the legs are "jacked " down to the seabed and the hull "jacked" up the sea surface.

Oil field: A productive oil or gas formation comprising one or more reservoirs, usually related to the same geological features.

Primary recovery: The first stage of oil production in which natural reservoir pressure is used to recover oil.

Produced water: Water originating from the natural oil reservoir that is separated from the oil and gas in the production facility.

Production: That phase of petroleum activities that deals with bringing the well fluids to the surface and separating them, and with storing, gauging, and other wise preparing the product for the pipeline.

Recovery: The total volume of hydrocarbon that has been or is anticipated to be produced from a well or field.

Reservoir rock: Porous and permeable rock, such as sandstone, limestone-containing petroleum within the small spaces in the rock.

Secondary Recovery: Recovery of oil or gas from a reservoir by artificially maintaining or enhancing the reservoir pressure by injecting water, gas or other substances into the reservoir rock.

Strata: Distinct, usually parallel beds of rock.

Vibroseis: A seismic survey technique that uses a large vehicle fitted with vibrating plates or produce shockwaves.

Used oil: used oil applies to any oil that is no longer useful to the orginal purchaser as a consequence of extended storage, spillage, etc.

Well completion: The activities and methods used to prepare a well for the production of oil and gas may include establishment of a low between reservoir and surface.

Wellbore: The well bore, the hole made by drilling; it may be open, or portion maybe ceased.

Work over: A process by which a completed production well is subsequently re-entered and any necessary cleaning, repair and maintenance work done.

References

[1] Appletion, J.D., Hooker, P.J., Smith, N.J.P., 1995. Report on the abatement of volatile organic compounds from stationary sources. Report to the department of the environment, London, contract no. PECD 7/12/138.

[2] Yannick, P., 2004. Solid/ Liquid Dispersions in Drilling and Production. Oil and Gas Science and Technology, Institut Français de Presse. France, vol., 59., No. 1.p.12

[3] Richard, S., 2003. Economics of Worldwide Petroleum Production (Second Edition), printed in U.S.A, Tulsa, Oklahoma.,p.1-9.

[4] Boy de la Tour, X., 1999. The Energy Future to 2020". Oil & Gas Science and Technology, Panorama 99.

[5] Decroocq, D., 2003. Energy Conservation and CO2 Emissions in the Processing and Use of Oil and Gas, Oil and Gas Science and Technology, Institut Français de Presse, France ,Vol., 58, No. 3,pp.331-342.

[6] Germain, J., 2000. Pétrole et Gaz dans le panorama énergetique mondial, France, Rapport IFP 53065.

[7] Alan, G., 2004. Oil To the National Italian American Foundation, Federal Reserve Board Washington, D.C.,www.federalreserve.gov/boarddocs/speeches/2004/200410152/default.htm. date of visit

[8] Marla, M., Tiana, W., Brian., F., Robert, J. B., 2000. Worldwide Petroleum Industry Outlook, Seventeenth edition 2001-2005 projection to 2010, contribution economics editor oil and gas Journal Penn Well, Tulsa., pp.251.

[9] James, L.W., 2004. Oil Price History and Analysis, WTRG Economics, http://www.wtrg.com/prices.html, 27.11.2002.

[10] U.S., EIA., 2002. International Energy Outlook, www.eia.doe.gov/oiaf/ieo/notessources. Html, 15.2.2003

[11] Michot, F. M., 1999. Houston's International Gas/Power Path, Energy Houston, U.2, no.1., pp.50.

[12] Michot, F. M., Garander., E. Casy., J. Gulen., G. 1999. Best Practices in Energy Sector Reform, Energy Institute White paper, University of Houston – College of Business Administration.

[13] Moore, D. S., McCabe, G. P., 1989. Introduction to the Practice of Statistics, Freeman, New York.

[14] Digital History., 2004. Politics of Oil, www.digitalhistory.uh.edu/historyonline/oil.cfm 20.9.2004.

[15] Paul, M., 2000. The Middle East and North Africa, Outlook for Oil in an Era of Deregulation, the Petroleum Economist ltd, London., pp. 6-11.

[16] Robert L. H..,2005. Peaking of World Oil Production: Impacts, Mitigation and Risk Management. http://www.hubbertpeak.com/us/NETL/OilPeaking.pdf. 16.08.2005.

