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Applying Lean Principles to Transform Conventional Oil & Gas Production Operations in a Gulf State into Cleaner Energy

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“Our task must be to free ourselves…by widening our circle of compassion to embrace all living creatures and the whole of nature and its beauty.”

Albert Einstein

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Abstract

There is much interest in the protection of the ecosystem within the oil and gas industry. This is particularly significant in the countries of the Middle East where the oil and gas sectors contribute a large part, in some cases all of the country economies. A case study research analysis into the Lean and Green principles of one of the State of Kuwait organisations could offer the country huge potential and could benefit other Arabian Gulf countries. In the chosen country (Kuwait), Kuwait Oil Company (KOC) has no other outlet for its business apart from oil and gas production. It also does not concern itself with other support business that could contribute to Kuwait's economy.

The case study KOC cannot act alone. Comparatively speaking it is smaller than similar oil company's in other countries in the region and its business strength is sensitive to the actions or inactions of those in competition around it.

On the other hand, in the Organisation for Economic Co-operation and Development (OECD) countries, energy efficiency is plays a large and valuable role in the sustainable development of respective economies. Energy demand remains stable as a result of steady improvements in the efficiency of energy use, in addition to utilising renewable energy sources in the OECD. Furthermore, OECD countries claimed that, in the absence of efficiency savings, the continuing use of oil and gas for energy production could cause CO_2 emissions to double by 2050.

This thesis has two purposes: the first is to analyse and develop a strategy for KOC by using the TOWS Matrix to integrate the internal weaknesses (W) and strengths (S), with the threats (T) and opportunities (O) in the external environment of the company and: the second is to apply the ‘‘lean and green’’ approach to the upstream oil and gas operations there are several perceived efficiency barriers in the oil and gas environment that have caused managers to be reluctant to make the required commitment. The use of lean and green principles was adapted for the upstream oil and gas operations to target the gathering centres (GC) of KOC. Value stream mapping was the main tool used to identify the opportunities for various lean techniques. This illustrate to managers the potential benefits such as reduced production lead-time, reduce environmental hazard, linked upstream operations with renewables resources and lower work-in-process as well as eliminate inventory.

In this research the investigation of oil and gas operations has been done using the strategic planning model and the TOWS Matrix was used for the analysis of critical issues faced by the case study company (KOC). The development of value stream mapping was the main tool used to identify the opportunities for various lean techniques. The approach was applied to a single case study on a hydrocarbon company using direct observation and interviews in an action research content. Mixed methods research was used to provide a better insight into the research problem in companion to either one of the single research methods approach. Mixed methods data collection and data analysis was conducted to provide strength, this offset the weakness of both the quantitative and qualitative research.

In this research the use of lean and green principles theoretically showed an efficiency improvement in oil and gas operations, the developed model that linking the current oil and gas operations with renewables would assure a leading position for the company. The findings of the work have add and contribute to hydrocarbon organisation in the lean and green literature and to the delivery of cleaner hydrocarbon organisation in the Middle East, which had not been previously considered

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Acronyms

API	American Petroleum Institute
BP	British Petroleum
CIA	Central Intelligence Agency
COQM	Crude Oil Quality Manual
GCC	Gulf Cooperation Council
GHG	Greenhouse
IEA	International Energy Agency
ION	International Oil Company
KISR	Kuwait Institute for Scientific Research
KOC	Kuwait Oil Company
KPC	Kuwait Petroleum Corporation
KPNC	Kuwait National Petroleum Company
L&G	Lean and green
MEW	Ministry of Electricity & Water
MENA	Middle East and North Africa
NOC	National Oil Company
OECD	Organisation for Economic Co-operation and Development
OEE	Overall equipment effectiveness
OPEC	Organization of the Petroleum Exporting Countries

R&T	Research & Technology
SWOT	Strength, weaknesses, opportunities, and threats
TOWS	Threats, opportunities, weaknesses, and strength
VSM	Value Stream Mapping
WEO	World Energy Outlook
WHP	Water handling plant
WIP	Work in process

Chapter 1 Introduction

This chapter focuses on the aims and objectives of this research. Firstly, the research background is introduced, setting the scene for the field of study. Secondly, the process of the research is discussed, outlining the methodology used, followed by the organisation of the thesis.

1.1 Introduction

This thesis focuses on the relative impacts of changes in inputs, industry structure and resources intensities, on the use of resources for the oil and gas operations of the ‘Kuwait Oil Company’ (KOC). The purpose is to deliver cleaner oil and gas production operations, in order to save both resources and energy. The should help to identify the reasons behind Kuwait’s position as one of the four highest carbon dioxide emitters per capita in the world, and of the highest emitters in the Middle East (Baumert et al. 2004; Waked & Afif 2012).

Over the last century, large corporations have attempted to innovate and have adopted advanced manufacturing systems and organisational approaches, in order to achieve simultaneous gains in industrial and environmental performance.

The philosophy of Tahchi Ohno (Ohno 1988), known as ‘Lean Thinking’, has transformed conventional methods and approaches to manufacturing. The lean systematic approach is one of achieving more with less to develop a business, while coming as close as possible to providing exactly what customer wants on time (Venkat & Wakeland 2006). Jones & Clarke (2002) state that such an approach is the dominating paradigm in current manufacturing, and it is therefore vital to understand its impact on environmental sustainability.

Lean production has led to improved production, along with increased efficiency, in a number of different industrial enterprises, through a flexible implementation process based primarily on management and the elimination of waste. The lean approach has allowed such enterprises to deliver quality products, eliminate inventory, and improve productivity (Arbós 2002).

Thus the adoption of lean manufacturing process innovations can create incentives for the adoption of environmentally responsible manufacturing strategies. The undertaking of unique research involving the fossil fuel industry can lead to innovation in delivering oil and gas production operations while addressing environmental costs and risks.

Adoption of lean manufacturing systems can also create considerable opportunities for the adoption of a cleaner fossil fuel industry and production strategy, since both draw upon the same underlying principles: (1) quality; (2) cost reduction; (3) improvement of productivity: (4) continuous improvement; (5) technological innovation.

This thesis will adopt a lean innovative approach towards efficient, and environmentally aware, oil and gas production operations.

1.2 Background to the Problem

Global energy demands are continuing to increase, driven primarily by emerging economies, led by China and India. Between 2012 and 2035, global energy consumption is expected to rise by 41%, compared to 30% over the previous decade, and 52% over the previous two decades (BP 2014a). Emerging economies are expected to experience a 95% growth in demand (BP 2014a), while energy use in countries within the Organisation for Economic Co-operation and Development (OECD) is expected to grow slowly, then decline during the later years of this forecast period. According to British Petroleum (BP), 95% of the growth in energy demand is expected to originate from non-OECD economies (BP 2014a), led by China and India, who will generate over 50%. In 2035, energy use in non-OECD countries is expected to be higher than that of 2012 by 69% (BP 2014a). However energy use will only grow by 5% within the OECD, and (even with continued economic growth) will fall after 2030 (BP 2014a).

Growth in energy consumption is projected for much of the remainder of the non-OECD countries. Between 2010 to 2014, due to rapid population growth and access to considerable domestic resources, energy demand increased by 85% in Africa, by 62% in Central and South America, and by 76% in the Middle East (EIA 2013a). The slowest projected growth among non-OECD regions is in Europe and Eurasia (EIA 2013a). The energy efficiency policies of the G8 (which have been in place since 1970) have promoted energy efficiency improvements in the majority of G8 countries, as illustrated by the decline in energy use (the level of energy efficiency is computed as the difference between actual and predicted energy) (Filippini & Hunt 2011). The International Energy Agency (IEA 2007a) states that the G8 has promoted energy efficiency, innovation, harnessing of lower emitting technologies and conservation of resources, in order to enhance private investment and a transfer of technologies, taking into account their own energy needs and priorities. The priorities are 'bottom up' awareness of climate change, and making available information needed by business and consumers in order to make improved use of energy and reduce emissions.

1.3 Global Future Energy Resources

Natural gas is considered a lower-carbon fuel relative to other fossil fuels and (in comparison to coal and oil) contributes to the lowering of CO_2 emissions (IEA 2014). Shell (Shell 2014a) states that natural gas has the potential to meet future global energy demands, and has the advantage of being capable of being converted into different forms of energy resources to satisfy the different types of industry and transport, while having less effect upon the environment.

Renewable energy and nuclear power are the world's fastest growing energy sources, with an increase of 2.5% per year. The generation of electricity from renewable energy resources is projected to increase globally (IEA 2013), forming a future threat for hydrocarbons. The global generation of renewable electricity is projected to increase from 4 539 TWh in 2011 to 6 377 TWh in 2017 (+5.8% per year) (IEA 2012).

Energy Consumption and Pollution in Industry

Between 1973 to 1987, the energy industry of OECD countries (including construction petroleum refining) accounted for 80% of their total industrial energy use (Howarth et al. 1991). In 2004 (IEA 2007a), total energy consumption worldwide was approximately 469 exajoules (EJ) (11 213 Mtoe). This was led by industry, which contributed one-third of this consumption, at over 147 EJ (3 510 Mtoe), including conversion losses from electricity and heat supplies. IEA (2007a) considers raw material production industries to be the highest energy consumers. The sub-sectors include the main manufacturing industries (led by the chemical and petrochemicals industries), followed by iron and steel, non-metallic minerals, paper and pulp, and non-ferrous metals. Together, these industries consumed 76 EJ of total energy in 2004 (67% of total industrial energy use) (IEA 2007a).

Approximately 30% of industrial energy use occurs within the petrochemical and chemical industry, followed by the iron and steel industry (i.e.19%) (IEA 2007a). The remaining 33% of total industrial energy use is by the machinery, tobacco and food industries, along with a large category of non-specified industries (IEA 2007a). Within the largest industrial energy consumer (i.e. the petrochemical and chemicals sub-sector) energy and feedstock use has doubled, while (despite strong growth in global production iron and steel production) energy use has been relatively flat. Energy use and CO_2 emissions have increased worldwide, with an average annual growth of 2%. Industrial final energy use increased approximately 61% between 1971 and 2004, although the growth rates are not uniform (IEA 2007a).

The issue of greenhouse gases (GHGs) resulting from industry has recently become a critically significant political, and environmental, concern. Much of the debate has now transferred to a discussion relating to the major factors causing climate change, along with its environmental effects, and the stringency of measures necessary to regulate GHG emissions. This change in the global climate, and its impact on the Earth's ecosystem, is predicted to have far-reaching consequences (Martinez 2004; Cox & Lowrie 2014).

1.4 Resources in the State of Kuwait

The oil industry accounts for 80% of Kuwait's revenue, and 95% of export revenue. Kuwait's electrical power system is dependent solely on oil and gas to generate electricity (Alsayegh 2008).

Globally, the slowest growth of demand among the major fuel sources up to 2035 is expected to be oil, with an average increase in demand of 0.8% a year. Non-OECD countries expected to play a major role in this increment of net demand on oil include the Middle East, China and India, and will together account for almost all of the net growth (BP 2014a). In March 2014, Kuwaiti Minister of Ministry of Electricity & Water (MEW) stated that the ministry will have difficulty in fulfilling the country's need for electricity and water within the next few years (Al-qabas 2014). In order to be able to supply future cities with electricity and water, MEW will need to generate 14000 MW, equivalent to the total amount of electricity generated since the 1960s (Al-qabas 2014). The rapid development in industrial activities, and the increased population in Kuwait, have caused additional strain on the water resources (Al-Rashed & Sherif 2000). Fresh water streams do not exist in the country, and its primary fresh water resource is desalinated seawater, with its secondary sources consisting of desalinated brackish water, treated wastewater effluent, and limited brackish groundwater. Desalting and treated water operations are fuelled solely by oil and gas (Al-Rashed & Sherif 2000).

According to the Minister of MEW, Kuwait's government provides an annual subsidy for the electricity and water supply, estimated to be approximately £6.2 billion. This subsidy accounts for 10% of oil production, and he also estimates that within five years this subsidy will reach 20% of oil production, i.e. the government will need to provide a subsidy of approximately £12.4. The Minister states that serious action must be taken in order to find solutions for this issue. Approximately 48% of the country governmental subsidy goes to the private sector (i.e. industry) to support their energy consumption. It has been estimated that Kuwait's government pays around £22 to supply electricity to each m^2 (Al-qabas 2014). MEW's 2019 plan is to generate 19000 MW of electricity, with the Minister questioning whether the Kuwait Petroleum Corporation (KPC) is capable of providing sufficient resources for potential power plants. This is particularly relevant since the old distribution mechanism of the current power plant will not to exceed 1000 housing unit in a year, whereas MEW has recently been obliged to offer a license for over 27000 units (Al-qabas 2014).

1.5 Statement of the Problem

The State of Kuwait economy, resources, energy and life resources, along with its agriculture, all depend on the production and export of oil to meet demand and security theses resources. This condition will be harder to meet in future, as a result of limited resources, with the additional possibility that oil might be overtaken by other sources of energy which do not currently exist in the country.

As noted previously, industry in Kuwait consumes approximately 48% (Al-qabas 2014) of the governmental subsidy of water and electricity. The largest industry in Kuwait is the petroleum industry due to the country's large resources of crude oil. The process fractional distillation used to obtain the oil used large amount of water, electricity and gas. Furthermore, the hydrocarbon industry runs on continuous production (continuously energy consuming), and constant flaring (high flare occurs occasionally) which is required for oil recovery. Therefore it is considered to be one of the most damaging industries for the environmental (IEA 2007a).

1.6 Purpose of the research

The State of Kuwait has one of the highest levels of gas emission per capita, but does not possess sufficient natural resources to secure its future. The increased demand on the finite oil and gas and other resources calls for research to boost the efficiency of oil and gas production operations, in order to flatten the annual curve of the consumption of these resources. Furthermore, this research will play a role in preparing the production of oil and gas production for a mix of energy sources, including renewables.

This research discusses issues related to the production of oil and gas, i.e. hydrocarbon market competition and the amount of electricity and fresh water required to effectively deliver oil and gas.

1.7 Aims and Objectives

The aim of this research is to investigate whether a 'Lean and Green' (L&G) approach could be applied to a major oil and gas producer. This has been achieved through a single case study the Kuwait oil Company (KOC) who are the main producer of oil and gas in Kuwait. Firstly by analysing the company's strategy using a TOWS Matrix, then secondly by applying the L&G approach to KOC's upstream oil and gas operations and finally by linking the current operations with renewables. The intention was to achieve an overall reduction in the use of resources but also a reduction in the environmental impact, whilst also considering to economic growth and future energy demands. The objectives of this research are as follows:

1- Review the academic literature of:
    a. The global energy outlook;
    b. State of Kuwait's economy in terms of energy dependency;
    c. KOC as a case study;
    d. Renewable energy technologies;
    e. Lean thinking, and green thinking=
    f. SWOT analysis and TOWS Matrix.

2- Conduct a SWOT Analysis and develop a TOWS Matrix to analyse the current and expected future environment, and to determine the direction of the case study (KOC) with respect to the ecosystem.
3- Investigate the existing oil and gas production operations in a single Gathering Centre (GC) of KOC who are seeking to re-engineer these operations. Use Value Stream Map VSM to identify the opportunities for various lean technique
4- Design/develop a photovoltaic model to supply oil and gas operations with cheap and clean renewable energy for a single GC in the case study..

5- Evaluate the proposed solutions and validate the theory upon which the strategy is based.

1.8 Relevant Search Area for the Literature Review

The literature reviews has covers a broad spectrum of subjects, including: (1) discussion about fossil fuel; (2) KOC; (3) lean applications and philosophy; (4) renewables; (4) The State of Kuwait economy; (5) The global environmental restrictions/low; (6) and strategic planning.

A literature review has been undertaken of the following sources of the information were used: (1) academic journals; (2) conference papers and proceedings; (3) reports from leading companies (i.e. British Petroleum BP and Shell); (4) The State Kuwait Petroleum Corporation (KPC); (5) governmental data reports and publications (i.e. from the MEW, the Energy Information Administration (EIA), and the Central Intelligence Agency (CIA)). (6) Textbooks (7) newspaper articles

1.9 Thesis Organisation

The thesis is divided into eight chapters:

Chapter 1 provides the background for the research, giving the reader an overview of the theme. The research aims and objectives are discussed, along with a brief description of the research process.

Chapter 2 reviews the existing background literature surrounding the topics of in interest.

Chapter 3 provides a conceptual framework for the research. It positions the research in the context of its philosophical stance, linking it to the research approach, which is discussed and identified, along with its limitations are comparisons with alternative approaches. The research process is then presented, along with an explanation of the administration of the research problem to be explored.

Chapter 4 presents information and data concerning the case study and its outcomes.

Chapter 5 forms a thematic analysis, demonstrating the methods used to analyse the data.

Chapter 6 focuses on the TOWS Matrix, describing the process of developing KOC's strategies in light of the demand on energy, environmental restrictions and the position of KOC in future global/Middle East markets.

Chapter 7 presents the fieldwork results obtained from the action research process. L&G tools and principles are employed as the primary analysis method to analyse the findings obtained from observation of KOC's site, the TOWS Matrix findings and the thematic analysis.

Chapter 8 concludes the major elements of the work undertaken in this thesis, and discusses the strengths and weaknesses of the research approach, along with the overall contribution of the knowledge established. It also puts forward recommendations for further research

Chapter 2 Literature Review

This chapter presents the background of the literature covering the seven different main subjects serving the aim of the research (see Objective (1) of the research in Chapter 1, section 1.7: Aims and Objectives, p.7). The intention is to provide an understanding for each area, and the ways in which they can be gathered together into a single area to engineer improved research outcomes.

2.1 Introduction

Fossil fuels (e.g. coal, oil, and natural gas) provide the energy to support current lifestyles and the world’s economy. Fossil fuels power all modern conveniences, from the planes in the sky, to the cars on the road. They heat homes, and light up the night. They are the bedrock on which human energy is based, but they are also a finite resource (Lowa Public Television 2004). Möllersten, Yan, & Westermark (2003) note that the 21st century is developing rapidly, thus affordable energy is required for global security and prosperity. Thus, increasing energy demand requires a means of efficient energy consumption (Zabalza Bribián et al. 2011), as well as a variety of energy resources (Stigka et al. 2014). This is due to the fact that:

- The current primary source (i.e. fossil fuels) is depleting.
- Fossil fuels are related to carbon dioxide (CO_2) emissions, with the primary human activity affecting the amount (and rate) of greenhouse gas (GHGs) emissions from the burning of fossil fuels.

Stigka et al. (2014) state that the environment is in turbulent change, resulting from abrupt changes in oil prices, the squeezing of the industrial supply chain, and mega-merges that misalign the direction of such change. The technological revolution is aligned with climate change, a debate threatened by the fossil fuel industry. The energy industry has the potential to evolve in a number of different ways, with companies wishing to implement a number of innovative strategies (Björkdahl & Linder 2014).

The approach of developed countries is to ration fossil fuel consumption (or reduce their dependence upon it) while energy companies are more likely to monitor and pursue solutions that are competitive. Ross & Steinmeyer (1990) put forward two assumptions:

Firstly, the current trend of rapid technological development is relatively open, and will continue. This will result in rapid economic growth (particularly in the emerging economies), aligned with an intense downward pressure on prices.

Secondly, technology will be harnessed to improve environmental and social performance, resulting in a more prosperous world.