[17] Marianne, H.,2002., International Foundry Forum 2002, World - wide Energy and Future Investment Requirements, Berlin.www.iea.org/textbase/speech/2003/haug/berlin.pdf. 20.08.2005.

[18] Campbell, C.J. Laherrere., J.H. 1998. The End of Cheap Oil. Sceintific Amerian., pp.78-83.

[19] Riva Joseph, P., Jr., 1995. World Petroleum Resources and Reserves, CRS Report to Congress, United States Library of Congress. www.mnforsustain.org/riiva_i_natural gas_distrbuttion_of_the_world.html.

[20] Joseph S.Barrera.., 2004. Saudi oil production reaching physical limits, http://lair.xent.com/pipermail/fork/Week-of-Mon-20040223/028576.html

[21] BP Amoco., 1999. Statistical Review of World Energy, www.bpamoco.com.11.12.2003.

[22] EIA., 2003. www.eia.doe.gov/oiaf/ieo/notes_sources 10.5.03.

[23] Williams, J. L., 2005. WTRG Economics Oil Price History and Analysis. http://www.wtrg.com/prices.htm

[24] National oil corporation., 2004. Exploration Activities and Promising Oil and Gas Future of Libya,www.ihsenergy.com/news/presentations/appex_2004/day_3/sahara_Libya.pdf. 20. 8.2005

[25] Oil & Gas Journal., 2004.Vol. 102, No. 47 (Dec. 10), From: U.S. Energy Information Administration. http://www.eia.doe.gov/emeu/international/petroleu.html .

[26]Global Policy Forum.,2004.The Global Compact's Ten Principles,www.globalpolicy.org/reform/indxbiz.htm.22.11.2005.

[27] Donald, L. R. L.,1990. Natural Gas Engineering Production and Storage. printed in Singapore.p.6-9.

[28] Dpartment of Environmental Quality., 2005. Environmental Management System Guidance Manual(2004), Michigan State, http://www.michigan.gov/deq/0,1607,7-135-3307_3668_4149-102117--,00.html. 10.10.2005.

[29] City of San Diego.,2005. Environmental Management Plan, Environmental Services Department EMS Manua,www.sandiego.gov/environmentalservices/ems/pdf/ems_manual.pdf.

[30] Institute for the Analysis of Global Security.,2002. The Future of Oil, http://www.iags.org/futureofoil.html, March 2004.

[31] EIA., 1999. Annual Energy Review, www.eia.doe.gov. 10.05. 2003

[32] International Energy Outlook.,2003, International Gas Market, www.eia.doe.gov. 08.05.2003.

[33] History: Energy Information Administration (EIA)., 1999. Office of Energy Markets and End Use, International Statistics Database and International Energy Annual, DOE/EIA – 0219(99) (Washington, DC, February 2001). Projections: EIA, World Energy Projection System.

[34] EIA.,2004, www.eia.doe.gov/emeu/international/reserves.html.20.03.2005.

[35] Asher, I., Richard, A., Startzman Maria, B., 2004. Gas Demand Growth Oil & Gas journal., pp. 20-26.

[36] Al-Fattah, S. M., Startzman, R. A., 2000. Forecasting World Natural Gas Supply Journal of Petroleum Technology., pp. 62-70.

[37] Uppsala University., 2002. International Workshop on Oil Depletion, www. Hubbertpeak.com/gas. 1509. 2004.

[38] Oil& Gas Journal., 2002. Natural Gas Reserves.volume 100: No. 52.

[39] U.S.EIA.,2002. Assumption to the Annual Energy Outlook, www. ia.doe.gov/oiaf/aeo/ assumption/international.html 20.01.2003.

[40]U.S.,EIA.,2001.Assumptions to the Annual Energy Outlook ,www .eia. doe .gov /oiaf/ aeo/ assumption/international.html . 20.01.2003.

[41] U.S., EIA., 1998. Non-OPEC fact sheet, www.converger.com/eiacab/nonopec.html. 11.03.2003.

[42] Jaecker,V.A., 2000. Reduction des émissions polluantes et du CO2. Etat des connaissances et des recherches dans le monde, France ,Paris, Rapport IFP 53 244, Oil & Gas Science and technology. IFP, Vol. 58, No. 3.

[43] George, E. K., Don, B. Felio., Thomas E. O` Connor., 2000. International Oil and Gas ventures; A Business Perspective, The American Association of Petroleum Geologists, Tulsa, Oklahoma, USA., pp. 12-37.

[44] Planet for life.,2004. The Coming World Oil Crisis, http://planetforlife.com/oilcrisis/. 16.08.2005

[45] BP Statistical Review of World Energy.,2005. http://www.bp.com/liveassets/bp_internet /globalbp/globalbp_uk_english/publications/energy_reviews_2005/STAGING/local_assets/downloads/pdf/statistical_review_of_world_energy_full_report_2005.pdf. 1.9.2005.

[46] History: (EIA), Annual Energy Review., 2002. DOE/EIA- 0384(2000) (Washington, DC, July 2001). Projection: 2000-2002 – EIA. Short term Energy Outlook, on-line version (January 8, 2002), website – www.eia.doe,gov/emeu/steo/pub/contents,htm 2003 –2020 –EIA, Annual Energy Outlook 2002, DOE/EIA-0383 (2002) (Washington, DC, December 2001).

[47] Stuart Baird, M., Eng, M. A., 1993. Energy of Ontario, Natural gas, www.iclei.org/efacts/natgas.htm. 10.2. 2003.

[48] Stoppard, M., 1999. A New Order for Gas in Europe., Oxford institute for Energy studies. Oxford University Press.

[49] Rögnvaldur, H., 1998. Petroleum Economics, Issues and Strategies of Oil and Natural Gas Production,Printed in USA., pp. 28-32.

[50] Austvik, O.G., 1997. Gas pricing in liberalized European Market, Energy policy, London,. pp.977-1012.

[51] Hardald,T., 2000. Oil and Gas in Central and Southern America , The Petroleum Economist Ltd., London., pp. 10-20.

[52] Mike. M., Nick White., 2001. Liberalising Gas Markets in Europe. Petroleum Economist Ltd. London., pp.6 .

[53] International Petroleum Encyclopaedia., 2002. “Worldwide Oil and Gas at a Glance”, Penn well Pub, printed in USA.,366pp.

[54] International Petroleum Encyclopedia., 2001. OPEC Grapples with Pressure to Change, by penny well corporation, printed in USA.,p. 258.

[55] Sachs, J.Warner, A.., 1995. Natural Resource Abundance and Economic Growth:Harvard Institute for International Development white paper.

[56] Hyne, N .J,. 2001. Nontechnical Guide to Petroleum Geology, Exploration, Drilling,and Production(2nded.),Tulsa,Oklahoma: Penn Well Corporation.http://en.wikipedia.org/wiki/ Natural_gas_field.13.10.2005.

[57] Joint E & P Forum / UNEP., 1997. Environmental management in oil and gas exploration and production, an overview of issues and management approach, France, Technical publication (report 37)., pp.1-25.

[58] John, M.. R., 1997. Introduction to Applied Environmental Geophysics. Geo–science Ltd, UK. West Sussex England., pp.191.

[59] Bourgoyne, Jr., A. T., Millheim, K. K., Chenevert, M. E., Young, Jr., F. S., 1991. Applied Dirlling Engneering, Richardson, Texas, SPE Textbook Series, Vol.2.

[60] Michael, J. Econmmides., Larry, T. Waters., Shari, D. Norman., 1998. Petroleum Well Construction. West Sussex England. pp. 6,7,128,129.

[61] Oil Field Publications Limited., 2003. Offshore Drilling & Production Concepts of the world, fifth edition., pp.14-16

[62] Thomas, O,. Allen., Alan, P. Roberts., 1993. Production Operations: Well Completions, Workover, and Stimulation, Penn well Corp., Edition: 4 – Hardcover, 310 pp.

[63] Mario, Z., Mike, Stephens., 1998. Petroleum Well Construction. West Sussex England., pp. 119-131.

[64] John, C. Reis., 1996. Environmental Control in Petroleum Engineering. Houston, Texas., pp.20-29.

[65] Norman, J. Hyne., 2001. Non technical Guide to Petroleum Geology Exploration, Drilling and Production. 2nd edition, printed in USA., pp. 1-15.

[66] William, S., Griffin, Phillips., 1998. Managing the Platform Decommissioning Process. SPE International Conference and Exhibition in China held in Beijing, China.

[67] Armando, N., 1995. Environmentally Safe Drilling Practices. Penn well Pub. Co., pp 2-10.

[68] Stephenson, M.T., 1992. A Survey of Produced Water Studies, in Produced Water, J.P. Ray and F.R. Englehart (eds.), Plenum Press, New York., pp. 548-603.