Globally, the demand for power is rapidly expanding, particularly in the Middle East, while at the same time fossil fuel resources are heading towards depletion. Oil consumption in the Middle East rose by 5.4% in 2006 (Gulfnews.com 2007), and about 4.5% in 2012 (Statista 2015) and energy consumption grew by 4.4% in 2014 (Bp 2015) , faster than any other region apart from China, (Gulfnews.com 2007; Bp 2015). Gas emissions have a direct link to global climate change, and are also considered one of the serious direct problems threatening global society. Reduction of CO_2 emissions is essential. One method of achieving this is through fixation of CO_2 existing biomass (Gulfnews.com 2007). In the Middle East, the regional average level of GHG emissions per capita is high, due to its fossil fuel intensive energy system, and the global increase in attempts to mitigate climate change, there is now a growing desire to curb emissions in the Middle East (WRI 2012).

In developed countries, companies are under pressure, not only to create profits, but also to develop cleaner operations in order to reduce environmental pollution. They are required to improve (or at least maintain) their environmental performance and their business decision-making processes must acknowledge the dangers of climate change. Economic growth needs to continue while at the same time there need to be a reduction pollution (i.e. ‘doing more with less’). Environmental targets for business are based on the allocation of energy and level of emission to different sectors (Simons & Mason 2003; Tate et al. 2014). Governments increasingly tighten environmental restrictions for organisations in order to reduce pollution from their business, i.e. in the UK, ‘environmental objectives’ have been set for the following sectors; transport, domestic and private buildings. This has been done through legislation on and taxation regulations and incentives for corporate behaviour (Simons & Mason 2003).

This chapter is divided in to three parts to provide clear understanding of the literature. Part (1) discusses subjects related to the energy in the world; it also highlights the State of Kuwait and Kuwait Oil Company (KOC) in regards to the economy, energy and the country resources. Part (2) discuses lean production, its evolvement and applications. It explores lean application to understand and develop operational solutions for the case study. Furthermore, part (3) presents strategic analytical tools that can help develop KOC’s strategy and plans. Finally part (3) is to conclude part (1) and part (2) of the literature and discusses the gap in the literature in regards this research.

As the title of this thesis indicates, the core of this study addresses the application of lean and green thinking to develop the conventional upstream oil and gas operations into a cleaner form KOC. It focuses on methods to stabilise each stage of the operational for processes, along with the separation of gas and water from the crude to meet the quality required for upstream operations

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2.2 Overview Part1 of the Literature (Energy)

IEA (2007) is of the opinion that until 2030 fossil fuels will remain the major source of energy, covering approximately 84% of global energy demand. Economists predict that by this time the supply of fossil fuels will have levelled out. IEA (2013) suggests that fossil fuels will continue to be the main source of energy, covering 80% of world energy use until 2040. However, there is an argument over whether fossil fuel reserves will be sufficient to meet the global demand for energy in 2030 (Shafiee & Topal 2009). In 2006, OPEC’s oil supplies were 84,631.1 million barrels per day, while in 2013 they reached 90,026.4 million barrel per day (EIA 2014b). IEA forecasts that oil will reach 101 million barrels per day (bpd) in 2035 (Uk.reuters.com 2013). Oil and gas reserves are forecast to be at approximately 1300 billion barrels and 6100 trillion cubic feet, respectively, in 2006 (Shafiee & Topal 2009). On the other hand, in order for energy firms to be competitive and to demonstrate progress, they need to contribute to helping the world to meet its growing need for all aspects of energy demand. Thus, in order to achieve a successful contribution, energy firms need to be able to offer affordable and secure energy without damaging the environment (Bp 2013).

BP (2013) predicts that energy consumption will rise by 40% within the next two decades, with over 90% expected to be sourced by emerging economies. BP also assumes that the strict energy policies, aimed at restraining growth in demand and curbing CO_2 emissions will be continued at their current level. Even if more aggressive policy measures are introduced, demand could rise by approximately 30%. In the medium term, demand for energy is constantly rising, and thus all future forms of energy will be required to meet the increased demand, but with fossil fuel remaining at the top of the energy mix for several decades, (see Figure 2.1. below). Production processes present a greater understanding of the barriers, leading to enterprises being characterised by more complex processes, thus leading to stricter control of their operations through practicing energy management to ensure energy efficiency. BP believes that an increase in energy efficiency and increased use of existing lower-carbon fuels can make a rapid and material impact.

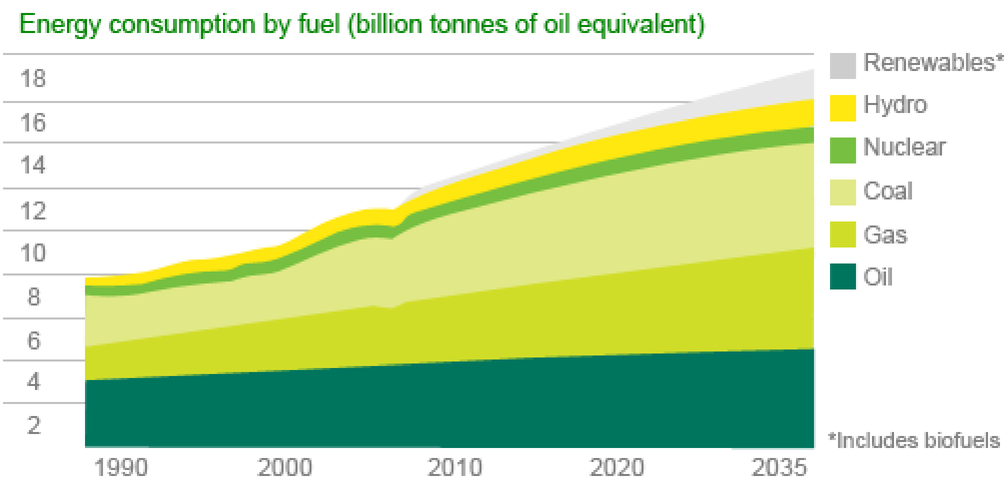

Figure 2.1 Global energy demand to 2035 (BP 2013)

An inverse relationship exists between fossil fuel reserves and prices: prices rise in proportion to the shrinking of reserves. Fossil fuel reserve trends tend to mainly depend on two important parameters: (1) consumption and (2) price. EIA has projected that energy consumption will increase at an average rate of 1.1% per annum, from 500 quadrillion Btu in 2006 to 701.6 quadrillion Btu in 2030. This can be linked to the annual energy consumption growth in 2007, which was 2% (Mason 2007).

World Energy Outlook (WEO) (2006) estimates a ratio of between 39 and 43 years for oil; 164 years for coal, and 64 years for gas (Shafiee & Topal 2009). Lior (2008) claims that the global fossil energy resources can be fixed at more or less level, while proven reserves of fossil fuels can also be raised with time, and the ratio of resources to production has remained practically constant for decades, around 40, 60 and 150 years for oil, gas and coal, respectively. Meanwhile, Maugeri (2004) suggests that the new oil discoveries are only replacing one-fourth of annual global consumption.

Crude oil is the most important fossil fuel in terms of global consumption, accounting for 36.4% of the world's primary energy consumption without biomass. It is impossible to predict exactly when fossil fuel reserves will run out, but the Director of Biochemistry at the University of York states that fossil fuel will eventually be depleted. The only unknown is when this will happen (Shafiee & Topal 2009).

Salameh (2003) states that "global oil supplies will only meet demand until global oil production has peaked, sometime between 2013 and 2020". Through supplementing alternative resources (e.g. coal, uranium or mixed energy) it may be possible to sustain global power requirements until the end of the 21st century.

BP (2013) states that, despite the discovery and development of new important fields, current global oil production is declining in 5% of the world's oil fields. This has led to the leaders of energy firms setting a strategy to keep moving to strict control within production operations and targeting more complex geographical locations, which might contain new fields. Significant factors related to meeting future energy demands concern the recruitment of appropriate skills, capabilities and technologies.

There are two methodologies to calculate the length of time until the depletion of fossil fuels: The first model is a modified version of Donald Klass' formula to compute fossil fuel depletion, which assumes the rate of consumption is constant. The second model calculates the ratio of global consumption to reserves, assuming that the production of fossil fuel is constant (Shafiee & Topal 2009) (see Table 2.1 below).

Table 2.1 Fuel reserve depletion time (Shafiee & Topal 2009)

Model	Ratio of consumption to reserve			Klass Modell			New Model		
	Oil	Coal	Gas	Oil	Coal	Gas	Oil	Coal	Gas
Year	40	200	70	34	106	36	35	107	37

A further model of consumption has predicted the average reserves of oil, coal and gas to be calculated as constant for 40, 200 and 70, years respectively, between 1980 to 2006. If the world retains the same consumption rates as 2006, reserves will last a further 40, 200 and 70 years, respectively (Shafiee & Topal 2009).

2.2.1 Energy Consumption & Consequences

Stern (2006) is of the opinion that the global society is under the threat of climate change. During the past 20 years, GHG emissions have increased due to energy consumption, in particular carbon dioxide (CO_2) emitted from the burning of fossil fuels. The Kyoto Protocol (1997) (UNFCCC 2011) states that between 2008-2012, developed countries should have committed to reducing their collective GHG emissions by at least 5% in comparison to 1990 levels.

In a climate-constrained economy, new environmental requirements for industrial companies have been imposed by regulatory bodies, and environmentally aware consumers (Möllersten 2002). In order for a business to be competitive, it must adhere to environmental regulations, and consider CO_2 emissions (Sharma & Vredenburg 1998; Björkdahl & Linder 2014)

Increased efficiency is a means of achieving energy saving, with a potential to reduce the overall amounts of energy used (and hence the carbon emitted globally) without negatively effecting economic growth. There are a number of different ways to increase efficiency, including: (1) improvements to vehicles; (2) application of technology; (3) programmes raising the awareness of the population concerning their use of energy. These gains can often be achieved at relatively low cost, or even a net overall saving. Increased energy efficiency across an organisation requires existing operations to incorporate energy use into their business plans, and to implement technologies and systems with which to implement improvements (Shrivastava 1995; Björkdahl & Linder 2014; Stigka et al. 2014).

2.2.2 Energy outlook in the Industry

Ma & Wang (2008) state that 11% of national energy consumption takes place within the continuous production industry, which also has an approximately 20% share of the entire industrial energy consumption. The industrial sector plays a significant role in improving energy efficiency. It accounts for approximately 30% of total energy consumption, and therefore energy efficiency is not only a solution for reducing energy costs, but is also an opportunity to demonstrate the rationing of consumption (Trianni et al. 2013). The European industrial sector represented almost 26.6% of the total European energy consumption in 2012 (Eurostat 2014), leading to industry having a responsibility to reduce its overall consumption and increase its efficiency. EIA (2014a) reports that one-third of total U.S. energy in 2012 was consumed in the industrial sector, which includes manufacturing, agriculture, construction and mining.

In 2014, total U.S industrial energy consumption grew to 5% higher than in 2013. The industrial sector will become the largest energy-consuming sector by 2018 and will remain so for the remainder of the projection period. Therefore efficiency plays a considerable role within energy-intensive industries, as they represent the majority of industrial energy usage.

Due to issues with nuclear power plants (particularly after the Fukushima crisis), the Europe Union has halted the building of new nuclear power plants, as well as taking the decision to gradually shut down number of existing plants over the coming years. The plan is to substitute nuclear with renewables for the generation of electricity. However, renewables will not be able to work efficiently unless a ‘Super Smart’ electricity grid is developed (Görbe et al. 2012).

On the other hand, in order to link a smart grid with the industry sector and obtain effective results, it is first essential to understand energy consumption in the industry, particularly within all the different manufacturing operations. This is vital to the understanding of the process chain of energy consumption, its processes and operations, in order to take advantage of eliminating any potential waste (IEA 2011). In this scenario, the load on the grid is reduced, along with emissions, leading to the development of a new level of environmentally friendly industry. This form of operation could result in new methods capable of ensuring the following: (1) cleaner production; (2) integrated planning and design; (3) cleaner operations; (4) the development of management processes in the industrial sector (Klemeš et al. 2012).

Ma & Wang (2008) suggested that, in order to be environmentally friendly, the approach of continuous production factories must expand to reach enterprise-level and processes must be optimised. Thus orders and raw material cannot be the only concern; there must also be a focus on energy-saving and emission-reduction represented by various enterprise energy-management systems. This approach has recently begun to attract increased attention from large factories and organisations. Zhao et al. (2012) argue that energy-saving-oriented production optimisation could not be fulfilled by the majority of the current enterprise-energy-management systems, as they mainly meet the requirements concerning data recording, energy data sampling, data displaying, and data analysis. Therefore enterprise-energy-management systems have a limited capability, and thus cannot play a further systematic role in energy-saving-oriented production optimisation. There are only capable of playing a monitoring role.

Energy leaders (BP 2010b; Shell 2014b) have suggested that diversity themselves into a number of businesses is a more valuable (or strategic) approach than the business itself. This includes expanding territory and reshaping a firm’s downstream business; in order to improve its response to the changing patterns of global energy demand, and target growth which is concentrated in emerging markets. For example, BP has approached this strategy through a decision to divest itself of a number of US-based businesses, notably the Texas City and Carson refineries. Furthermore, BP is concerned about the challenges of climate change, and therefore its main focus is on the limitation of greenhouse gas emissions. Carbon prices have already been included in their new project development plans, in order to encourage efficiency.

Energy challenges are a major concern for energy firms and for policymakers, as their responsibility is not to leave any gap within a global supply chain of oil and gas, while at the same time GHGs need to be reduced. The challenges are global and complex, they involve many complex energy decisions, linking geopolitical concerns with environmental trends and the populations' energy needs and aspirations (BP 2010b).

Energy efficiency plays a critical role within all aspects of energy utilisation, including energy security benefits, and industrial competitiveness, all linked to environmental benefits (Patterson 1996). Hasanbeigi et al. (2013) believe that one of the opportunities in covering the efficiency gap is to take a cost-effective approach. This offers an opportunity to cover the efficiency gap, or energy improvements, in many industries. The existence of an efficiency gap results from number of obstacles; from the suggestion and adoption of programmes, to realising cost effective energy savings, along with effective energy efficiency policies and potential emission reductions. On the other hand, industry concentration and labour productivity are significant variables that affect energy intensity.

The delivery of energy efficiency (particularly within industry) requires a detailed picture of operations and processes, including technology inside the plant, as well as insight into the ways in which potential future technology could be used, (Zhang & Wang 2008). It is also essential to understand the potential obstacles to the adoption of energy-efficient methods and technology, such as reliability and cost (IEA 2011). Providing clear evidence of developing energy efficiency is not easy to obtain, particularly with the appearance of unexpected barriers (Worrell et al. 2001).

From the perspective of energy consumption, machines or instruments in plants in the industrial sectors have been revealed to be significantly inefficient (Avram & Xirouchakis 2011), with a considerable number of approved machines having lost 30% of their efficiency, leading to a lack of efficient energy consumption (Hu et al. 2012). In order to reduce energy waste during production, the researcher suggests a number of approaches, including energy management, simulation, eco-design, sustainability, and reducing consumables (O'Driscoll & O'Donnell 2012). Productivity, within a machine's level of technological advancement, and in the form of machine throughput, also has a measurable impact on overall energy efficiency (Santos et al. 2011).

Energy consumption must be accurately understood before it can be effectively enhanced, including: display and quantification of the resources allowing for the development of the plant; where, why and how many resources (including energy) are being consumed within industrial facilities (O'Driscoll & O'Donnell 2012).

In order to reduce the impact upon the environment, employers within industry tend to follow a number of strategies, including: removing old equipment and implementing energy efficient technologies, in order to teach employees how to identify and eliminate waste in energy and other resources (Björkdahl & Linder 2014). In manufacturing facilities, in particular, machines consume a large amount of the industrial sector's electricity (e.g. compressors, power motors and ventilation and air conditioning), in addition to machine tools, while at the same time it is also necessary to maintain adequate heating (O'Driscoll & O'Donnell 2012). Implementations of energy management have become widespread within the industrial sector and have proven their capability to improve energy efficiency within manufacturing operations (Thollander & Dotzauer 2010).

2.2.3 Energy outlook in the Middle East and North Africa (MENA)

According to Khatib (2014), in 2012, the proven reserve of crude oil in the Middle East was 795 billion barrels, and in North Africa an estimated 65 billion barrels. This indicates that the Middle East and North Africa (MENA) has total proven reserves of crude oil equal to 52%, of global proven reserves of crude oil. The MENA region is equally endowed with proven rich reserves of natural gas. At the end of 2011, these amounted to 88 trillion cubic meters (tcm) out of total world reserves of 208 trillion (i.e. 42%). Doukas *et al*. (2006) suggest that oil and gas will remain the major energy source for the future. A number of forecasters have suggested a rapid expansion of oil and gas demand and consumption, due to accelerated development, which has enriched the economies of petroleum exporting countries in the region. World demand for natural gas is projected to increase rapidly in 2010 (EIA 2013b), being the fastest growing area of consumption, with 60% being bought by the power generation sector.

Armaroli & Balzani (2007) state that it is counter-productive for the world economy if energy consumption and fossil fuel production remain at their current level over the following decades, with the world's rapidly growing oil demand rising to almost 1000 barrels a second. Fossil fuel will become scarce for many reasons, including: global insecurity will result from increasing fuel prices (i.e. a war for energy); the negative effects of fossil fuel gas emissions will appear; climate change; loss of arable land; desertification.

Between 2004-2030 (IEA 2005), energy supplies will demand a cumulative infrastructure investment of about $1.5 trillion, or $56 billion per year, in the MENA region. Furthermore, if the energy remains the primary business in the MENA region, the primary carbon-dioxide emissions from power generation and water desalination will double by 2013. Prior to the start of the 'Arab Spring' in January 2012 (BBC 2014d), the MENA region was a major exporter of crude oil to its largest customer, the USA. In 2013/2014 this oil and gas production decreased due to the war in Iraq and Syria, which has affected the size of the fossil fuel business in the MENA region. On the other hand, IEA and BP believe that the US will be energy independent by 2035, through the development of its own shale gas and crude oil production. Thus the oil and gas business may shrink over the following decades in MENA, posing a considerable threat to the economy of MENA countries' economies, particularly the GCC countries.

Gas turbines are designed for the economics of power generation to favour natural gas, and therefore their contribution to a rational use of energy still negligible. In the GCC countries, CO_2 emissions are high per capita, in relation to Gross Demotic Product (GDP) [1] compared with the 25-EU. Moreover, the population is increasing in GCC countries, and therefore the consumption of electricity is increasing accordingly. Passive solar systems will help to reduce energy costs, and will meet the demands of the sector, along with the promotion of the rational use of energy (Doukas et al. 2006).

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[1] (Gross Domestic Product – GDP, 2012), Gross Domestic Product - GDP' the monetary value of all the finished goods and services produced within a country's borders in a specific time period, though GDP is usually calculated on an annual basis. It includes all of private and public consumption, government outlays, investments and exports less imports that occur within a defined territory. GDP = C + G + I + NX
Where:
"C" is equal to all private consumption, or consumer spending, in a nation's economy
"G" is the sum of government spending
"I" is the sum of all the country's businesses spending on capital
"NX" is the nation's total net exports, calculated as total exports minus total imports. (NX = Exports - Imports)

There is a global initiative to find alternative sources of energy in response to these trends (Meisen & Hunter 2007). There is a need to replace fossil fuel to reduce detrimental trends, reduce carbon emissions, and conserve the cost of non-renewable natural sources, i.e. uranium, natural gas, and oil. The development of renewable resources will result in economic and socio-political benefits to the region, while reducing (or at least mitigating) the increase in carbon emissions will have a significant impact on the control of global warming.

Climate change control schemes imply a considerable deployment of renewable energy in MENA, with wind and solar power accounting for approximately 60% of total electricity supply by 2050 (Van der Zwaan et al. 2013). In the absence of Copenhagen pledges for countries in the MENA, no national climate management measures are to be implemented until 2020, other than the announced targets for the deployment of renewable energy (these are the ambitions of a number of countries, such as KSA, Turkey, and the UAE) (Van der Zwaan et al. 2013).