[69] Gray, P. R., 1993. NORM Contamination in the Petroleum Industry. J. Pet. Tech., pp. 12-16.

[70] Deeley, G.M., 1990. Use of MINTEQ for Predicting Aqueous Phase Trace Metal Concentrations in Waste Drilling Fluids, Proceedings of the U.S. Environmental Protection Agency's First International Symposium on Oil and Gas Exploration and Production Waste Management Practices, New Orleans.pp.1013-1023.

[71] Associated Waste Report., 2000. Preliminary Investigation of Selected Asociated Wastes, http://www.epa.gov/epaoswer/other/oil/execsum.pdf. 12.12.2005.

[72] Alberta Centre for Boreal Studies. 2001. The Oil and Gas Industry in Alberta: Drilling and Production http://www.borealcentre.ca/facts/drilling.html.25.5.2005.

[73] Judith, K., 1989. Petroleum Development in Amazonian Ecuador: Environmental and socio -cultural Impacts. Washington, D.C., Natural Resource Defence Council., p.12.

[74] George, L., 1990. Minimizing Environmental Problems from Petroleum Exploration and development in Tropical forest Areas, the World Bank, Washington DC., p. 76.

[75] John, C. Reis., 1996. Environmental Controls in Petroleum Engineering. Houston, Texas., pp. 71-77.

[76] George Ledec., 1990. Minimizing Environment Problems from Petroleum Exploration and development in tropical Forest Areas, the World Bank, Washington DC., p. 2.

[77] Andreas, S., 1998. ISO 14001 Implementing an Environmental Management system. Ellipson, Basel Switzerland. http://www.ellipson.com/files/ebooks/ISO14000.pdf 30.09.2004

[78] National Research Council. 1985. Oil in the Sea: Inputs, Fates, and Effects, Washington, D.C., National Academy Press.

[79] Jones, L. W., 1988. Corrosion and Water Technology, Tulsa, Oklahoma,. OGCI Publictions .

[80] Valkovic, V., 1978. Trace Elements in Petroleum, Tulsa: Petroleum Publishing company.

[81] Proctor, N. H., J. P., Fishman, M. L., 1989. Chemical Hazards of the Workplace, New York: Van Nostrand Reinhold.

[82] Rick, W., 2004. Oil, Gas To Remain Dominant Commodities. World Energy Conference.

[83] Burnham, K., Bey M., 1991. Effects of Crude Oil and Ultraviolet Radiation on Immunity Within Mouse Skin., J. Toxicology and Environmental Health, Vol. 35., pp. 83-93.

[84] Burnham, K., Rahman, M., 1992. Effects of Petrochemicals and Ultraviolet Radiation on Epidermal IA Expression in Vitro. J. Toxicology and environment al Health, Vol. 35., pp.83-93.

[85] Interim Report., 1987. Wastes from the Exploration, Development and Production of Crude Oil., Natural Gas and Geothermal energy, U.S. EPA, Washington, DC.

[86] Oil and Gas Forum., 2002. The oil and Gas Industry and Environment.. http://www.oilandgasforum.net/oefonline/module5_voluntaryinitiatives.htm.20.06.2005

[87] George, G., 2002. Industry Codes of Practice and Other voluntary initiative:their Application to the Mining and Metals Sector, prepared by Stratos.,Ottwa, Canada.p4-8.

[88] High Seas Convention., 1958. Art. 24 of the, 450 UNTS 82.

[89] Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter .,1972.cohttp://www.londonconvention.org/documents/lc72/1996%20PROTOCOL.doc.20.06. 2005

[90] API's Environmental Stewardship Programme Pledge for CAREFUL Operations, www.api.org/, accessed 27 February 2002.

[91] The Energy Charter Treaty.,1996. Kluwer Law International, An East-West Gateway for Investment and Trade, Reprinted in T.W. Walade, London,.pp. 621-659.

[92] Peter, R.,2004. Fossil Fuel Demand is Increasing .http :// www .abc.net.au / pm / content /2004/s1193436.htm.5.09.2005

[93] American Petroleum Institute., 1995. Onshore Oil and Gas Production Practices for Protection of the Environment (Washington DC, API, 2nd ed,).

[94] Oil Industry International Exploration and Production Forum., 1993. Oil and Gas Exploration and Production in Mangrove Areas: Guidelines for Environmental Protection (Gland, Switzerland: IUCN/E&P Forum, Report No. 2.54/184).

[95] ARPEL, 1996. Code of Environmental Conduct, above n5; APPEA, APPEA Code of Environmental Practice, www.appea.com.au/environment/code.html; UKOOA,Environmental Principles, www.ukooa.co.uk

[96] The International Convention on the Prevention of Marine Pollution from Ships and its Protocol., 1978. Reprinted in 12 int' l Legal Materials (ILM) 1319 (1973), 17 ILM 546.

[97] The Centre for Energy, Petroleum and Mineral Law and Policy.,2000. MARPOL1973/78. www.dundee.ac.uk/cepmlp/journal/html/vol2/article211.html.30.06.2005

[98] International Union for the Conservation of Nature and Natural Resources., 1991. Oil Exploration in the Tropics: Guidelines for Environmental Protection (Gland, Switzerland: IUCN,).
[99] Danial Yergin., 2000. Prize a brief history of petroleum. www. Maverickenergy.com. 27.10.2002.

[100] Hatamian, H., 1998. Natural –Gas Supply and Demand Problems. JPT., pp. 58-62

[101] Terasen Gas.,2004. Gas Pricing. www.terasengas.com/_AboutNaturalGas/GasPricing/ default.htm.12.06.2005.

[102] Waddams, F. C., 1980. The Libyan oil industry. Croom Helm, London., 366 pp.

[103] Don Hallett., 2002, Petroleum Geology of Libya. Elsevier Science B.V. 503., pp 17-43.

[104] Gurney, J., 1996. Libya; The Political Economy of Oil. Oxford Institute of Energy Studies. Oxford University Press., p. 241.

[105] UNEP Paris., 1985. The Impact of Water-Based Drilling Mud Discharges on the Environment. Industry and Environment Overview Series.

[106] Adopted from BP statistics., 1999. www.lags.org/futureoil .htm. 2004.10.20

[107] National Energy Information Center.,2004. International Petroleum Production, http://www.eia.doe.gov/emeu/international/petroleu.html#IntlProduction.27.12.2004.

[108] EIA.,2004. Libya Country Analysis Brief, www.eia.doe.gov/emeu/cabs/libya.html 1.08.2005

[109] Waeil, A., 2003. Planning for Safety Inside Arabian Gulf Oil Company, M.Sc. dissertation in Teesside university., pp.52-53.

[110] ISO.,1996. www.iso.org 2004.09.09

[111] William, D. McCain, Jr., 1990. The Properties Petroleum Fluids, penn wells book Second Edition., printed in USA., pp. 1-11.

[112] Saint John Energy., 2004. ISO 14001 Environmental Management System ImplementationManual.www.sjenergy.com/Inside_Saint_John_Energy/pdf/EMS_2004_Revision_11.pdf.

[113] Edward, R. G., McGinty, K. A., 2001. EMS Model Manual Specific to Pennsylvania Municipal Operations" reported to Pennsylvania Department of Environment protection. http://www.dep.state.pa.us/dep/deputate/pollprev/Iso14001/SampleEMS.pdf. 10.5.2005.

[114] Global Environmental Management Initiative (GEMI)., 2000. ISO 14001 self Assessment checklist. http://www.gemi.org/ISO_111.26.09.2005.

[115] Environmental agency, Bristol., 1998. Oil and Gas in the Environmental, London., p.23.

[116] College and University Environmental Management System Implementation Guide., 2001. www.epa.gov/ne/assistance/univ/pdfs/emslmpGuide1.pdf

[117] Clapp Jennifer., 1998. The Privatization of Global Environmental Governance: ISO 14000 and the developing World. Global Governance 4 (3): pp. 295-316.

[118] Wojtanwicz, A.K., Field, S.D., Krilov, Z., and Spencer, F.L., 1989. Statistical Assessment and Sampling of Drilling Fluid Reservor Pits, Tulsa., pp. 162-170.

[119] Arscott, R. L., 1989. New Directions in Environmental Protection in Oil and Gas Operations," JPT., pp.336-339.

[120] Thomas William, L., 1997. USE ISO 14001 as a Manager for Process Risks, Hydrocarbon Processing, Vol. 76., issue 11.