2.2.4 Towards a Cleaner World

Due to the current heavy reliance on fossil fuels globally, energy-related carbon dioxide emissions are estimated to increase from 31.2 billion metric tons in 2010 to 36.4 billion metric tons in 2020, and then to 45.5 billion metric tons in 2040 (IEA 2013). Major global growth of gas emissions results from non-OECD energy consumption, which is heavily reliant on fossil fuels to meet national energy demands. Non-OECD gas emissions are estimated to stand at approximately 31.6 billion metric tons in 2040 (i.e. 69% of the global total). In comparison, OECD emissions are estimated to total 13.9 billion metric tons in 2040 (i.e. 31% of the world's total) (IEA 2013). The European Directive 2009/ 28-33 (European 2009), aims to achieve a 20% reduction in GHG emissions through a 20% increase in the share of primary energy from renewable energy sources, while setting a further target of a 20% reduction in energy use, compared to the primary energy level in 2005. However, high-efficiency cogeneration is currently only capable of reaching a saving of 10% of primary energy (European 2012), leading to the need to promote the strategic role of improved energy efficiency at different levels, including the commercial, industrial, residential, and transportation sectors.

Barriers have been categorised as: (1) 'structural' barriers (e.g. fuel price inflation and governmental policies); (2) 'behavioural' barriers (i.e. linked to the decisions of decision-makers or agents towards energy efficiency or lack of information). Behavioural barriers include misplaced incentives to apply energy efficient technologies and practices (Hirst & Brown 1990). Operational barriers have not been classified according to the taxonomy, which is exclusively linked to theoretical barriers because it appears to belong neither to behavioural or structural barriers. The researcher therefore concludes that it is more appropriate not to include this in either of the barrier categories, as suggested in the explicit reference due to the possible overlaps and interactions between theoretical barriers (Palm & Thollander 2010; Trianni et al. 2013).

Energy efficiency is significant in the managing of all energy related procedures (Nielsen & Wenzel 2002). Improving energy efficiency is desirable for a number of reasons, with the main criteria being to accurately understand and quantify current consumption patterns (IEA 2011). Lean thinking is required to provide both this quantification, and transparency for all patterns of materials, resources and energy flow, including local consumption, within manufacturing facilities. This not only improves understanding of energy usage, but also gives a broad quantitative perspective on day to day consumption (Bauch 2004). Therefore, lean thinking not only facilitates the improvement of processes and developments, but it also fully supports the implementation of the smart grid/time of day pricing infrastructure.

2.3 State of Kuwait

Wood & Alsayegh (2014) stated that the State of Kuwait has spent over $5 billion to repair damage to its oil infrastructure. Between 5 to 6% of the State's total area is inhabited, with the majority of the population concentrated within Kuwait’s city and its suburbs, leading to the population density being considered as high. Wood & Alsayegh (2014) point out that GDP in Kuwait was $70.7 billion in 2010, with an average growth rate of 5% over the past ten years. In the three years leading up to 2012, the ranking of Kuwait’s GDP (i.e. purchasing power parity) to the rest of the world was 53. Table 2.2 gives a general overview of the State of Kuwait (CIA 2014a).

Table 2.2 An overview of information concerning State of Kuwait (CIA 2014a)

	Kuwait
Location	Middle East, bordering the Persian Gulf, between Iraq and Saudi Arabia
Area	Total: 17,818 sq km country comparison to the world: 158
Land Boundaries	total: 462 km border countries: Iraq 240 km, Saudi Arabia 222 km
Coastline	499 km
Climate	dry desert; intensely hot summers; short, cool winters
Terrain	flat to slightly undulating desert plain
Natural resources	petroleum, fish, shrimp, natural gas
Land use	arable land: 0.62% permanent crops: 0.28% other: 98.99% (2011)
Elevation extremes	lowest point: Persian Gulf 0 m highest point: unnamed elevation 306 m
Total renewable water resources	0.02 cu km (1997)
Freshwater withdrawal (domestic/industrial/agricultural)	Total: 0.44 cu km/yr (45%/2%/52%) per capita: 164 cu m/yr (2000)

Natural hazards	sudden cloudbursts are common from October to April and bring heavy rain, which can damage roads and houses; sandstorms and dust storms occur throughout the year but are most common between March and August
Environment - current issues	limited natural freshwater resources; some of world's largest and most sophisticated desalination facilities provide much of the water; air and water pollution; desertification
Environment - international agreements	party to: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Environmental Modification, Hazardous Wastes, Law of the Sea, Ozone Layer Protection signed, but not ratified: Marine Dumping
Population	Kuwait’s Public Authority for Civil Information estimates the country's total population to be 3,996,899 for 2014 note: includes non-nationals
Population growth rate	1.883% (2012 est) 1.7% (2014 est)
Major cites population	Kuwait (capital) 2.23 million (2009)
Industrial production growth rate	4.1 % (2010 est)
Exports - commodities:	oil and refined products, fertilizers

2.3.1 State of Kuwait Economy Spine (Oil)

CIA (2014b) estimates Kuwait's oil reserve at approximately 104 billion barrels. State of Kuwait holds 6% of the world's oil reserves (EIA 2013c), and therefore the petroleum industry accounts for nearly half of GDP, along with 95% of export revenues, 95% of government income, and 80% of the country revenues (Alsayegh 2008). As a member of the Organisation of the Petroleum Exporting Countries (OPEC), Kuwait was the world's tenth largest oil producer in 2012 (EIA 2013c), exporting the third largest volume of oil globally, despite having the second smallest land mass among OPEC member countries. In 2012, Kuwait's total oil production was approximately 2.8 million barrels per day (bbl/d), 2.6 million bbl/d being crude oil and 200,000 bbl/d being non-crude liquids (EIA 2013c).

Within the country itself, the electricity and water sectors account for the majority of the energy consumed, i.e. approximately 50% of total energy used in 2009 (CIA 2014a). The remainder was distributed among other sectors, as follows: 30% for the oil sector; 19% for transportation; 1% for the household sector. Total domestic energy consumption in 2009 was 536.000 barrel per day, an increase of 9% from approximately 491.000 barrel per day in 2008 (CIA 2014a). This increase was due to the high level of consumption in the sectors of the Ministry of Electricity and water (MEW) (4%), oil (almost 22%), and transportation (almost 5%) (Ministry of Oil 2014). Kuwait's energy consumption reached the equivalent of 195 million barrels of oil in 2008 (see Table 2.3) (CIA 2014a). The country's daily domestic consumption of crude oil amounted to approximately 20% of total production until 2004, this taking place in five power plants and three oil refineries, along with other petroleum and petrochemical industries (Al-Nassar et al. 2005).

Table 2.3 fossil fuel in Kuwait (CIA 2014a)

	Kuwait	Country comparison to the world
Oil - production	2.45 million bbl/day (2010 est.)	12
Oil - consumption	354,000 bbl/day (2010	36

	est.)	
Oil - exports	2.127 million bbl/day (2009 est.)	8
Oil - imports	0 bbl/day (2009 est.)	208
Natural gas - production	11.49 billion cu m (2009 est.)	40
Natural gas - consumption	12.38 billion cu m (2009 est.)	42
Natural gas - exports	0 cu m (2009 est.)	128
Natural gas - imports	890 million cu m (2009 est.)	61
Natural gas - proved reserves	1.798 trillion cu m (1 January 2011 est.)	20

2.3.2 Energy outlook in Kuwait

According to Ramadhan & Naseeb (2011), fossil fuel is an optimal source of rich gas emissions. Since fossil fuel is the only source of energy in Kuwait, rising demand leads to increased emissions. Furthermore, the country’s electricity generation and water desalination is powered exclusively through fossil fuelled conventional power planets, with desalted seawater being practically the only source of fresh water. Despite the risk of the depletion of its main source of energy, the high levels of fossil fuels consumption are negatively affecting the country’s environment, through the emission of carbon dioxide, NOx and SOx gases. Globally, it is rated the third highest CO_2 emitter per capita, thus negatively impacting on its global image.

The figures reveal that the proportion of domestic oil consumption by Kuwait needs to be reconsidered, but without investigating non-economical domestic oil consumption. As BP forecasted, (BP 2014c), nearly 93% of growth in energy demand is expected to take place in the non-OECD countries, therefore a comparison between Kuwait (non-OECD country) and one of the OECD country will show the differences in energy demand and consumption. Norway (OECD country) is chosen to show the difference for a compression due to several reasons:

- Norway is an interesting comparison because of their culture of consuming energy use habits and purchase patterns in the home, (Wilhite et al. 1996) Energy use habits and purchase patterns in the home in Kuwait seems neglected (Bachellerie 2012).
- Norway has long, cold winters last for six months with average temperatures below zero and moderate summer season, (Wilhite et al. 1996). Therefore the heating season in Norway starts in mid-October until mid-April. Kuwait has exactly the opposite; long summers and moderate cold (Al-Nassar et al. 2005), and moderate winter (Al-Temeemi & Harris 2001).
- Both countries produce and export oil (CIA 2014a; CIA 2014b)
- Both countries have low populations (CIA 2014a; CIA 2014b)

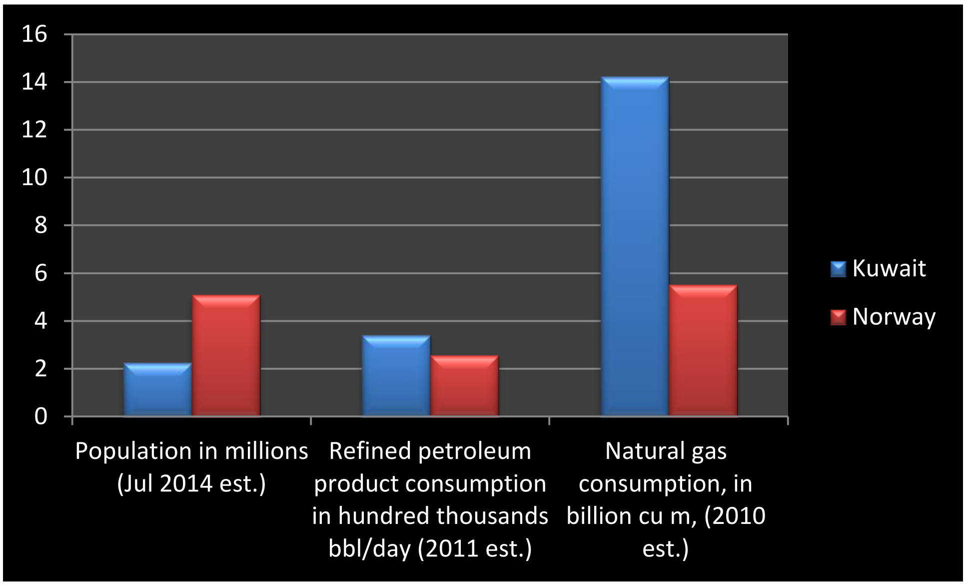

Figure 2.2 Comparison between Kuwait and Norway (CIA 2014a; CIA 2014b)

Figure 2.2 (above) compares three different factors in relation to Kuwait and Norway: (1) levels of population in 2014 (million); (2) the consumption of oil (hundred thousand bbl/day) in 2011; (3) the consumption of gas (billion cu m) in 2010. It is clear that the consumption of oil and gas is far higher in Kuwait than in Norway, despite the fact that Norway's population is more than double that of Kuwait.

- In 2010, Kuwait's gas consumption was 158% higher than that of Norway.
- In 2011, the Kuwait's daily crude oil consumption was 37.2% higher than that of Norway.
- In 2014, Norway population was 129% higher than that of Kuwait

OPEC's figures assume crude oil prices to be an average of $104 per barrel (EIA 2013c), and that Kuwait's oil production is 2.45 million barrels per day at negligible cost, thus Kuwait produces crude oil valued at $255 billion per day (£1.48 billion at 2/09/2014, when the currency rate was $1 equal to £0.6). With domestic consumption at a rate of 339, 000 barrels per day, Kuwait consumes $35 million (£21.15 million) of its own fuel every year, i.e. 13.8% daily total oil production.

2.3.3 The State of Kuwait Energy Power System

The State of Kuwait energy system is owned and operated by the government organisation known as the Ministry of Electricity & Water (MEW), and depends exclusively on fossil fuels (i.e. gas and oil) to generate electricity and desalted water for the country (Alsayegh 2008). MEW is the only provider of water and electricity in the country, with five generating power plants distributed along the country's coastline, with the distance between the power plant furthest north and that furthest south being 160km. Total capacity of all five power plants in 2011 was 12 GW, expected to reach 28GW in 2030 (IAEA 2011). The electricity network covers approximately 6% of Kuwait's area (i.e. the inhabited area), which is about 8909Km^2 of total land area of 17,818Km^2 (Alsayegh 2008). Kuwait's energy system therefore possesses a large number of links within a small area, leading to a small impedance network, which causes a high level of short circuits. Furthermore, on average the transmission network is low loaded, with the electric network consisting of four voltage levels, including 275, 132, 33 and 11 kV sub-networks (IAEA 2011). The network has now been upgraded to 400 kV (Alsayegh 2008).

Air Conditioning (A/C) consumes the greatest proportion of electricity indoors in schools, houses, offices and shopping centres, particularly during the long summer season (from May to October) when temperatures can reach 50C^o. Lowest levels of energy are consumed during February, December and January, when the temperature can, on rare occasions, drop to as low as 0C^o. A/C is the only ventilation technique available in the country during the summer months. Nearly 45% of annual production (Al-Nassar et al. 2005; Wood & Alsayegh 2014) is consumed through heating, ventilation and air-conditioning (HVAC) (see Figure 2.3, below). Moreover, the five main power plants in the country are the primary sources of sulphur dioxide (SO_2) and nitrogen oxide (NO_x) emissions. A number of power plants consist of eight steam turbine units consuming 281.34 t/h of fuel, emitting 1563 and 480.3 g/s of SO_2 and NO_x, respectively (Al-Nassar et al. 2005).

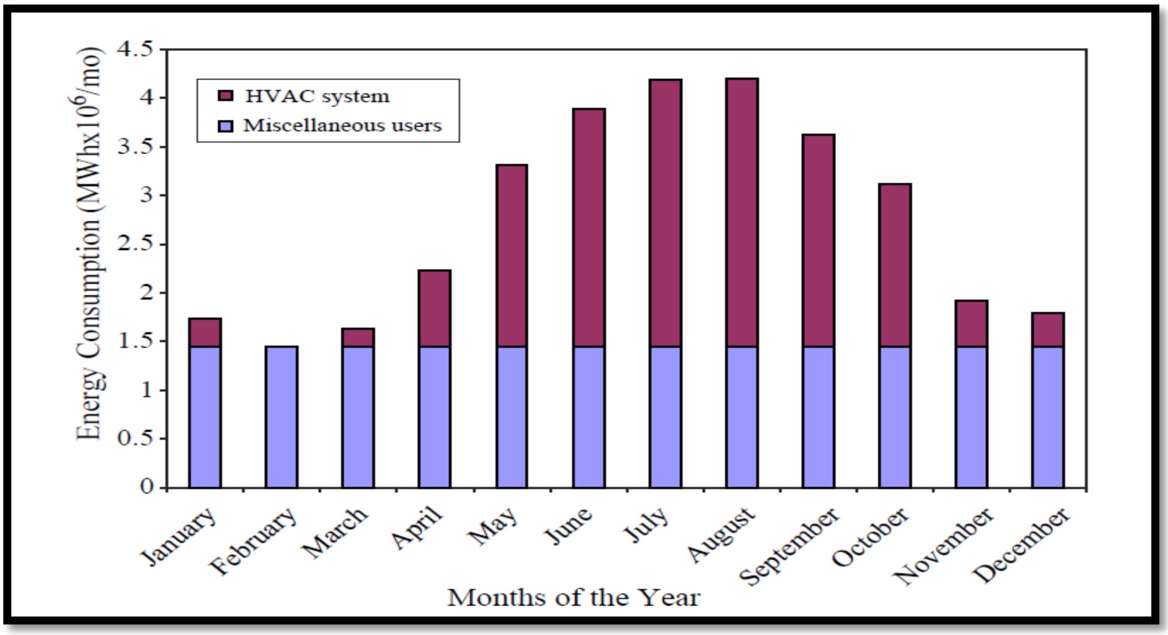

Figure 2.3 Monthly Energy consumption in Kuwait for 2002 (Al-Nassar et al. 2005)

A reduction in the emission of gas pollutants is therefore required, in order for the quality of air in the country to be enhanced. In order to also gain economic benefits, it is essential that this is achieved through a reduction in fuel consumption for the generation of electricity (Al-Nassar et al. 2005). MEW has forecasted a growth in demand of water and electricity of approximately: (1) 8% between 2010 and 2015; (2) 6% between 2015 and 2020; (3) 3% between 2020 and 2030 (Wood & Alsayegh 2014).

No reserves of uranium exist in the country and power plants are not designed to operate with uranium. The fuel types and total consumption used to fulfil electricity demand in 2005 are presented in Table 2.4 Total fuel consumption for electricity generation in the year 2005 (Alsayegh 2008), (IAEA 2011; Alsayegh 2008).

Table 2.4 Total fuel consumption for electricity generation in the year 2005 (Alsayegh 2008)

Fuel Type	Total Consumption
Heavy oil	46,349,361 Barrels
Crude oil	19,323,394 Barrels
Gas oil	782,700 Barrel

Natural Gas	90,656 M ft^3

Table 2.5 below demonstrates a radical increase in current electricity consumption from the 380 kWh needed in 1960. The cause of this radical rise is primarily the rise in consumption per capita since 2000, with an increase of approximately 6.8%, leading to the annual consumption in 2008 being 13,142kwh. A further reason is the sustained population growth, which averages 3.9% per annum, (Ramadhan & Naseeb 2011).

Table 2.5 Electricity status in Kuwait (CIA 2014a)

Kuwait			% Increase
Electricity – production	49.82 billion kWh (2009 est.)	55.55 82 billion kWh (2011 est.)	11.5
Electricity – consumption	42.58 billion kWh (2008 est.)	46.71 billion kWh (2010 est.)	9.7
Electricity - exports	0 kWh (2009 est.)	0 kWh (2009 est.)	-
Electricity - imports	0 kWh (2009 est.)	0 kWh (2009 est.)	-

The main reason that the growth rate in consumption per capita has surpassed the population and GDP growth rates includes: (1) Electricity has been practically free, as the government has subsidised over 95% of electricity costs since 1966. Citizens and residents pay only 2 fils/kWh (i.e. less than 1 Cent/kWh) of the actual cost of producing electricity, which is 34 Fills/kWh (i.e. £0.072/kWh). (2) The ineffective collection of electricity bills. Over the past few years this has stood at only 55%, thus re-enforcing irresponsible consumption of electricity (Ramadhan & Naseeb 2011; Wood & Alsayegh 2014).

The rise in income has influenced the country’s lifestyle and use of household appliances which has grown with a lack of concern in relation to consumption, and which is reflected in the demand. (Wood & Alsayegh 2014) recommend that detaching the association between oil price, electricity and water demands can be achieved through the application of a programme of restricted energy and diversifying the economy so that oil does not remain more than a certain percentage of the country’s revenue. This can be reinforced by a government development of targets of energy efficiency and alternative energy strategies.

2.3.4 ‘Kuwait Oil Company’ (KOC)

The information in this section has been sourced from the Kuwait ‘Oil Company’ (KOC) official website (KOC, 2014).

The KOC’s official website (KOC, 2014) KOC Ltd. was established in 1934 by the Anglo-Persian Oil Company (known later as the British Petroleum Company and Gulf Oil Corporation, and now known as the Chevron Corporation). Company activities extended to include exploratory operations, on-shore and offshore surveys, drilling of test wells, and developing of producing fields, in addition to exploration for crude oil and natural gas.

Kuwait’s Government took 100% ownership of the KOC in 1975. Kuwait Petroleum Corporation (KPC) was established in 1980 to bring all state owned oil companies into one entity. The discovery of API[2] 52 crude oil represents a considerable increase in the company’s exploration abilities.

[2] The API stands for; ‘’American petroleum Institute's inverted scale for denoting the 'lightness' or 'heaviness' of crude oils and other liquid hydrocarbons. Calibrated in API degrees (or degrees API), it is used universally to expresses a crude's relative density in an inverse measure lighter the crude, higher the API gravity, and vice versa because lighter the crude higher its market value. Oil with API greater than 30º is termed light; between 22º and 30º, medium; below 22º, heavy; and below 10º, extra heavy. Asphalt on average has an API gravity of 8°, Brent Crude of 35.5°, and gasoline of 50°. Formula: {(141.5 ÷ relative density of the crude (at 15.5°C or 60°F)} - 131.5’’ (businessdictionary.com).

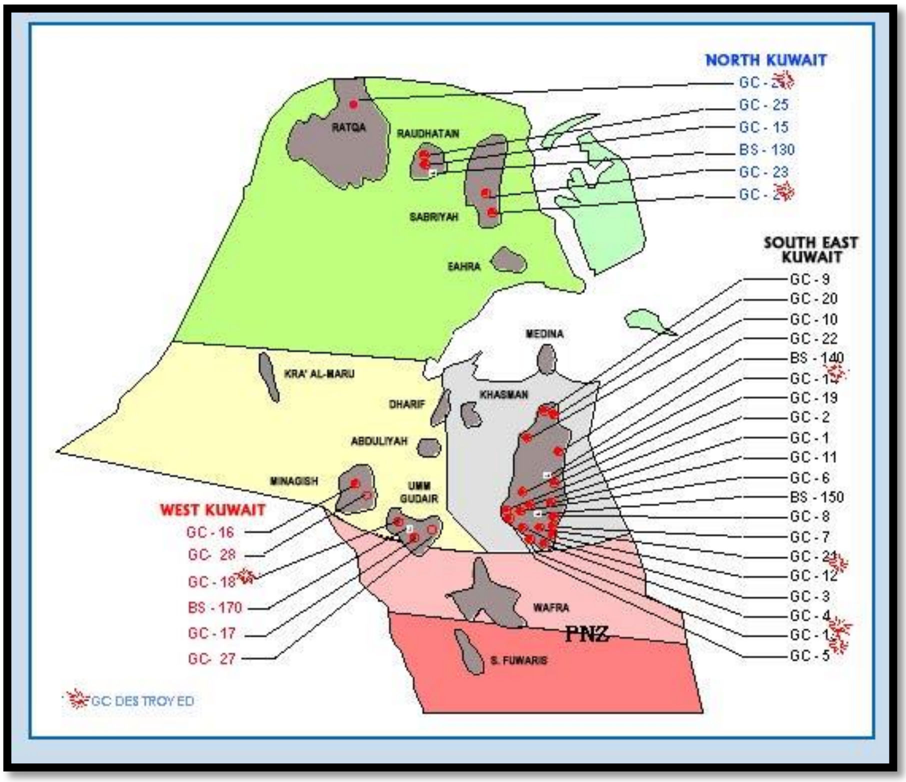

Figure 2.4 Oil fields and Gathering Centres of KOC (KOC, 2014)

Figure 2.4 Oil fields and Gathering Centres of KOC, shows a map of Kuwait which, includ the KOC's oil and gas fields and Gathering Centres (GC). KOC owns the oil and gas fields in the country, and has divided the country into three territories (north, south, east, and west) in order to regulate its operations and manage the fields. The GC's mission is to stabilise the crude by a multi-stage stabilisation process, while also separating out the gas and water in order to meet the quality required for downstream operations.

2.4 Renewables and Meeting Energy Demand

Despite the recent economic recession, non-fossil energy resources are expected to create economic growth, since global energy demand keeps increasing, and there is a lack of commercially viable and easily storable alternatives (WEF 2012).

At the same time, new technologies are making unconventional fossil resources (such as shale gas, oil sands and coalbed methane) more available and economically attractive. Furthermore, emerging renewable resources (e.g. biofuels, wind and solar power) also have the potential to make a significant contribution, as their markets mature and technological advances make them more affordable and efficient. Therefore, BP has established its own low-carbon renewable energies in 2005 and continues to invest (BP 2010b). Having already invested over $5 billion in its alternative energy business, it was aiming to spend over $1 billion in 2011 (BP 2010b). In order to align the rapid growth of the low-carbon energy market, BP has constrained their investment in lower carbon options, matching the best core of future market growth. They have created an effective business in biofuels, which is well positioned to tackle opportunities in a rapidly growing sector. Low-carbon power is also included in their investment, as well as substantial and growing wind generating businesses based in the US. BP believes that maintaining a diverse energy mix, with a broad and diverse mix of fuels and technologies, is the only way to meet energy challenges. Thus BP’s portfolio includes conventional oil and gas, as well as oil sands, shale gas, deep-water production and alternative energies. According to BP’s estimations, emerging renewable resources (such as biofuels, wind and solar) will meet around 6% of total global energy demand by 2030. BP believes that, over a longer period, renewable resources will play an essential role in addressing the challenge of climate change, as well as offering important energy security benefits.

However, even with the benefit of current carbon prices, renewable, low-carbon energy is not yet competitive with conventional power and transportation fuels (BP 2010b). Significant research and technology advancement (as well as industrial scaling-up) are required before they will be ready to fulfil a large portion of the world’s energy needs. BP is working alongside industry, research and academic partners, policymakers and regulators to develop, and deploy, alternative energy technologies, so enabling them to play a significant role in their energy mix ultimately. BP believes that there is a need for policy support for increased technology research and innovation in order to provide low-carbon options for the future (BP 2010b). This section of the literature attempts to conclude the ways in which BP as a company is working with oil and gas and attempts to mix its resources. However such a debate is controversial, since BP is an International Oil Company (INOC) and KOC is a National Oil Company (NOC) operating under government rules.

It is more beneficial in this case to include literature focussed on the governmental level and their energy strategy plans. In Denmark, the vision is turning towards a holistic supply with green energy (The Danish Governemnt 2011). Despite the fact that Denmark owns its own oil reserves, the Danish Government has set a strategy to become independent from all forms of fossil fuel by 2050. This strategy is unique in both Denmark and the rest of the world. The strategy outlines the energy policy that is being implemented to create a sustainable green society in Norway. This is a society distinguished by a stable energy supply that will ensure that Denmark remains competitive. The strategy presents new energy policy initiatives aiming at reducing a dependence on fossil fuels (The Danish Governemnt 2011).

Fossil fuel dependency in the energy sector will be reduced by 33% in 2030 from the 2009 level. There will be an increase of up to 33% in the share of renewable energy by 2030, in comparison with 2006, due to a strong focus on improvement in energy efficiency. The government's goal to ensure Denmark is independent of fossil fuels by 2050 is based on a realisation that the world is facing a new era for energy policies. In their report, the Danish Government (The Danish Governemnt 2011) have concluded that the 20th century was driven by cheap and plentiful fossil fuel, and they are now attempting to find a new alternative means of satisfying their country's energy demands.

2.4.1 Sustainable Energy Management & Energy Investment

Successful sustainable industrial energy, and energy management, is required to fulfil consumer demand, and meet strict environmental requirements. There are number of barriers surrounding sustainable energy management. Möllersten (2002) and Möllersten et al. (2003) conclude that the most significant of these include the following:

- Lack of capital and personnel resources dedicated to energy.
- Use of capital for competing investment priorities.
- Capital is subject to high hurdle rates for energy efficiency improvements.
- Lack of information and high transaction costs for obtaining reliable information.
- Difficulties in quantifying energy savings.
- Lack of acceptance.
- Long lifetime of equipment.
- Fear of decreased product quality.
- Prioritising reliability over lower energy costs.
- Doubts concerning the technical feasibility of measures.
- Underinvestment in research and development (R&D).

Möllersten et al. (2003) argue that where there is a considerable level of need for R&D in the technical field, the firm will act to achieve successful sustainable energy management.

However, (particularly for high cost energy industry energy) management may not be qualified in such an area. Möllersten claims that, although energy cost effectiveness is important in energy-intensive manufacturing companies, competitiveness is seen as even more important. Companies need to focus on their strategic issues, e.g. sources of raw materials, and development of sales. Therefore, a company will not spend the required amount from its limited capital to find a method to save energy. Meanwhile, the UK's Department of Energy & Climate Change (DECC 2012) suggests that the energy performance of energy intensive industries play a significant role. It requires both time and cost to reduce energy consumption in the industrial sector and reduce GHGs emissions. The UK Government has already set its strategic objectives, along with rules and regulations towards a more efficient and cleaner industry.

2.4.2 Renewable Energy in the Middle East

Al-Nassar et al. (2005) stated that heavy fossil fuel consumption has an impact upon both the climate and the environmental performance, whether on a country, or regional, level. The literature attempts to identify a potentially clean source of energy and renewable power, particularly in Kuwait. (Meisen & Hunter 2007) have suggested that the world market will become favourable to renewables. MENA has seen an observable development of electricity generation sources by renewable resources in the last ten years, the highest rate in the world market. The most rapid development has been in solar power generation (30.9%), followed by wind turbine power generation (30.7%) (Meisen & Hunter 2007). Currently, little renewable energy industry exists in the Middle East, and therefore expanding the renewables industry would lead to substantial economically gains from the reduction of the consumption of domestic fossil fuel reserves (Van der Zwaan et al. 2013).

A report by the Electrical Engineering Department at King Saud University states that there are 3,000 – 3,500 hours of sunshine per year in the Middle East, i.e. 5.0 kW/m^2 of solar energy per day (Meisen & Hunter 2007). In Iran, the average solar radiation is approximately 19.23 Mega joules per square meter and the potential of wind and solar energy combined is approximately 6500 MW. If utilised efficiently, renewable energy has the capability of meeting all world energy demands (Meisen & Hunter 2007). Harnessing renewable energy resources has the potential to significantly expand the lifetime of fossil fuel reserves in the Middle East to serve future generations, along with decreasing carbon emissions and encouraging socio-economic development for sustainable wealth (Bachellerie 2012).

2.4.3 Renewable Energy in the GCC Countries & Rational Use

Renewable energy sources, along with the rational use of global energy, have been the focus of considerable concern during past decades. Energy sources have already contributed to improving the security of global energy supplies, particularly in OECD countries. Therefore it is beneficial to limit the dependence on conventional limited energy resources (Doukas et al. 2006; DECC 2012; BP 2014b). Renewable energy sources are considered the main factor in the abatement of climate change. GCC countries (i.e. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) have accessed the Kyoto Protocol (UNFCCC 2011). They have also signed and ratified the United Nations Framework Convention on Climate Change (UNFCCC 2011)

The six GCC countries have demonstrated a growth in their GHG emissions, headed by the Kingdom of Saudi Arabia (KSA), due to the electricity generation to meet the demands of industrial and civil development over the past decade (Qader 2009). At the same time, the contribution of renewable energy sources, and their rational use in GCC countries, is relatively low (Qader 2009; Doukas et al. 2006) state that this is due to the following:

- Considerable availability of resources of oil and natural gas, and a greater amount of technology depending on oil and gas for power.
- A lengthy period of depreciation of investment, and the high cost of renewable energy projects.
- Lack of availability of funding for enterprises for such projects.
- These projects require a high level of enterprise, and the results are still unpredictable, leading to a considerable amount of financial, technological and performance risk.
- Lack of awareness concerning the performance of modern and innovative technologies.

The GCC region has sufficient potential to develop new technologies and explore and utilise renewable energy (e.g. solar energy) (Doukas et al. 2006). Currently, there is considerable focus among GCC countries on the need for solar technology to reduce energy costs in the final demand sector. Therefore, strategic policies for ensuring the sustainability of buildings, and guidelines for future sustainable architecture, have been initiated, gaining considerable attention.

2.4.4 Renewable Energy Projects in Kuwait

Al-Nassar et al., (2005) have cited the State of Kuwait's potential for wind energy, undertaking an evaluation of wind, including variations in strength and its prevailing direction. They used data concerning wind direction, speed, and frequency distribution from January 1998 to December 2002, in order to analyse potential wind energy in nine sites in Kuwait (see Figure 2.5).

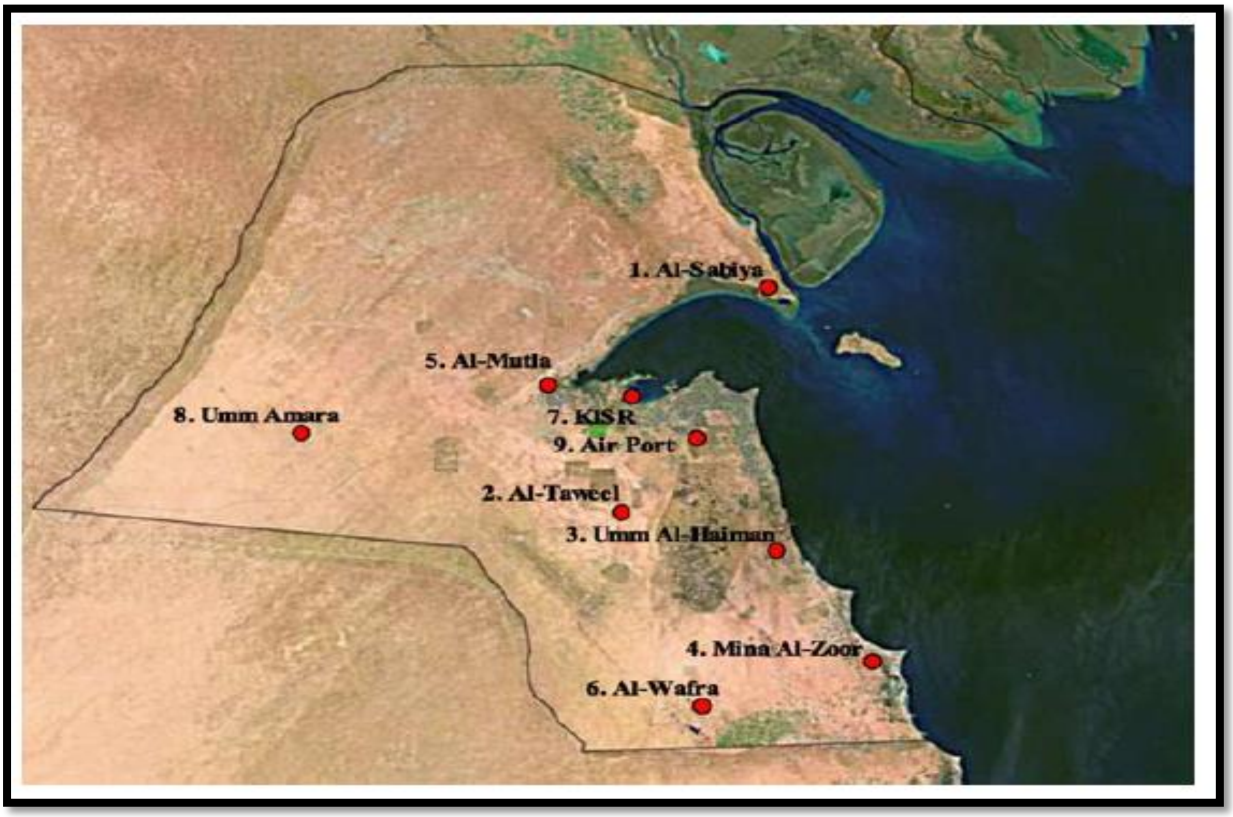

Figure 2.5 Distribution of meteorological stations around Kuwait (Al-Nassar et al. 2005)

Al-Nassar et al. (2005) recommends further analysis concerning the feasibility of installing and maintaining a wind farm in the Kuwaiti desert. This would reduce SO_2 and NO_2 emissions in order to protect the environment and would reduce on fuel consumption in response to economic factors.

Thus the availability of vast amounts of solar radiation (with almost 365 days sunshine a year) and the availability of wind power, has the potential to develop renewable resources in the Middle East (Van der Zwaan et al. 2013).

Research concerning renewable energy resources, along with the rational use of energy has been undertaken in the GCC region. A number of both medium and small projects have been conducted by institutions, scientific research centres, companies and some relevant governmental and no-governmental bodies (Doukas et al. 2006). A successful installation and testing of a number of solar cooling systems has been undertaken in Kuwait, along with 100 KW solar power systems and a solar thermal energy powered multi-stage-flash desalination unit. The pilot project focussed on the use of vapour absorption chillers fired by hot water at less than 100 C, using flat plate collectors (Doukas et al. 2006).

In addition, in 1985 a considerable amount of funding was allocated to develop water cooling applications, small and medium projects were tested and installed, with more anticipated in future (Al-Homoud et al. 1996). A flat plate collector and a small Vapour Absorption Refrigeration (VAR) system of 5–10 tons cooling capacity (TR) were used in this system. During the early eighties, large installations of this system were carried out in Kuwait for school buildings, followed by a further installation comprised of 300 m^2 of a flat plate collector area and three 10 TR VAR chillers. This project was also used for an office building of the Ministry of Defence in 1983.

According to Al-Hasan et al. (2004), the PV system is a promising technique, capable of enhancing the performance of the traditional grid utility system, particularly at peak times in Kuwait. The PV system has been evaluated in Kuwait, establishing that the peak load matches the maximum incident solar radiation. Thus, PV can be an optimal solution to cover domestic demand at peak time. Utilisation of solar thermal energy for cooling is currently limited during this period, not exceeding 35%, while solar thermal energy has the capability to produce 50-70% of the power required (Doukas et al. 2006). Electrical energy is required in subsystems for auxiliary motors and the treatment of water in their cooling towers, the latter being an important factor in arid zone countries, where soft water is produced from seawater desalination. Thus the overall realistic conversion of solar-to-cooling is further reduced (Doukas et al. 2006).

2.4.5 Renewable Energy in Kuwait’s Oil Sector

Bachellerie (2012) published a report discussing alternative sources of energy in Kuwait. According to Bachellerie (2012) renewables are the ideal way to conserve Kuwait’s daily oil consumption, leading to the optimisation of oil exports, with a significant influence on the country's economy. Kuwait Petroleum Corporation (KPC) is primarily in charges of managing domestic and foreign oil investments, and in 2008 began to consider the possibility of using solar power in its petroleum sector. KPC believes that this would enhance both the environment and prices, since energy demand is currently increasing (Bachellerie, 2012). The KPC Research and Technology department (R&T) organised a workshop to review 'New Energy Technologies' and explore 'Renewable Energy Applications in the Oil Sector', involving four main organisations: (1) the Kuwait Institute for Scientific Research; (KISR) (2) Kuwait Foundation for the Advancement of Science (KFAS); (3) Kuwait University; (4) and KOC. The workshop addressed the following: (1) methods of using renewable energy technologies in KOC/KPC activities; (2) the use of solar energy in the country; (3) fuel cells used in desalination; (4) the application of renewable energy (Bachellerie 2012) .