[121] Farhad, F., Hoag, G. E., Shili, L., Robert, J., Carley Peter, Z., 2000. Detection and Remediation of Soil and Aquifer Systems Contaminated with Petroleum Products: an overview, Journal of Petroleum Science and Engineering., p. 26, 169-178.

[122] Kostecki, P.T., Calabrese, E .J., 1989. Soils Contaminated by Motor Fuel: Research Activities and Perspectives of the American Petroleum Institute. Petroleum Contaminated Soils., p. 1, 13-19

[123] Sullivan, M. J., Custance, S. R., Miller, C.J., 1990. A Risk Assessment for Crude Oil in Residential Surface Soils, Annual Hydrocarbon Contaminated Soils conference , Amherst, MA, Sep. 24.

[124]Arabian Gulf Oil Company., 2004. Environmental Procedures Manual. Benghazi, Libya.

[125] Neal, E. Thurber., 1992. Waste Minimization for Land-Based Drilling Operations". JPT., pp. 542.

[126] Jeffrey, A. Miller., Alonzo Lawrence., 1997. Pilot Plant Treatment of Natural Gas Produced Waters to Meet Beneficial Use Discharge Requirements, SPE/EPA Exploration and Production Environmental Conference held in Dallas, Texas, 3-5 .pp.155-161.

[127] Lyn Arscott., 2003. Sustainable Development in the Oil and Gas Industry. JPT, pp.79-83.

[128] E&P Forum., 1996. The physical and Biological Effects of Processed Oily Drill Cuttings., Summary report. Report No. 2.661.

[129] National Oil Corporation., 2005. www. Noclibya.com/Noc-site/bid-round-arabic.htm. 30.03.05

[130] Martin, R. 1998., National Centre for Environment and Decision-making Research (NCEDR) http://www.ncedr.org/pdf/ISO14001.pdf. 22.09.2005.

[131] Greg Croft .,2005 The Ghawar Oil Field, Saudi Arabia.www.gregcroft.com/ghawar .ivnu, 17.05.05

[132] Ken, K., 2005. Prospects for the World Oil Market and Crude Oil Prices for 2005. General Manager, Energy Strategy Dept. Institute of Energy Economics, Japan.
[133] Zhiguo,G. D., 1997. Environmental Regulation of Oil and Gas. Scotland, UK., pp. 4-9-20.

[134] Atmosphere, Climate & Environment Information Progamme.,2000. Encyclopedia of the Atmospheric Environment, (Climate Change) ,www.ace.mmu.ac.uk/eae/english.html. 30.06.2005.

[135] Jonathan. W., 2000. The Law on Offshore Wastes Discharges in Different Jurisdictions OSPAR, M.A., Ph.D., M.Inst.Pet., for Ekologicheskaya Vahkta Sakhalina (Sakhalin Environment Watch),http://www.offshore-environment.com/ospar.html.10.06.2005

[136]AFEAS.,2004.Current Provisions of the MontrealProtocol, www.afeas.org/montreal_ _protocol.html, 10.06.2005.

[137] Wikipedia., 2005. Kyoto Protocol, http://en.wikipedia.org/wiki/Kyoto_Protocol# Financial_commitments. 23.06.2005.

[138] Oil and Gas Exploration in Arctic and Subarctic Onshore Regions., 1993. Guidelines for Environmental Protection (Gland, Switzerland; Cambridge, UK: IUCN/E&P Forum, Report No. 2.55/185.

[139] E&P Forum., 1991. Oil Industry Operating Guideline for Tropical Rainforest, Report No. 2.49/170.

[140] Exploration and Production Waste Management Guidelines., 1993. Report No. 2.58/196.

[141] Decommissioning, Remediation and Reclamation Guidelines for Onshore Exploration and Production Sites., 1996 Report No. 2.70/242.

[142] EPA's Shipyard Sector Strategies., 2004. EMS Implementation Guide for the ShipbuildingandShipRepairIndustry.http://cmsshipbuilders.advancedlegal.com/pdfs/8122005 81837A.pdf. 1.10.2005.