KPC has demonstrated its interest in renewable energy technology within the private sector. When oil prices rose in the 2000s, KPC established a $100 million venture capital fund (2006) focused on renewable technologies (Bachellerie 2012). During late 2010 and early 2011, KPC's CEO gave a speech expressing an interest in moving forward to renewable energy technology, stating that KPC is concerned for the country's environment, and thus needs to take advantage of renewable energy technologies. KPC's CEO also declared that KOC (one of their upstream subsidiaries) is considering the use of solar energy as an alternative to oil for the production of energy. KOC announced that it would launch tenders for two pilot solar-power schemes in the first quarter of 2012: the first for the construction of a five Megawatt (MW) photovoltaic power plant, and the second for the integration of a concentrated solar power plant, to produce steam for enhanced oil recovery (Bachellerie 2012).

2.4.6 Renewable Technology and its Applications

The National Renewable Energy Laboratory NREL (2014) states that renewable energy is distinguished by its sustainability (i.e. it will never run out), and, unlike hydrocarbon energy, is developed from constant resources, as outlined below:

- Solar Power: utilises energy from sunlight, either indirectly or directly. It can be used for heating and cooling, generating electricity, lighting, water desalination, and many other commercial and industrial uses.
- Wind Power: captures the energy of the wind through wind turbines.

- Biomass Energy: utilises energy from plants, and plant-derived materials, e.g. wood, food crops; grassy and woody plants; residues from agriculture or forestry; and the organic component of municipal and industrial wastes.
- Geothermal Energy: utilises the heat from the earth, drawn from hot water or steam reservoirs located near the earth's surface and within the earth's mantle.
- Ocean Energy: traps thermal energy from the sun's heat and mechanical energy from the tides, underwater currents and waves.
- Hydropower: captures energy from flowing water to power machinery and produce electricity.

In the Middle East in particular, the energy captured from sun's heat can be used in two ways: (1) distributed photovoltaic systems; (2) large central solar thermal power stations. A number of locations and stations could be fed by electricity through solar power. Photovoltaic systems do not require a grid and form the ideal method, with the customer controlling demand, while solar thermal power stations are best suited for the high demand of urban areas (Meisen & Hunter 2007).

Photovoltaic System

Photovoltaic (PV) technology involves the generation of electricity from light, using semiconductor material capable of releasing electrons (i.e. the negatively charged particles that form the basis of electricity). There are four types of solar PV systems, which can be employed according to the needs of the region in which they are installed. EREC (2010) states that it is:

- Grid connected: Connection to the local electricity network allows any excess power produced to be sold to the utility.
- Grid supported: A system can be connected to the local electricity network, as well as a back-up battery.
- Off-grid: Completely independent of the grid, the system is connected to a battery via a charge controller, which stores the electricity generated and acts as the main power supply.
- Hybrid system: A solar system is capable of being combined with a further source of power (e.g. a biomass generator, wind turbine, or diesel generator) to ensure a

consistent supply of electricity. A hybrid system can be connected to the grid, supplement the grid, or be a stand-alone system.

Solar photovoltaic technology has higher start-up costs in comparison with other renewable technologies. However, it has a number of distinctive attributes:

- Long life span.
- Considerable flexibility.
- Simplicity.
- High levels of reliability.
- Low maintenance costs.
- Technical potential for rural electrification.
- The returns of this investment are considerable in both socio-political and economic terms (EREC 2010).

Solar Thermal

According to EREC (2010), solar thermal technology methodology is the concentration of energy by heating up water in a dark vessel, then transferring the heat to operate a conventional power cycle. The heat is then stored in liquid or solid media (e.g. molten salts, ceramics, concrete, or newly developed salt mixtures) in order to be utilised at night. There are two methods to concentrate solar power within the solar thermal system:

- Focus sunlight directly onto solar cells.
- Generate electricity through an intermediate medium (i.e. heating water to drive steam turbines).

Solar thermal can be used in many different areas, including:

- Domestic water heating.
- Space heating in residential and commercial buildings.
- Heating swimming pools.
- Solar-assisted cooling.
- Industrial process heat.
- Desalination of drinking water.

Meisen & Hunter (2007) indicate three systems which utilise solar thermal technology:

- Parabolic trough systems: shaped mirror reflectors are used to concentrate sunlight onto thermally efficient receiver tubes placed in the trough's focal line.
- Central Receiver (Solar Towers) Systems: A circular array of heliostats (i.e. large individually tracking mirrors) is used to concentrate sunlight on to a central receiver mounted at the top of a tower.
- Parabolic dish systems: A parabolic dish-shaped reflector is used to concentrate sunlight onto a receiver located at the focal point of the dish.

Figure 2.6 illustrates the ways in which solar thermal technologies can tap into electrical power grids (Meisen & Hunter 2007).

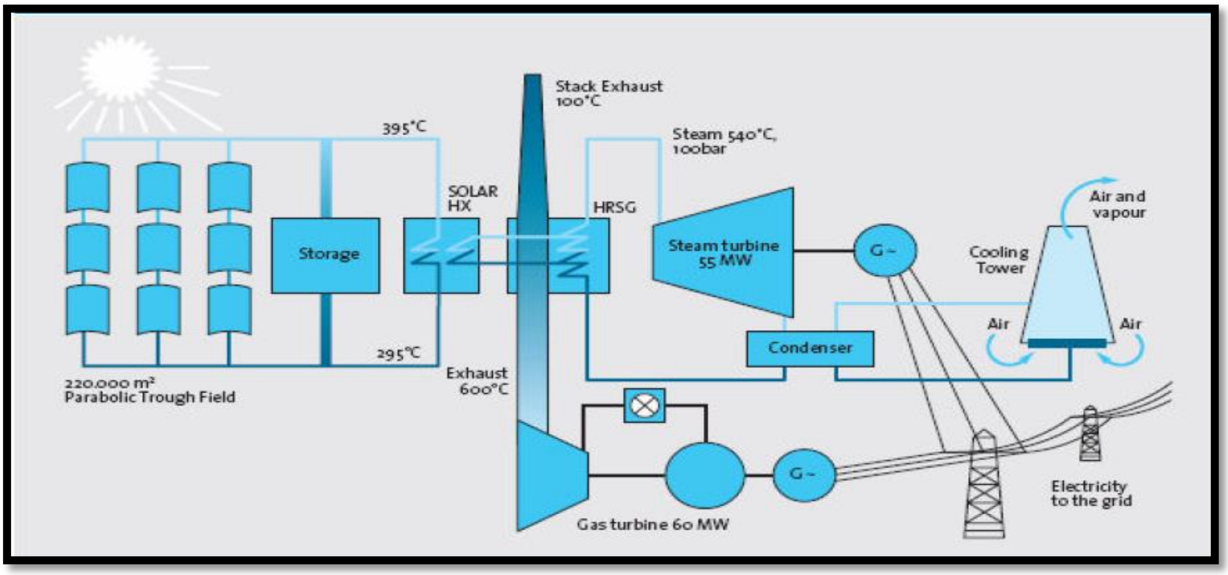

Figure 2.6 Integrated Solar/Combined Cycle System (Meisen & Hunter 2007)

Cost of implementing Solar Technology:

Solar power systems require the least amount of land of the electricity generation technologies, since they have no need of any additional infrastructure for mining, and (unlike nuclear power and fossil-fuel systems) produce no waste in need of disposal (MED-CSP 2005). Furthermore, land used for solar power is generally under-used and infertile (Meisen & Hunter 2007). At the same time, the fact that solar power not pose any environment threats is demonstrated by the fact that solar collector fields may also be used for agriculture and for the shade they provide, and in rural areas, in particular, photovoltaic systems can easily be affixed to the roofs of commercial and domestic buildings (MED-CSP, 2005).

2.5 Summary of Part 1

Part 1 of the literature provided a brief background of energy outlook in the world, and discussed the difference between OECD counties and non-OECD countries in light of energy production and consumption. It highlighted in the discussion the State of Kuwait and Kuwait Oil Company (KOC) in regard its economy reliance, energy resources and attitude toward the environment.

A brief discussion of the energy issues within heavy industry was presented. Two different countries were assessed to see how they are attempting to resolve the problem of unexpected future demand and sustainability of energy resources within the global environmental setting.

In the following section, Part 2 turns the attention to management philosophy, providing a review of lean thinking and a number of interdisciplinary of lean philosophy it commonly found. A review of the general considerations in strategic planning for organisations is discussed including the SWOT analysis and the TOWS Matrix (threats, opportunities, weaknesses, strengths) tools.

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2.6 Overview of Part 2 of the Literature (Lean Philosophy and SWOT analysis)

Toyota Production System (TPS) has been developed in the automotive sector (Ohno, 1988), Toyota Motors Corporation is a well-known Japanese automobile company and the initial innovator of lean production, being the first firm to apply lean concepts on their shop-floor (Ohno, 1988). Hines *et al.* (2004) are of the opinion that this innovation resulted from a scarcity of resources and considerable amounts of competition in the Japanese market. It included the following associated innovations: (1) the just-in-time (JIT) production system; (2) the Kanban (a signalling system for implementing JIT production) method of pull production; (3) respect for employees; (4) high levels of employee problem-solving/automated mistake proofing. However, the Kanban method of pull production contains difficulties in relation to identifying high levels of employees capable of solving automated mistakes. In addition to several weaknesses, it has demonstrated deficiencies when dealing with important issues, e.g. productivity variety, stress of supplier, and long geographical distance between customers (Cusumano, 1994).

On a different level (strategy level) for a firm to be in the position of the competition **a** SWOT analysis is generally concerned with determining the position of the firm in relation to its competitors (Hill & Westbrook, 1997). A number of leaders and-managers consider a SWOT analysis to be a useful tool thorough the contrasting of a firm’s Opportunities and Threats with its Strength and Weaknesses in order to improve its competitiveness, (Nikolaou & Evangelinos 2010).

This part of the literature on lean philosophy and SWOT analysis view industry as subsets of the broader body of knowledge related to technology and operations and an organisation’s strategies.

2.7 Lean Philosophy

Eliminating waste and excess from the tactical product flows at Toyota through the ‘Toyota seven wastes’ design of Lean Operation Management or Toyota Production System (TPS), it called as well Lean Production has also exhibited a model of capital-intense mass production with its large batch sizes, dedicated assets and ‘hidden wastes’ (Shingo, 1998). Taiichi Ohno has led the application of lean production for Toyota car engine manufacturing during the

1950s, followed by the application of lean principles in vehicle assembly during the 1960s, and then in 1970s covering the wider supply chain (Holweg, 2007). Initially, the lean approach was a 'secret' between Toyota and specific companies, but later a manual was written in Japanese, which then took almost a decade to be made available in English. Western companies had only a limited interest in lead production until the book 'The Machine that Changed the World' highlighted the performance gap between Toyota and Western automotive companies, (Womack et al., 1990). Paraphrased, the meaning of lean production (or lean manufacturing) was clearly the superior performance it achieves over production output in comparison to the demands of the mass production system. The structure of lean in Western manufacturing was to emulate the shop floor techniques, but this resulted in issues relating to organisational culture. Lean demonstrated only a local impact, rather than on the entire performance of the system. The weaknesses of the lean system up until 1990 consisted of an incapacity to predict variations in customer demand (Holweg & Pil, 2001). The system was only concerned with aspects of tools, eliminating waste and reducing lead time. Unfortunately this system neglected the human aspect of manufacturing (Holweg & Pil, 2001). However, After 1990, lean gradually began to be considered outside of the shop floor (Hines, *et al.,* 2004). In 1996 Womack and Jones were prompting new designs of lean principle that were developed in successful western cases. They used the 'value stream mapping' tool and the 'lean supply chain' to develop their new lean principles, with a main core piece of thinking, which was to understand customer value (Piercy & Rich 2004).

Lean production demonstrates flexibility in fields other than those of production. Lean knowledge originated on the Toyota shop-floor, as a means of developing the Toyota assembly line, but later lean production itself was developed to become a more comprehensive method. Examples of the Lean philosophy evolution phases (lean production evolvements) are discussed below.

Lean Construction

Jørgensen & Emmitt (2008) state that lean construction was originally adopted from lean manufacturing, related to architecture and engineering. In the construction sector, lean has demonstrated an ability to increase productivity and project performance (e.g. via the Egan report, DETR, 1998). Lean methods in construction are highly visible in countries such as the USA, the UK, and Denmark. The history of the process of the lean approach being transferred from manufacturing to the construction sector has revealed revolutionary results, through its application, tools, and systems. Meanwhile, lean construction took little account of the literature related to lean manufacturing, despite the fact that there are clearly common elements between the two (Jørgensen & Emmitt, 2008), as outlined below:

- A focus on eliminating waste, in relation to the delivery of the artefact or service representing value to the end customer.
- An end customer who sets the value and identifies waste.
- A supply chain and production management that responds to consumer demand.
- The processes and flows of processes are focused on the production management approach.
- The primary approach of the system concerns issues of waste elimination/reduction.

Lean & Supply Chain

Farzad & Kuan (2011) believe that the concept of lean and supply chain management has recently emerged from lean production. Globally, supply chain professionals have been tasked with reducing waste, increasing turn over and building greater flexibilities into their supply chains. Some of these areas overlap with lean. There are six major attributes of the lean supply chain:

1- Demand management;
2- Cost and waste reduction,;
3- Process standardisation;
4- Industry standardisation;
5- Cultural change;
6- Cross-enterprise collaboration.

Barla (2003) is of the opinion that participants who are lean adopters have reported the following: (1) improved collaboration; (2) an increased use of standards in processes and materials; (3) a reduced inventory level; (4) JIT delivery; (5) a general reduction in cost of goods sold when compared to non-adopters. Mollenkopf *et al*. (2010) claim that the lean supply chain strategy focuses on the reduction of waste, aiming to eliminate non-value adding activities related to equipment, tools, time, labour, inventory and space across the supply chain. The lean supply chain strategy enables organisations to ensure the best quality for services and products, along with a reduction in cost. The lean supply chain represents the managerial aspect of lean thinking, applying the JIT approach to supply chain management, and focusing on specific functional areas of the supply chain (including lean logistics). Due to the widespread acceptance of lean supply chain practices and growing pressure for environmental management, firms have begun to incorporate environmentally friendly practices into their waste reduction schemes.

2.8 Lean and Green (L&G)

Florida (1996) has focussed on the relationship between lean and green, discussing the capability of lean to produce output capabilities and improve environmental performance. A small number of studies have attempted to illustrate the association between leanness and greenness. However, in general, environmental improvement may be an underlying result of other factors, e.g. firm attributes and the availability of suitable raw materials (Florida 1996).

The proponents of lean and green (L&G) insist it leads to a reduction in pollution, since lean is a distinctive factor of 'zero waste' (Hajmohammad *et al.*, 2013; Yang *et al*. 2011). However, critics have pointed out that reducing one factor of production may increase another, i.e. efforts to increase efficiency, and reduce the inventory, could lead to further production of waste. Furthermore, since small batches of production are considered a lean attribute that requires machines to be replaced, such a process requires the disposal of unused materials.

Womack *et al*. (1990) put forward a further argument, focussed on reducing activities. Lean production aims towards waste reduction, with managers keen to invest in waste reduction processes, thus leading to lower pollution levels. A lower inventory requires employees to be more aware of changes in the production process, thus leading to a need for more educated and professional employers and a greater awareness of the possibility of lower levels of investment being required for pollution reduction. Lean creates an opportunity to reduce the cost of pollution by discovering opportunities to prevent pollution, however if managers expect pollution reduction to be costly, they may never investigate the value of pollution itself (King & Lenox, 2002).

Porter & Linde (1995) suggest that many opportunities for pollution reduction are still unexploited, including new insights into the importance of undirected and distributed costs and benefits. King & Lenox (2002) claim that lean production may provide managers with new expectations of the potential costs and benefits of pollution reduction activities. Bergmiller & McCright (2009) suggest three fundamental components to create a theoretical model of a green operation system: (1) that senior management should commit resources for a green management system, with policies empowering employees to make environmentally friendly decisions as a basis on which to establish a ‘green’ organisation; (2) that green management systems can support organisational culture in identifying and treating sources of pollution, eliminating waste during company operations; (3) that green waste reduction techniques lead towards green results.

2.8.1 Lean & Green Construction

According to Klotz *et al.* (2007), population and industrial expansion lead to a constant increase in energy and water consumption, resulting in an increase of GHG emissions. A green building approach will address this issue through the use of innovate and efficient designs, environmentally friendly construction and operational output. This is done using the following techniques:

- Optimising the potential of the site (i.e. by choosing a location with consideration for the requirements of energy and transportation).
- Optimising energy use (i.e. consideration of the use of renewable energy; reducing energy consumption therefore increasing energy efficiency).
- Conserving water (i.e. minimise runoff and consider recycling).
- Using environmentally preferable products.
- Enhancing indoor environmental quality (i.e. good ventilation and minimising voltage compounds (VOCs)).
- Optimal operational and maintenance practices (i.e. minimising environmental impacts).
- Energy efficiency for indoor environmental quality, in order to ensure ‘green’ buildings.

The energy efficiency of green buildings has the potential to reduce adverse effects on the environment, reduce waste and minimise energy, thus providing a healthy environment for occupants. This is sufficient to enable a building to use the following: 39% of total energy use; 68% of total electricity consumption; 30% of raw material use; and 12% of potable water in the U.S; 38% of the carbon dioxide emission (EPA, 2012b).

Green technologies and materials frequently cost more than conventional ones, however, the Governor’s Green Governed Council (GGGC, 2010) claimed that there are a large number of technologies and strategies which are of equal cost, with some even costing less than traditional methods. They suggest that finding an effective mixing of green and traditional strategies would result in the same (or only slightly increased) costs than the conventional approach. Lean construction contains every process required to produce low cost green output, including the programming, planning and procurement, right from the drawing up of the design, to the construction and then the final occupancy (Aziz & Hafez, 2013; Klotz et al., 2007).

Ballard (2008) claims that the reduction of cost is a method that might require that a product, or process, or design that delivers value for the customers within constraints. This method is defined as an application of a production-oriented business management philosophy that pushes the business to deliver continuous improvement and innovation. In plants, experiments and breakdowns (i.e. intended deviations from the standard) workers can be trained to show where improvements can be made. Thus, improvement of processes can be achieved through reducing variation and focussing primarily on the root causes of breakdowns and experiments. The buffer of an inventory is to absorb variation, first to reduce the buffer and then to match the buffers to actual variation. In the construction industry under lean principles, buffers of inventory frequently result in reduction of capacity, time and cost. This can be seen in Ohno's philosophy of 'lower the river to reveal the rocks' (Ohno, 1988). The elimination of waste could cause variation in the production system, adding value for the final customer and revealing where improvement is needed. Ohno's approach is to reduce time, capacity, and buffers of inventory and finance.

2.8.2 Lean & Green (Value Stream Mapping)

The lean approach is to combat waste. It focuses on the reduction of non-value added activity, time in order to produce a product in the optimum period of time required. This leads to either a positive, or a negative effect upon the environmental performance (Venkat & Wakeland, 2006). Value stream mapping (VSM) is a lean tool specialising in examining the time needed to produce the product, and the proportion of time that adds value (Abdulmalek & Rajgopal, 2007). It provides the basis for optimising performance over the single dimension of time, (i.e. without considering the resources consumed and the resulting waste from the manufacturing and overall supply chain). Value stream mapping includes flow associated with the use of energy, water and materials, in order to identify hidden sources of waste within the value stream (EPA, 2005). Value stream mapping can be used as a model of lean and green processes that can be used to reach sustainable value stream mapping. It also has the capability of supporting supply chain decisions in relation to sustainability, quality, cost, and improvements in delivery arrangements (EPA, 2012a).

Value stream mapping is a means of visualising the opportunities for improvements by applying value added activities in a holistic value stream process (Freire & Alarcón, 2002). By drawing a map of the current situation, the flow of physical goods and information will be easily targeted by value-added activities, aimed at eliminating waste, improving quality, and reducing cost (Venkat & Wakeland, 2006). Value added time percentage is the key to highlighting both value-added and non-value added activities. During the previous decade, time compression through the supply chain in the industrial sector has demonstrated positive indications of the enhancement of quality, cost, and delivery. These resources are included in a value stream map to address environmental questions, in parallel with time compression during the development of the future state map. However, the future state map is still not sufficient to reveal the most effective manner to eliminate waste. At the same time, it is unclear how to resolve the conflict between time compression and environmental performance, in order to gain optimal performance (Venkat & Wakeland, 2006).

The economic equivalent of time compression (the leading indicator of environmental energy) consists of emissions of carbon dioxide. There are two perspectives to carbon dioxide. (1) As an input, it is related to the following: transport, industry, and domestic energy usage and mode. (2) As an output, it is related to other emissions related to carbon dioxide which can be quantified as a dioxide equivalent (Dües *et al*., 2013). Hence, the main objective for protecting the environment concerns the elimination of CO_2 emissions related to the market, thus value interfaces with the environment are added at every stage, and potential value is added to an activity in relation to the elimination of emissions. Karp (2005) claims that the issue of environmental performance becomes more complicated when the entire supply chain is considered. Lengthy transportation (either from the supplier, or to the customer) requires more fossil fuel energy, thus emitting increased levels of carbon dioxide. Thus he has developed sustainable value stream mapping through adding sustainability metrics such as the following: “supply chain carbon dioxide divided by market weight of product” (Venkat & Wakeland 2006), P (2). Karp (2005) advocates adding environmental aspects to value stream maps.

However, the original lean document by Womack & Jones (Venkat & Wakeland, 2006) does not focus on environmental performance metrics. It focuses on the lean implementation that creates lower cost manufacturing processes. EPA (2005) notes that typical metrics need to be included in order to measure environmental performance, as follows:

- Scrap (i.e. non-product output);
- Materials used;
- Hazardous materials used;
- Energy used;
- Water used;
- Air emissions;
- Hazardous waste;
- Water pollution.

None of the previous elements are directly optimised in a typical lean implementation, resulting in the difficulties of understanding the effect of lean operations on environmental performance (Venkat & Wakeland, 2006).

On the other hand, a report issued by the Green Supplier Network (GSN, 2012), entitled ‘Lean and Clean Value Stream Mapping’, illustrates examples of environmentally friendly value stream mapping (see Figure 2.7 simple clean value stream mapping below). The line representing the materials contains a variation of a timeline that can be developed for any type of resource (e.g. water, energy, total materials, and/or a critical substance used in the product). A materials line (located at the base of a value stream map) demonstrates the amount of raw materials used by each process in the value stream, along with the amount of materials that end up in the product (thus adding value from a customer’s perspective). The materials line illustrated below (see Figure 2.7 simple clean value stream sapping, below), compares the amount of water used (and needed) in the milling and parts-washing processes in a product line.

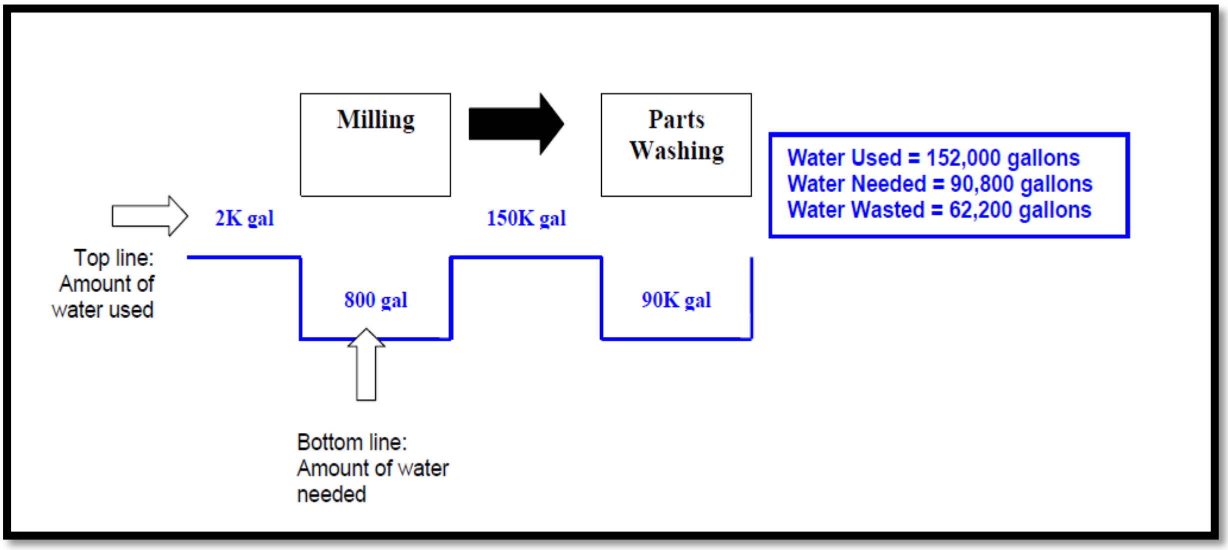

Figure 2.7 Simple Clean Value Stream Mapping (GSN, 2012)

Once data has been collected for the materials line, the differences between the amounts of material used, and the amount needed for the product, will become apparent. This map assists in targeting the largest sources of waste for prioritising improvement, even in the case of gas emissions (GSN, 2012).

2.8.3 Lean & Green Production

The U.S Environmental Protection Agency (EPA, 2003) states that lean operations have a highly environmentally friendly culture, i.e. since lean operations seek to eliminate waste and prevent pollution, they also provide a good platform for environmental management tools (e.g. life-cycle assessment and environmental design). Liker (2003) hypothesises that lean production systems help companies improve their production by using fewer resources (i.e. primarily material, human resources and time), with this structure being similar to a green operation's system in that both are concerned with management systems and 'waste reducing techniques'. Successfully applying lean principles would develop lean management systems similar to those of green management. At the same time, learning to identify lean waste, and implement lean waste reduction techniques, will cause lean results to appear within production operations. Others claim successful lean by implementing a green system within the organisation (Bergmiller & McCright, 2009).

King & Lenox (2002) note that evolving lean production contributes to the reduction of costs related to pollution, either by reducing the cost of improving the environment, or providing insight into green ways of delivering a reduction in pollution. Environmental management systems share a number of characteristics with lean production, most of these emphasise monitoring and improvement of facility waste streams, including continuous improvement and collaborative problem solving. King & Lenox (2002) hypothesise that lean production is capable of motivating companies to imbue their work with activities that lead to a reduction in pollution. However, they doubt if managers will increase the extent to which waste is reduced within the production process, and the extent of treating waste on the shop-floor.

2.9 Criticism and Gaps of Lean

Over the time that the lean concept has developed, a number of criticisms (either within or outside the lean movement) have identified various gaps in lean thinking

Andersson *et al*. (2006) point out that lean observers have objections concerning lean flexibility, believing that lean lacks the basic flexibility necessary for a system operating in a real situation (i.e. without the time to think, or space to experiment, particularly in creative environments in a competitive world, as reflected in their own experiences). Observers suggest that lean is neither sufficiently simple nor flexible to react to new conditions or unexpected circumstances, due to its focus on perfection. Lean has been criticised in the literature for its shortcoming, thus lean organisations become susceptible to the impact of change. Furthermore, JIT can cause congestion in the supply chain, leading to delays, pollution and shortage of workers. Lean cannot deal with such conditions, being designed only for particular market conditions at a certain period of time (Andersson et al., 2006).

Thus early attempts to implement JIT operations resulted in problems embodied in the inventory being passed back along the supply route to suppliers, who failed to recognise that the impact of the issue had not been removed (Sako *et al.*, 1994). Strategically speaking, lean is not integrated (Antony *et al*., 2003) and has been criticised for an inability to apply a series of different tools and techniques concerning level thinking in lean programmes. This could generate a lack of sustainability in many lean transformation programmes, since deploying strategic information has a significant impact on the system, and lean needs to be assisted by other management principles (e.g. Six Sigma) in order to optimise services, operations or products (Antony et al., 2003).

In some cases, lean has struggled to cope with the variability, due to the fact that it focuses solely on the shop-floor and neglects the human aspect (Hines *et al*., 2004; Andersson *et al*., 2006). This leads to a lack of perspective on the lean production system, when it is creating a high workload for the shop-floor workers. Lean production is de-humanising and exploitative, and so should not only focus on the mechanistic tools and techniques and motivation, it should also respect employees. The group criticised the lean concept for a lack of effectiveness in the market successes of newly developed products (Hines *et al.,* 2006). It lacks alignment of the market success of product development strategy with the wider strategic plan of the business. Furthermore, due to a lack of understanding of customer demand, it frequently undertakes unnecessary development activity leading to a high failure rate in relation to new products. Hines *et al*. (2006) claim that lean is not sufficiently efficient to develop processes such as standardisation, along with a lack of focus and internal communications and its ineffective control of high volume development environments. They also claim that lean is not the most effective concept to demonstrate how to learn from mistakes, and is incapable of meeting deadlines and achieving fiscal control.

Lamming (1996) criticises the fact that the flow of raw materials within the lean value stream "from supplier to the final customer" lacks integration and the interface between the stages of "firm, supplier, and customer'' need artificial strategies to ensure the development of added value to the firms' vision. The issue arises that these stages are restrained by a large number of other factors (e.g. labour skills; convenient configurations of technology; geographical location of raw materials) and that such factors act as boundaries creating a limitation of smoothly flowing attributes. Furthermore, the final stage is the critical one in retail markets, as the consumer is continually seeking for lower retail prices. However, cost reduction is dependent on the "start point of the supply flow". This could comprise materials or components, so the perfect departure would be from the supplier to the consumer. As a result, a number of contributors have proposed flexible solutions (Hines *et al*., 2004), introducing a greater emphasis on dealing with: (1) the variability in customer demand; (2) flexible assemble-to-order systems; (3) creating virtual supply chains and greater use of IT tools. The ability of lean production to cope with variability has been criticised, and the lean approach identifies a means of adding value for the customer by seeking to manage variability and so create capacity by utilising assets more effectively than in traditional systems (Christopher & Towill, 2000).

The application of 'Kanban pull scheduling' is suitable for repetitive demands, but inflexible for varied demands, thus leading to criticism (Cusumano, 1994). Many companies do not prefer Kanban pull scheduling, because it has limited means of achieving a customer-driven schedule. Other sectors possess greater ability to acquire variation in customer demand than Kanban. On the other hand, the Kanban system is not a practical method as it requires a physical exchange of a production, or delivery ticket. It is impractical to track, or control ordered components simply by cards that are attached to boxes, particularly in the case of overseas suppliers with larger load (Cusumano, 1994).

2.10 SWOT Analysis

A SWOT analysis, (see Table 2.6 SWOT, analysis, p. 58) can be beneficial in clearly identifying a firm’s strategy, facilitating the visualisation of weaknesses that need to be strengthened, along with the strengths that can be best deployed to gain a competitive advantage. This leads to an opportunity to harness the firm’s advantages and guard itself against the threats. A SWOT analysis is currently the key tool used in the planning of an organisation’s sustainable development. There are a number of examples of successful applications of a SWOT analysis in the field of industry (Nikolaou & Evangelinos, 2010; Dyson, 2004; Weihrich, 1993). A number of European countries have also used the SWOT analysis for their selection of policy priorities and ensuring that horizontal policy coherence is included in their national strategies for sustainable development (Rauch, 2007) and energy planning (Markovska et al., 2009).

The two main components of SWOT are the indicators of the internal situation for organisations, as described by the existing Strengths and Weaknesses (e.g. its employees, geographical location, and activities). The external situation is described in terms of its existing Threats and Opportunities (e.g. the global market and future demand). Identifying strengths and weaknesses in a competitive analysis forms the basis for a comparison of the business within the competitive arena. In such a comparison, it is not a straightforward matter to determine what strength is or a weakness and any assessment must be made while bearing in mind the organisational environment (Finlay, 2000).

2.10.1 TOWS Matrix

The majority of large firms prepare strategic plans and at the centre of this strategy formulation is the identification of the SWOT, which is traditionally referred to as the SWOT analysis. However, since analysis does not accurately reveal the relationships between internal and external factors, the TOWS Matrix was developed by Weihrich (1982), to demonstrate the advanced results of a SWOT analysis. The TOWS matrix has since been used and developed in a number of different countries and in a variety of situations and levels (Weihrich, 1982; Weihrich, 1999; Dyson, 2004; Proctor, 2000).

To integrate the feasibility of a systematic SWOT analysis, many European firms have begun to apply a variation of the SWOT analysis in the TOWS matrix, in order to develop their strategies (Weihrich, 1993; Weihrich, 1999)**.** The concept of the TOWS matrix concerns the identification and pairing of the various factors (see Table 2.6).

Table 2.6 SWOT analysis (adapted from an account by Nikolaou & Evangelinos, 2010 and Dyson, 2004)

SWOT	Strength	Weaknesses
Opportunity	+S +O	-W +O
Treats	+S-T	-W-T

In order to evaluate the impact of a number of different factors on the performance of an organisation, the TOWS Matrix is employed as a tool with which to discuss the analysis. The TOWS Matrix helps to organise the findings of the Matrix in such a way as to facilitate the generation of strategies. It allows the organisation to identify its strengths, weaknesses, opportunities and threats, in a systematic manner. The TOWS matrix is described as a robust tool for developing plans in an organisation, with the cross impact matrix illustrating what is currently being planned and what can potentially be done (Proctor, 2000). For example, Daimler-Benz has applied the TWOS matrix to surmount the pressure of competition from the Japanese car market. This helped the company to undergo dramatic change, venturing into the production of non-defence and defence electronic equipment, along with consumer goods and aerospace (Weihrich, 1993).

2.11 Summary of Part 2

Part two of the literature chapter has given a brief history of the lean production system and the lean concept, with its outcome and how it has been adopted by different disciplines. This section also contained arguments about whether lean is green, the lean gaps and criticisms about the lean concept. Section 2.8 described SWOT analysis and the TOWS Matrix (threats, opportunities, weaknesses, strengths), as logical processes that can be used to develop firms' strategies.

Part three will discuss the links between parts one and two of the literature review, in order to identify the research gap in the literature. It will also provide the logicbehind the of gathering data.

2.12 Gaps in the Literature

The literature review was conducted in order to meet the aim of objective one, to identify gaps in the literature, which this section has done.

World energy outlooks have indicated that a large amount of conventional energy consumption is taken up by the industrial sectors, specifically in continuous production (Eurostat, 2014; EIA, 2014a; BP, 2010b; Shell, 2014b). The increase in the pace of energy consumption has resulted in an increase of GHG emissions (Ross & Steinmeyer, 1990; UNFCCC, 2011; BP, 2010b). A considerable number of studies have focused primarily on the success and failure of governmental regulations and policies in achieving reduction of fossil fuel consumption (Simons & Mason, 2003; Möllersten, 2002; UNFCCC, 2011). Studies also how the need for an energy mix in order to secure energy supplies for the future (Bp, 2013; Salameh, 2003; Doukas et al., 2006), (objective (1) to achieve objective (4)).

This study focuses on the State of Kuwait, whose main industry is oil and gas production and oil export, which rely on continuous production. Globally, Kuwait is one of the largest emitters of toxic gas emissions related to the processing of ‘crude oil and gas’ (EIA, 2013c). The country ranks as the third largest carbon dioxide emitter per capita (WRI, 2012; Ramadhan & Naseeb 2011), (objective (1) to achieve objective (4)). Despite the risk of the depletion of oil and gas (Shafiee & Topal, 2009; Lior, 2008; Maugeri, 2004), Kuwait’s economy and power generation depends entirely on the production and consumption of crude oil (EIA, 2013b; Armaroli & Balzani, 2007; IEA, 2005; Alsayegh, 2008). A number of studies have pointed out that Kuwait’s consumption of energy by industry is due to population growth and the constant rise in customer demand (Bp, 2013; BP, 2010b; Shell, 2014b). Therefore the country’s future energy usage is focused on the success of organisations in improving their productivity and efficiency (BP, 2013; EIA, 2014a; Ma & Wang, 2008; Patterson, 1996; Hasanbeigi et al., 2013; Avram & Xirouchakis, 2011; Santos et al., 2011), (objective (1) to achieve objective (2).

Nevertheless, for the most part, these researches have remained prescriptive in their diagnosis of the causes of inefficient production operations in the industry and its usage of resources. Their discourse has been limited to alluding to the need for organisational and managerial transformation, without investigating the details of the necessary processes design, material utilisation and organisational structural and strategy changes needed for the success of efficient consumption of resources (Görbe et al., 2012; Klemeš et al., 2012; Zhao et al., 2012; Shrivastava, 1995; Trianni et al., 2013). At the start of this research, a number of studies elaborated upon the necessary details of world energy outlook. This included energy in the future, energy firms and additional details concerning the working methods of the Kuwait Oil Company (KOC), which attempted to address this gap in the literature. However, there were few details concerning KOC in the literature and an intensive investigation is needed to explore the company (see Chapter 4; The Case Study for further details), (objective (1) to achieve objective (3).

In order to identify the gaps and potential of market competition the focus of this research was placed on KOC's strategy (Mason, 2007; Shafiee & Topal, 2009; Bp 2013; Sharma & Vredenburg, 1998; BP, 2010b; Shell, 2014b; BBC, 2014c). At the same time, a deeper investigation was conducted into the company's GCs operations, with the view that the use of L&G techniques and strategies in relation to oil and gas recovery could lead to the achievement of gains in optimum efficiency and cleaner productivity, (Bp, 2013; Zhang & Wang, 2008; Worrell et al., 2001; O'Driscoll & O'Donnell, 2012), (objective (1) to achieve objectives (2,3 and 4).

It appears that when it comes to the application of L&G strategies for oil and gas productions and recovery operations there is no evidence of previous studies in the literature. Therefore, this current study is the first attempt to apply L&G methods on the shop-floor of oil and gas production operations, in order to deliver cleaner and more effective efficiency operations. The dynamics of the relationship between oil and gas recovery and L&G remains unexplored in the literature and its importance to the debate is yet to be established (objective (1) to achieve objective (3 and 4), .

From the literature and the studies investigated, it appears that a number of lean observers doubt whether lean can be green, integrated or flexible (Hines *et a*l., 2004; Hines *et al*., 2006; Andersson *et al*., 2006; Sako *et al*., 1994). However, this study will attempt to highlight any potential gaps and defects of lean strategies, in order to integrate L&G operations in oil and gas case. On the other hand, a number of lean proponents have established the integrity and capability of lean to deliver efficient and green organisations (Ohno, 1988; Womack *et al*., 1990; Womack & Jones, 1996; King & Lenox, 2002; Florida, 1996), (objective (1) to achieve objective (3).

The literature of renewable energy applications, in particular, remains thinly researched, even though it is visible on the global oil and gas firms' business plans (see section 2.2.2 Energy outlook in the Industry), (BP, 2014c; BP, 2014b; Shell, 2013). Meanwhile, investigations concerning the reliability and efficiency of renewables to help to moderate Kuwait's climate (Doukas *et al*., 2006; Van der Zwaan *et al*., 2013; Alsayegh, 2008; Al-Nassar *et al*., 2005) have established additional constraints and variables to the interaction between L&G and the operational and structural arrangements of an organisation (objective (1) to achieve objective (3, and 4).

By focusing on the point of interaction between oil and gas production operations and L&G and linking these with renewables, this thesis will illuminate the research aspect of the debate.