[143] Virgina Department of Environmental quality., 2005. ISO 14001 Environmental Management System. http://www.deq.virginia.gov/ems/iso14001.html.10.10.2005

[144] Victorian Government EMS Initiative., 2003. Guidance Notes for the Preparation of the Environmental Management System Manual. www.epa.vic.gov.au/government/ems/docs/ Guidance_Notes.pdf

[145] Beth. E,. 2000. ISO 14001 – Environmental Management System Manual, City of Gastonia Wastewater Treatment Division. http://www.p2pays.org/ref/19/18500.pdf

APPENDIX

Appendix A

Environmental aspects of oil and gas drilling by AGOCO

Activity	Environmental concern
Well site planning	Inappropriate site selection and lease layout: Disturbance wildlife, terrain and vegetation.
Well site construction	Without careful consideration of environmental issues, the area can impact • Alteration of drainage patterns, • Reduction in biodiversity of plants and animals, • Disturbance of native vegetation, and • Surface disturbance and erosion.
Drilling completions and workovers	Precautions are necessary to avoid: • Spills and releases, • Release of sour gas, • Improper disposal of fluid and solid waste, • Contamination of shallow aquifer system, and • Contamination of surface water and ground water
Operations and maintenance	• Well control and flaring of gases, • Vegetation management programmes, and Response preparedness for spills and releases.

AGOCO 2004

Environmental aspects of oil and gas production by AGOCO

Activity	Environmental concerns
Planning and site selection	Proximity to water bodies and environmentally sensitive area • Disturbance of wildlife, fisheries, habitat and livestock • Changes to soil conditions, which may create future reclamation problems • Disturbance of historical and archaeological resources • Disturbance of sensitive terrain and rate plants • Hydrogeology conditions • Terrain stability and drainage • Integrity of geological formation
Clearing and construction	Creating access to new areas where access should be limited or prohibited • Soil disturbance and erosion • Disturbance of wildlife, fisheries, habitat and livestock • Disturbance of sensitive terrain and rare plants • Disturbance of drainage patterns and terrain stability
Facility design and layout	Pollution prevention vs. treatment at end of pipe • Off-lease contamination from facility surface runoff • Fires, spills and leaks from poor facility layout • Inadequate emissions control • Inadequate spill prevention and containment controls • Extensive surface disturbance
Operations and maintenance	Spills and releases • Waste management problems • Air emissions • Noise from stream production • Environment monitoring and reporting • Alterations in local hydrology because of large water source requirements
Abandonment decommissioning	Future land use concerns • Residual soil, surface water and groundwater contamination

AGOCO 2004

Environmental aspects of pipelines by AGOCO

Stage of activity	Environmental concern
Planning	Route selection • Archaeological concerns • Socio-economic issues • Public consultation • Reclamation planning
Construction	Access roads • Access to new area • Right-of-way clearing, timber salvage, debris disposal • Soil handling and erosion, revegetation • Slope stabilization • Stream crossings and bank protection • Hydrostatic testing • Wildlife, fisheries and habitat protection
Operation and maintenance	Emission controls (compressor and testing) • Vegetation management • Spills and release – clean up • Erosion control • Hydrostatic retesting • Storages tank • Pipe replacements
Abandonment/ decommissioning	Pipeline abandonment • Site clean up • Restoration and reclamation

AGOCO 2004

Appendix B

Procedure Training Sign-in sheet

Procedure Number:…… Revision Number:……

Procedure Name:……

Trained By:……..

By signing this document, I certify that I have been trained and fully understand the importance of adhering to the above listed procedure and the possible environmental consequences of deviating from this procedure.

Training Received			**Training Sufficient**	
Name	**Signature**	**Date**	**Trainer's initial**	**Date**

Revised Date:
Effective Date:

Appendix C

Table of contents of the environmental procedures manual of AGOCO (June 2004)

- **Environmenal management system and procedures manual**
  - **Environmental poliy**
  - Code of practice for the implementation of AGOCO environmental policy
  - **General environmental considerations for plannung**
  - General environmental considerations for all operations.
  - Procedure for the preparation of a Project environmental impact assessment(EIA).
  - Guidance document on Emergency response planning.
  - Guidance document on the completion of audits and inspections
  - **Environmental operating codes practice.**
  - Site selection of wells sites and facilities.
  - Lease prepaaration and well site construction.
  - Bunding requirements for tanks and facilities
  - Drilling waste management.
  - General Housekeeping.
  - Vegetation management
  - Surface water and ground waterprotection.
  - Protection of historical resources.
  - Noise control
  - Control of atmospheric emissions.
  - Reduction of green house Emissions.
  - Incident management and spills site reclamation.
  - Well site and facility reclamation.
  - Management of earthen piths.
  - Waste management.
  - Code of practice for storage tanks and containers
  - Disposal wells and produced water management.