2.13 Summary

The aim of the literature review was to develop an understanding of the relevant work in the research area and to provide an understanding of the original work that has already been conducted.

The next chapter describes the conceptualisation and development of the research problem. This is presented by conducting a single case study that uses mixed methods approach. The next chapter describes the research cycle and outlines the methods that will be used in this research. It will also describe the in depth research that will be undertaken with the case study company.

Chapter 3 Methodology and Methods

This chapter begins by positioning the research in the context of its philosophical stance, then linking this to the research approach. The chosen methodological approach taken by the researcher is outlined, along with its limitations. Finally, the research process discusses the ways in which the research process is to be administered.

3.1 Introduction

This research has already analysed the current situation in Kuwait and its Oil and Gas industry. It has also made a comment on the expected future environment through means of a single case study that shows the direction of the company and gives potential developments that could be used as a means of achieving this end. In reality, however, this is a highly complex process, particularly when applied to a company as diversified as Kuwait Oil Company (KOC). By using the TOWS Matrix (employed in a number of different studies of large firms (Weihrich, 1982; Proctor, 2000) to analyse their strategies and tactics), the strategy formulation process model (Table 6.1 TOWS Matrix, adopted from (Weihrich 1993; Weihrich 1999), pp.152-154) will aid this analysis and provide the framework for the discussion.

Lean and green (L&G) has been widely employed in the new trend of manufacturing (King & Lenox 2001; Simons & Mason 2003; Florida 1996), in order to improve efficiency in relation to oil and gas operations. This current research has investigated KOC’s upstream oil and gas operations in relation to L&G, along with the interaction of L&G principles and tools within oil and gas production operations. It has also investigated the feasibility of linking oil and gas production operations with renewable energy resources, in order to create a mix of energy resources for these operations.

This chapter presents the research question (see Section 3.2 Research Question in this Chapter),the overall conceptual framework and the major research propositions and dimensions (see Figure 3.1 research plan, below), (Voss et al., 2002; McCutcheon & Meredith, 1993). This research has focused on a number of keys areas in order to deal with the subtleties and intricacies of complex production, management and issues that may impact upon environmental performance and the consumption of resources. In particular, the research has analysed the relationships between the environment, potential global needs and the fossil fuel industry, in a manner that would not have been possible without using the two main research approaches.

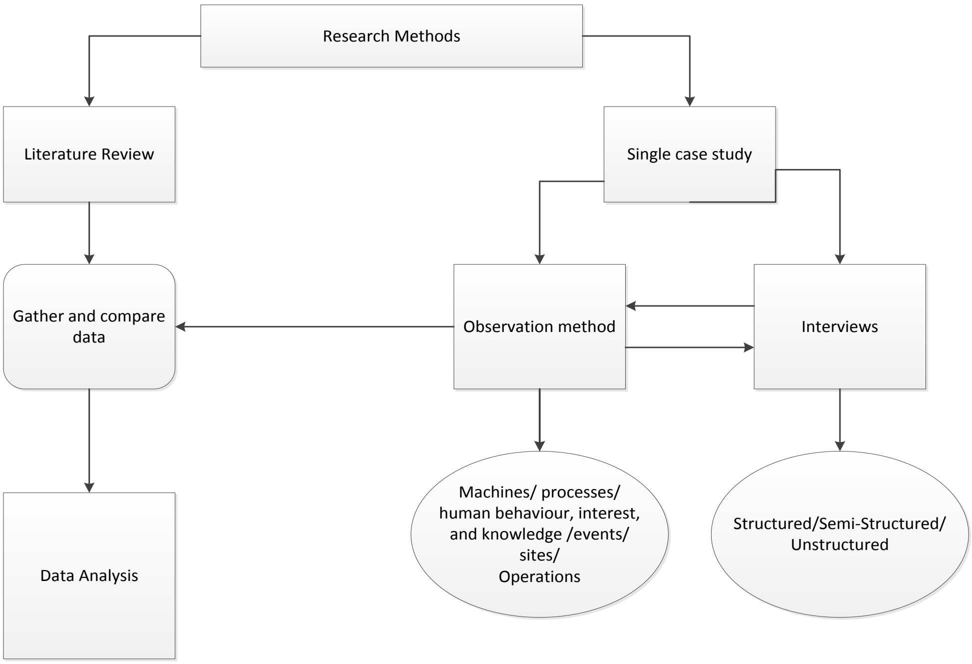

Figure 3.1 Research plan (derived from Voss et al., 2002; McCutcheon & Meredith, 1993)

3.2 Research Questions

Over the last eighty years the hydrocarbon industry in Kuwait, represented by KOC has dominated the energy market without adopting environmental management practices or trying to change to a cleaner energy market, like the BP (BP, 2014) and Shell (Shell, 2013) approaches. However, now governments are putting more pressure on industries to clean up their businesses and put better environmental protection measures in place. Therefore, the main research question is:

What are the benefits and challenges to KOC adopting an environmental strategy? To what extent isL&G capable of delivering clean and efficient operations in the oil and gas industy?

As discussed in Chapter 2 (the literature review), all industries (and in particular the hydrocarbon industry) are currently facing tighter legislation that is designed to protect the ecosystem. On the other hand, the global community is experiencing concerning about future shortages of energy supplies. Thus, efficiency in operating and mixing energy resources must become common in large energy firms across the world in preparation for the known energy shortages in the future. In addition, the literature review has revealed that a considerable opportunity exists in the Middle East to harness clean energy as a its primary source of energy, in order to support current conventional energy. In the Arabian Gulf countries (and particularly in Kuwait), fossil fuel is currently the main (and almost only) source of energy, apart from Abu Dhabi in the United Arab Emirates (Masdar, 2014) who have a different energy approach and operates using clean resources. However, renewable energy systems still cannot attract the attention of investors and governments in the region for a number of reasons. These primarily consist of the immature status, high cost and low efficiency of renewable technologies, in addition to the cheap extraction of crude oil and gas in the region. On the other hand, researchers and practitioners have increasingly established that achieving the desired efficiency gains from advanced manufacturing technology, requires adopting developed organisational arrangements, work organisation structures, and educated human resources.

Adopting L&G encompasses within its systems the energy needs of organisations and the ability to integrate productivity and efficiency. It represents total quality management, including teamwork, increased autonomy and a level of problem solving skills. L&G also provides organisations with a 'greener' image and extends the life of their oil and gas resources. These improvements appear to offer a satisfactory response to the advocates of organisational change, as a prerequisite to effective implementation of advanced manufacturing methods. Table 3.1 illustrates the links between keys objectives and key questions addressed in this thesis:

Table 3.1 links between objectives, key objectives and key questions

Objective	Key objective	Key questions
1. Review the academic literature: a. The global energy outlook; b. Kuwait's economy in terms of energy dependency; c. KOC as a case study; d. Renewable energy technologies; e. Lean thinking. f. SWOT analysis and	To figure out the global demand on energy and to assess the problem of climate change in relation to future energy demand. To investigate the energy situation in the state of Kuwait including its economic reliance and its sources of income. To explore renewable energy	To what level can L&G be consistent, flexible and comprehensive in developing complex oil and gas production operations? Is it possible to build a feasible renewable energy system in a country such as Kuwait and to supply industry with clean and cheap energy? If yes, what

TOWS Matrix.	systems and find a operational system that is compatible with Kuwait's situation, in terms of climate. and To understand the concept of lean and lean and green. To explore the concept of a SWOT analysis and investigate its effectiveness	type of system is suitable can be linked with heavy industry and integrated with Kuwait's climate? What are the risks of applying a L&G system? What would be the benefits for KOC and Kuwait, if KOC was to emerge onto the clean market
2. Conducting SWOT Analysis to developing TOWS Matrix to analyse the current and expected future environment, and determine the direction of the case study (KOC) with respect to the ecosystem	To investigate and develop the current strategy and tactics of KOC.	How will KOC respond to the energy demand threat, that will affect the domestic energy market? How will KOC confront fierce competition from the global market?
3. Investigate the existing oil and gas production operations in a single Gathering Centre (GC) of KOC seeking to re-engineer these operations. L&G were adapted to enhance the efficiency of GC's, Value Stream Mapping	To exhibit the extent to which the characteristics of a lean production system are capable of delivering efficient L&G operations, in the oil and gas production.	If L&G is consistent, comprehensive and flexible enough, can it used in oil and gas production operations? How can the results be used at the conceptual (i.e. design) level?

(VSM) was the main tool used to identify the opportunities for various lean techniques.		
4. Design/develop a photovoltaic model, to supply oil and gas operations with cheap and clean renewable energy, for a single GC in the case study.	To establish new concepts of mixing energy sources, that could be implemented for oil and gas operations, within Kuwait	For a single gathering centre, how efficient and cost effective is mixing oil and gas resources with renewables
5. Evaluate the proposed solutions and validate the theory upon which the strategy is based.	To validate the hypothesis of 'a sustainable and green hydrocarbon industry'	To what extent is the proposed future value stream mapping successful and realistic for delivering efficient and green processing, at the gathering centre?

These keys questions will give an improved insight into KOC's position in the current (and future) hydrocarbon market. It will also provide information on how long the hydrocarbon market will be able to retain absolute power in the energy market. These questions will provide a platform for the examination of the dynamics of L&G and its interactions in oil and gas production operations, which aim to develop a cleaner fossil fuel industry. This relationship will be examined in terms of the assumptions associated with the coupling of both lean applications with oil and gas operations, in a single case study.

This research has addressed the critical consequences of interaction between L&G and oil and gas production operations in detail and provides evidence to reveal the points of harmony and its dimensions. The research has exhibited the capability of L&G to develop a cleaner fossil fuel industry.

3.3 Research Concept

At the macro level (KOC strategy level), this research aims to describe a logical process of developing a coherent KOC strategy, that takes into account the ecosystem. The TOWS Matrix has been employed to complete this task (see objective 2). KOC has been selected because it is the main regulator of Kuwait's economy. KOC faces competition from its peer companies in both the Middle Eastern market and at the global market level. In addition, the company needs to fulfil a high domestic consumption of oil. The TOWS Matrix was focused on the oil and gas industry, due to its significance in the country's economy and in analysing its position in future markets. An identification of national and international factors in the social, economic, political and technological areas was employed, in order to determine (and forecast) KOC's strengths, weaknesses, opportunities and threats.

- The hydrocarbon industry accounts for nearly half of Kuwait's GDP, i.e. 95% of export revenues; 95% of government income; 80% of the country's revenue (Alsayegh, 2008).
- According to the Minister interviewed, public sector salaries cost multi millions Kuwaiti Dinars each month. These salaries are sourced directly from the revenue derived from oil exports.
- The Ministry of Water and Electricity (MEW) has the primary right to ensure its requirements of oil and gas are fulfilled from daily production, which directly affects the quantity of oil and gas left for export.
- The rate of energy consumption in Kuwait is constantly rising, with its cost being directly deducted from the income of fuel oil production.

Therefore, at the micro (operational) level (see objectives 3 and 4) the research aimed to demonstrate a new wave of cleaner hydrocarbon industries. This is an attempt to improve oil and gas production by delivering more efficient operations that consume fewer resources, in order to:

- Ensure the slowdown of the depletion of oil reserves.

- Increase the amount of soil available for export
- Deliver efficient oil and gas operations that can be efficiently linked to renewables, so leading to a mixing of sources of energy for these operations.
- Improve the hydrocarbon industries environmental record, by reducing greenhouse gases emissions

The research looked at the degree of compatibility between L&G (the most widely used form of new manufacturing strategies) and the implementation of L&G to oil and gas operations, in the form of advanced manufacturing technology. On the micro level (objectives 3 and 4) the research sought to identify: (1) The positives associated with the integration of L&G and oil and gas production operations; (2) The benefits to the overall association of L&G applications within the oil and gas operations; (3) If the coupling of L&G and oil and gas production operations is capable, then the resulting new concepts of efficiency that can be used across the whole industry (4) The possibility of lean oil and gas operations demonstrating productivity that attracts the attention of manufacturers and stakeholders.

These questions form the approach of this investigation. The assumptions were investigated to establish current strategies of manufacturing (i.e. lean thinking) and to establish complex, highly polluting, forms of industry (i.e. oil and gas production operations). There was an exploration of the potential for harmonic integration in the application of L&G, through its coupling with oil and gas production operations, to form an advanced green manufacturing style.

The adoption of L&G by advanced manufacturing systems creates a substantial opportunity for the implementation of green design and production strategies. Lean thinking seeks to ensure a dedication to productivity, improvements in quality, cost reduction, other continuous improvements and technological innovation both on the shop-floor and within management.

3.4 Methodology

This section begins with an overview of the mixed paradigms methodology used in this research, i.e. qualitative methods supported by quantitative methods (Creswell, 2013; Dainty, 2008). A key feature of this mixed methods approach is its methodological pluralism, which frequently creates results that provides broader perspectives (Azorín & Cameron 2010). One single method approach can be imitated by biases that are not obvious until you compare them with other methods. Mingers & Brocklesby (1997) (p.492) note that:

> ‘’Adopting a particular paradigm is like viewing the world through a particular instrument such as a telescope, an X-ray machine, or an electron microscope. Each reveals certain aspects but is completely blind to others … each instrument produces a totally different and seemingly incompatible representation. Thus, in adopting only one paradigm one is inevitably gaining only a limited view of a particular intervention or research situation … it is always wise to utilise a variety of approaches’’.

Therefore, mixed methodology has been selected to conduct this research.

Creswell (2013) notes that Campbell and Fiske (1959) were most likely the first to use the mixed methods approach to study the validity of psychological traits. Others were subsequently encouraged to use their mixed method matrix to examine multiple approaches to data collection in a study (Greene & McClintock, 1985). In organisational study mixed methods research plays a role in encouraging the use of a diversity of methods (multiple methods see Section 3.4.4 Choice of Mixed Methodology Multiple Methods) and involving both the macro and micro domains (Azorín & Cameron 2010). This has promoted the use of mixed method design and this approach is now also mixed with field methods (e.g. observation and official documents) and interviews. The choice to use mixed methods on the case study was done in order to facilitate: (1) an investigation of the outcomes achieved; (2) the new levels that can be reached; (3) the themes that emerge in relation to the interactions (particularly in relation to the application of L&G and its implementation to the oil and gas production operations within KOC; (4) to establish the strategy of the company and its future plans.

Research enquiries can take three forms: (1) descriptive; (2) exploratory; (3) causal. Two of these (i.e. descriptive and exploratory) are relevant to the current study (Zainal, 2007). The choice of a research design should depend on an researcher’s understanding and insight into the research itself (Robson, 2011).

3.4.1 Exploratory Research

Exploratory research design and descriptive research design possess similar characteristics and both can, at times, be used interchangeably. In exploratory research, the design is employed to investigate a phenomenon, by posing questions to a group or a population and is rigid when applied in a single case study (Darke et al., 1998).

3.4.2 Descriptive Research

Zainal (2007) states that a definition of descriptive research is an observation, followed by a description of, the variables and can be undertaken in either a quantitative, or a qualitative, manner. Descriptive research design focuses on hypothesising the kinds of trends expected and may differ from the research findings: thus it can be guided by hypotheses. These trends may be used to infer possible relationships between variables and derive hypotheses that can be tested in a casual manner. Descriptive research focuses on identifying the participants' understanding of their experience, environment, tasks and duties. Participants are interviewed to gain the required information and then this information is used to illustrate the description of the situation, i.e. to explain what has occurred to generate the event (Zainal, 2007).

3.4.3 Relevance of the Methodology

The study entitled 'Empirical Research Methods in Operations Management' (Flynn *et al.,* 1990), established the importance of empirical research in the development of operational management, while also stating that further research is required. In order to conduct valuable research, the primary element is to collect empirical data from real life. Over time, linking the practices and theories of operation management has been established. A number of authors have advocated and encouraged the use of empirical data to conduct operational management research, pointing out that such an approach can provide a systematic approach to conducting empirical studies. The benefit of empirical research is to provide a baseline for longitudinal studies, as well as a platform to document the conditions of operational management. On the other hand, it contributes to providing unique parameters and distributions for mathematical and simulation modelling studies. Theory building and verification can be a significant outcome of the use of empirical data (Flynn et al., 1990).

Voss et al., (2002) advocate the case study approach, claiming that it is the most effective research method in operation management. They further note that, in order to conduct research in operation management, the case study method has demonstrated rigid and powerful outcomes in terms of the development of a new theory. To reflect the contemporary environment (and also to deal with the growing frequency and magnitude of changes in technology and managerial methods), operations management researchers have called for greater employment of field-based research methods. A case study is used in a limited number of in depth cases. In published papers, case studies account for 4.94% (Voss et al.

2002), with field studies at 3.80% (Voss et al. 2002). Statistics reveal an increasing number of papers based on case research and therefore this current thesis is following both Voss et al., (2002) and Flynn et al., (1990) in attempting to address issues relevant to practices on the shop floor.

3.4.4 Choice of Mixed Methodology Multiple Methods

According to Azorín & Cameron (2010) using more than one single method in research design is classed as multi-method research. Multi qualitative or multi quantitative, multi method research has been conducted in this research (under the higher dimension approach within a mixed methodology research design framework), to integrate the qualitative and qualitative and quantitative methods (Azorín & Cameron 2010). A number of authors have used the phrase of 'mixed methodology, or multi method (Azorín & Cameron 2010), but in this thesis Multi-Method research will be used.

The most effective means of obtaining results that inform and aid others, is the adoption of multi-methods research (Creswell, 2003). Furthermore, multi methods can be nested together to provide improved understanding of different levels of analysis (Eisenhardt, 2011). In many cases, the automatic approach of mixing methods has led authors to develop a procedure for mixing methods that are concerned with the strategy of the inquiry and to undertake the numerous terms and shape procedures for research (Jick, 1979). Creswell (2003) notes that it has become possible to identify the research strategy based on the research question, thus in this study, mixed methodology, multi-method research is considered the most appropriate for achieving the desired results.

Mixed methodology is required to enhance the current study and this will be done by using two methods. This is a particularly useful technique in relation to the fossil fuel industry, where a mixed method is essential to enhance understanding in some phases of the research. This is demonstrated by the fact that measuring (or identifying) the use of electricity in the Gathering Centres (GCs) cannot employ qualitative data, while a study of company strategies to deal with electricity consumption cannot employ quantitative data, Thus, mixed methodology is essential to the identification of problems.

Mixed methodology, multi method research provides improved insight into the research problem, in comparison with either one of the single research approaches used here. Other data collection tools will be used to gain more information. The historical argument for mixed methodology research for over thirty years (Jick, 1979) has been that it provides strengths to offset the weaknesses of both quantitative and qualitative research. At the same time, the strategy of multiple employments of sources of data, observers, methods and theories in investigations of the same phenomenon, provides strength and validity to the overall findings (Greene & McClintock, 1985) .

It should be noted that quantitative data obtained from KOC consists of highly confidential historical data, particularly data related to oil and gas production between 2008 and 2012. This involved an official letter being forwarded from Loughborough University to Kuwait Ministry of Higher Education requesting KOC to release data for this research (further details of the formal procedures can be found in 3.6.2 Direct Observation).

This research has been influenced by a number of interdisciplinary factors, including energy markets, operation management, business management, behavioural approaches and engineering. Therefore, a number of methods have been employed for this research, ranging from site observation and interviews, to the collection of numerical historical data (Kovács & Spens, 2005). It is noteworthy that this research has so far favoured research. According to Blaikie (2007), when one research incorporates both reasoning methods, it is then known as 'abductive' reasoning. Both inductive and deductive reasoning approaches are included, detailed readings of collected data will be used to derive theory through the deductions made from the literature review (see Figure 3.2 p. 75)

From this understanding of inductive and deductive reasoning, the researcher will commence with an area of study (i.e. the literature review) and allow the theory to emerge from the data (i.e. a single case study) (Goel & Dolan, 2004; Dainty, 2008). It has been argued that the deductive approach needs to be evaluated for validity (Goel & Dolan, 2004).

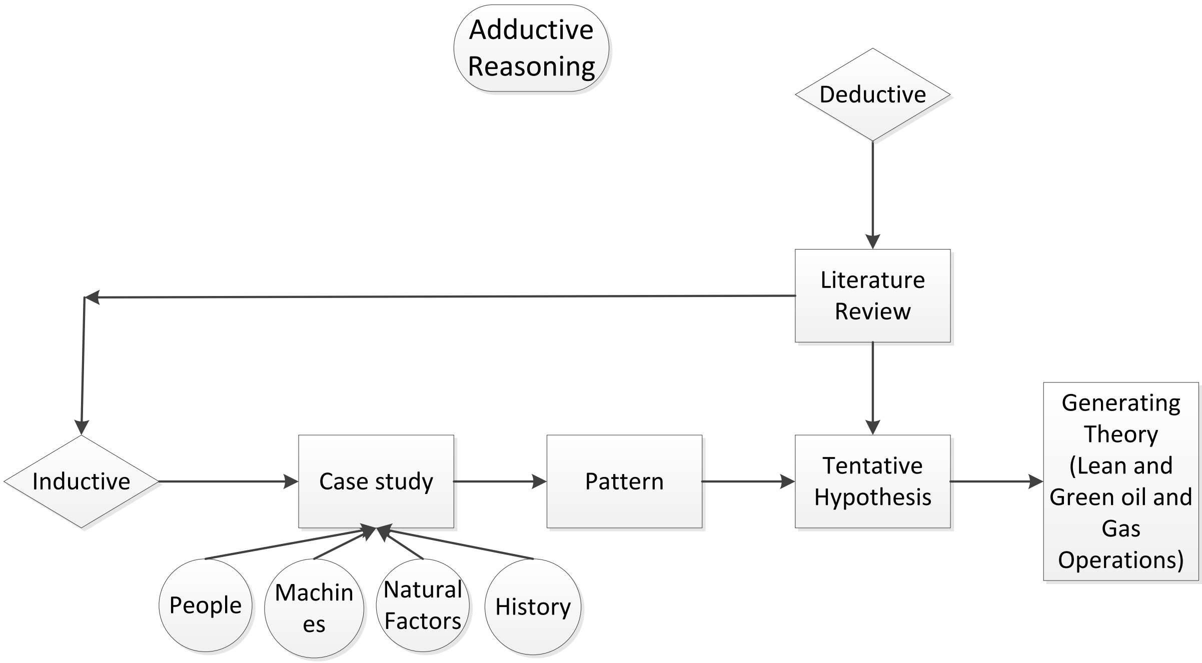

Figure 3.2 Research reasoning approach

3.4.5 Triangulation of Methods

Dainty (2008) states that triangulation methods refer to the use of at least two, or more different methods in a study, in order to check the results of the first method., A problem is explored using different techniques, to give more confidence in the results. Triangulation is a design strategy that validates data through cross-verification from two, or more sources. Multiple methods aim to overcome intrinsic biases and problems associated with the use of the single method (Creswell, 2013; Dainty, 2008; Greene et al., 1989). A combination of multiple methods possesses a greater chance for the enhancement of the validity of inquiry findings. Methodological triangulation can be employed to assess the identical phenomenon and can be the ideal approach to integrate field work and interviews (Greene & McClintock, 1985).

Triangulation can be something other than scaling, reliability, and convergent validation. It captures a more holistic and contextual portrayal of the problem under study. The use of multiple methods can contribute to uncovering some unique aspect of a hidden variance that might not be visible by a single method. For example the analysis of overlapping variance (Greene et al., 1989), i.e. the qualitative method plays a significant role in some research, by selecting data to identify the problem and achieve conclusions that might not be reached by other methods. This leads to elements of the context being illuminated. Triangulation may be used to support the understanding of the researcher and the reader by revealing further dimensions, alongside examining the phenomenon itself (Jick, 1979).

A key objective of formulating the questions has been to determine the benefits of applying L&G applications within oil and gas production operations, in order to deliver cleaner oil and gas production operations. Furthermore, an attempt has been made to establish if there is an opportunity to begin using mixed sources of energy for oil and gas production operations and if there are opportunities to extend the lifetime of the State of Kuwait's oil reserves.

3.5 Research Methods

The Kuwait Institutes for Scientific Research (KISR), the Ministry of Electricity and Water (MEW), the Kuwait Petroleum Corporation (KPC) and the case study of the 'Kuwait Oil Company' (KOC) were engaged in structured/semi-structured/unstructured interviews. Site observations were conducted with researchers, managers, team leaders, senior engineers, operators and the Minister of the Ministry of Commerce and Industry. The research and data collection methods were based on the methods outlined in this chapter, Table 3.2 demonstrates the links between objectives and methods.

Table 3.2 links between objectives and methods

Objective	Method
1- Review the academic literature	Desk study
2- Conducting a SWOT Analysis to develop the TOWS Matrix, in order to analyse the current and future environment and to determine the direction of the case study (KOC) with respect to the ecosystem	Pilot Interviews Structured and semi-structured Interviews
3- Investigate the existing oil and gas production operations in a single Gathering Centre (GC) of KOC, who are seeking to re-engineer these operations using the L&G approach.	Semi-structured Interviews/ unstructured interviews, direct observation, machines manuals, archival data and historical data provided by the KOC Literature review (Desk study) mainly for

	lean and green part. Value Stream Mapping
4- Design/develop a photovoltaic model to supply oil and gas operations with cheap and clean renewable energy, for a single GC in the case study.	Historical data about electricity consumption in the specific gathering centre, provided by KOC Semi-structured interviews/ unstructured interviews with KISR researchers to investigate the ideal renewable system that suits the gathering centre operations, as well as the Kuwait climate.
5- Evaluate the proposed solutions and validate the theory upon which the strategy is driven.	Reflexivity Multiple sources of data (triangulation methodology) Workshop with Stakeholders Direct site observation For more information about objective 5, see Table 3.10 steps undertaken to ensure research validity and reliability in (p. 111, section 3.8 Validity and reliability)

3.5.1 Main Study conducted KOC

The researcher's objective was primarily aimed at fulfilling the requirements of the research and secondly to develop a model for a sustainable and cleaner hydrocarbon industry, along with more efficient oil and gas production operations. The main study was conducted in KOC fields and offices and was judged to be accurate when the researcher undertook the research process. The time spent in KOC primarily involved the researcher communicating closely with the following: operators; operations managers; strategy and planning managers; R&T group; R&D group; Environmental & Health and Safety teams.

3.5.2 Duration of the study

The validity of the qualitative methodology results was also improved through focusing on the case study over a period of years, i.e. from February 2012 until December 2014. This did not take place constantly from within the company, but with frequent contact with its personnel for further data and updates. Studying KOC over a long period of time increased the researcher's ability to gain insights into the process of interaction between oil and gas production operations and the potential adoption of L&G application, along with the approach of the company. Following the time spent in this fossil fuel company over a two year period, it was possible to observe micro level details concerning strategy, operations, employees, challenges and opportunities. Furthermore, it was possible to check operators' behaviour and feedback concerning their tasks and to identify additional details concerning oil and gas operations, over the period of study. It also helped to identify the company's reaction to the oil crises in 2014, in terms of production and business diversity. Through the relationships established between a number of operators and researchers during this time, constant questions could be put to these operators through contact via social media, including obtaining any information that might be missing.

The current study is not longitudinal, but it was possible throughout the two-year duration to identify the relationships between the various actors (i.e. from managers to team leaders to supervisors and operators). The duration of the study made it possible to judge the reactions of these actors and estimate the potential for them to incorporate the application of L&G application over time and also to understand the significance of the strategy for the firm.

3.6 The Case Study Method

The methodology looks at a single case study to explore the relationship of oil and gas production operations to the organisation's L&G and hydrocarbon strategy. A single case study was chosen due to the exploratory nature of the study, along with the level of detail in the data required to look at this specific area of interest. The use of a single case design provides intensity and allows an increase in the quality and quantity of the data obtained (Barnett et al., 2004). An in-depth case study can compensate for a lack of generality, by revealing a greater depth of understanding concerning the set of events and personal behaviours. A particular strength of the case study method is that it permits a combination of these data collection methods, so enabling the researcher to capture the complex reality under scrutiny (Saunders et al., 2009).

Research questions such as ‘How’ and ‘Why’ are more explanatory, and more likely to lead to the use of the case studies and histories as the preferred research strategy. ‘How’ and ‘Why’ questions deal with operational links need to be traced over the time and focus on establishing the final analysis rather than the frequencies or incidents. ‘How’ and ‘Why’ questions facilitate the understanding of the nature and complexity of the processes taking place (Benbasat et al., 1987). The case study forms an ideal tool to examine the contemporary phenomenon of ‘waste in oil and gas operations’, but cannot be controlled in relation to relevant behaviour. Therefore, a case study relies on a large number of techniques, adding two sources of evidence, i.e. direct observation and systematic intervening. The strength of the case study is its ability to deal with the full variation of evidence, including documents, artefacts, interviews and observations, citing a decision concerning the subject as the major focus of case studies, (e.g. processes of organisations, programmes and institutions) (Eisenhardt, 2011).

A case study offers a comprehensive view of an event, giving a rich picture and enabling the researcher to obtain analytical insight, with each study having a subject of interest (i.e. a person, place, event, or phenomenon) and an analytical frame within which it is studied (Thomas, 2011).

Yin (2009) and Tellis (1997) have established evidence that a case study may be developed from five sources, including: (1) letters; (2) agendas; (3) administrative documents; (4) formal studies; (5) or evaluation of the same site under study. Documents in a case study need to be corroborated with evidence from other sources, including access to the organisation’s library and a review of their files, including proposals for projects or programmes.

1- Archival records can be:

- Service records (e.g. those showing the number of clients served over a given period of time).
- Organisational records (e.g. an organisational chart and budget over a period of time).
- Maps of the geographical characteristic of a location.
- Lists of names and other relevant commodities.

- Survey data (e.g. census records or data previously collected concerning the site).
- Personal records (e.g. diaries, calendars, and telephone listings).

The majority of these archival records have been produced for specific purposes and a specific audience (i.e. other than the case study investigator). This is a factor that must be fully appreciated in order to interpret the usefulness of any archival record. In KOC, a number of achievable records were handed to the researcher in response to an official request by team leaders, i.e. in response to this request; the electricity consumption in a specific GC was given to the researcher.

2- Pilot Interviews

The majority of case study interviews are open-ended, enabling the investigator to ask key respondents for both the facts and their own opinions on certain events. This was the style of interview undertaken for the current research.

3- Focused interview

This style of interview remains open-ended, but the interviewer is more likely to be following a specific set of questions derived from case study protocol, being more structured and along the lines of a formal survey. Overall, interviews are an essential source of case study evidence, due to the fact that the majority of the research is concerned with human affairs, which should be reported and interpreted through the eyes of specific interviewees as well as well-informed respondents, who can provide important insights into a situation.

4- Direct observation:

This involves making a field visit to the case study 'site' in order to create an opportunity for direct observation, i.e. leading the way to establishing the visible behaviour of the targeted phenomena. In the current study, direct site observation was undertaken for one GC and one water handling station.

5- Participant observation:

This is a specific mode of observation, in which the investigator is not merely a passive observer, but instead may assume a variety of roles within the case study situation, even participating in the event being studied. In this current research, the researcher did not have the opportunity to follow such an approach.

6- Physical artefact:

This is a technological device, a tool or instrument, or a work of art, etc. Such artefacts may be collected (or observed) as part of a field visit and has been used extensively in anthropological research. This approach is not applicable to this current study.

Yin (2009) and Tellis (1997) address the fact that overriding principles are important to any data collection during case studies. The benefit from these six sources of evidence can be maximised if three principles are followed. When used correctly, these principles are relevant to all six sources and can help to deal with the problem of establishing the construct validity and reliability of a case study.

Multiple sources of evidence are the methods of constructing validity for a case study and are a major strength of case study data collection. It consists of the opportunity to use many different sources of evidence (Yin, 2009) which far exceeds that of other research strategies. The use of these multiple sources in a case study allows an investigator to address a broader range of historical, attitudinal, and observational issues, with their greatest advantage being the development of converging lines of activity, i.e. a process creating multi-evidence in relation to a single phenomenon. On other hand, potential issues of construct validity also can be addressed, due to the fact that multiple sources of evidence essentially provide multiple measures of the same phenomena. A case study database is the most effective way of organising and documenting the data collection for a case study. The data evidence base and the report of the investigator (whether it takes the form of an article, report, or book), forms a chain of evidence, from the derivation of any evidence from the initial research questions to the final conclusions of the case study.

3.6.1 Site Selection Criteria

The main research question was to what extent can lean production used to develop green operations in Kuwait industry? During the initial stage of the research, the focus of the study was concerned with issues relating to the improvement in efficiency of existing operations, within industrial organisations and the mixing of energy sources for these operations, through the use of lean processes. The research question at this stage was not yet determined so the main driver was to identify the unit of analysis (Baxter & Jack 2008). The aim is such observations/decisions were to make an improvement to the framework/model, which would contribute to an improved method of work organisation in a lean & green environment.

In order to decide on the analysis technique, the researcher first needed to decide on the level of detail required and the sample size that would be used (Elo & Kyngäs 2008). Sample selection should be determined by assessing the size of the total population for inclusion in the study (Tellis, 1997) and in this case, sampling strategically, in order for the sample to be representative of the industry from which it is drawn (Elo & Kyngäs 2008). The sample was intentionally selected according to the needs of the study (Boeije 2009). Therefore the researcher identified which sample elements were needed from the industry i.e. individuals related to the industrial production in Kuwait, personal working in energy sector and developers of the energy strategy in the country.

According to Zietlow, (2015) sample size needs to be large enough, although there is no specific size that it should be. The sampling strategy in this qualitative research should target a wide range of perspectives and experiences (Zietlow 2015). Various viewpoints were sampled at different organisations among three different groups of people: managers, production team leaders and researchers.

KOC, EQUATE (a petrochemical company) KISR and MEW were visited by the researcher. In regards to KOC and EQUATE initial contacts and the first visit to each company were arranged through emails that were facilitated by the Training Department of both companies. Approval emails from both companies were received. In regards to MEW and KISR no permission was needed to get access to their buildings, for further details see (3.6.3 section interviews). Information and data from the designated sample elements was identified through seven pilot interviews, which are available in Table 3.3 as following:

Table 3.3 list of the conducted pilot interviews with the samples

Organisation	Number and nature of the pilot interview	The main reason of visiting
MEW	One unstructured	To identify the energy system (production/supply) in the country, to identify the organisational structure and to identify the issues between the ministry and the industrial sector in the

		country
KISR	One structured One semi structured	To understand the country's energy strategy and to learn about their comprehensive plan of Kuwait; to investigate the government's priority to ensuring energy resources can be developed in an environmentally sustainable way, to identify the industrial organisations that could place extra load upon the energy system in the country.
KOC	On structured Two semi structured	To explore the nature of the company's operations, to explore the possibility of reducing oil production and to identify the electricity resources that fuel KOC's operations.
EQUATE	One semi structured	To explore the nature of the company's operations and to explore the resources of electricity that fuel EQUATE operations.

The management of EQUATE showed no interest in the research approach that the researcher put forward and they did not demonstrate flexibility in supplying answers for the questions that were asked. This led to a reduction in the sample size that was used in this study and the following organisations were used instead, KOC, KISR and the MEW. These organisations are the main and largest organisations in Kuwait according to their business/activities related to the industry and energy.

These samples helped to identify the problem and to develop an appropriate research design and to assess which data collection instruments would be used, as well as to help to identify the gap in the existing knowledge (Boeije 2009). After conducting the seven pilot interviews, the information were used to identify whether the samples would be able to provide the project with data and whether this data could potentially help to fulfil the objectives of the study. After all pilot interviews had been conducted, a list of the findings of the pilot study was collated, see below:

- Kuwait's economy is reliant upon the production and export of oil (Alsayegh 2008), which could pose serious threats to the country's economy.
- Kuwait is rated as the third highest CO_2 emitter, per capita in the world (Ramadhan & Naseeb 2011).
- Kuwait experiences frequent power cuts
- The largest industry in the country is oil and gas production (KOC interviewee, MEW interviewee)
- The MEW is struggling to meet energy consumption and demand in the oil and gas production industry (MEW interviewee).
- KOC's production operations are operating in a conventional management style (KOC interviewee, KISR interviewee), thus there is space for improvement.
- KOC's oil and gas operations do not require high intensity energy to operate. A link to renewable energy is possible (KISR interviewee, KOC interviewee). KISR interviewees were excited about this study and are seeking an opportunity to link the existing oil and gas operations with renewables. They have advocated a research study and have also promised to provide all the data which is needed to build a renewable system model.
- Every kilowatt being saved from electricity consumption leads to savings in oil consumption.

- There is waste within oil and gas production operations, some interviewees suggested that the researcher should identify sources of waste and they also recommend other potential improvements that could be made.

The outcome of the pilot meetings was a more developed research question: What are the benefits and challenges if KOC adopted environmental strategy? And to what extent is Lean & Green (L&G) capable of delivering clean and efficient, oil and gas operations?

At the beginning of this section the major concern was over the use of the appropriate unit of analysis. After the samples were identified, the pilot study accomplished and the pilot findings discussed, the research question clearly emerged. Therefore it became clear that the purpose of this research is now to explore the Kuwait Oil Company (KOC), as a single case study of a hydrocarbon industry. At this stage in the research the central focus being studied is the lean & green production strategy and how it can be applied in oil and gas operations.

Extra key factors that give KOC an advantage over other organisations include the following:

1- Large Enterprise: KOC is a subsidiary of the Kuwait Petroleum Corporation (KPC), which is ranked of as one of largest National Hydrocarbon Corporations in the world. KOC (the subsidiary) is a major producer of oil and gas in the State of Kuwait, thus enabling KPC to outperform the competition from a growing number of National Oil Companies (NOCs), i.e. KPC own entities that are increasingly seizing the sole rights to major oil reserves. KOC is one of the largest oil and gas companies globally and rank as one of the top ten companies by daily production volume, in terms of oil and natural gas.

2- Further Access: for reasons of practicality, it was important to be able to conduct interviews at all levels in the company. In addition to the type of business, key factors in determining the choice of the KOC as a single case study for this research include the fact that it also uses raw materials and carries out production operations. A key element in deciding on the chosen KOC sites was gaining agreement from the management in conducting this study. This was particularly important as the research involved multiple access, pilot interviews and interviews with a cross section of actors within KOC. The group arranged access to speak with the following employees:

    - The Production Team Leader and Senior Engineers.

- The Production Plant (i.e. Gathering Centres).
- The Research and Technology (R&T) manager.
- A Senior R&T Engineer.
- Shop-floor operators.
- A Field Development Expert.
- The Transportations Group Team leader.
- A Senior Health, Safety and Environment Engineer.
- A Planning Group Senior Engineer.

3- KOC in its role as a member of the OPEC.

4- KOC as the country's main source of income.

The supervisors and KOC managers were generous in securing corporate level introductions to different teams within the company, as well as in facilitating access to middle management for the duration of the study. Consequently, corporate and middle management facilitated the cooperation and further access to lower levels of the organisation. This including admission to prohibited areas, particularly on the shop floor (GCs), as well as access to documentation which was considered helpful to the research under investigation.

Types of raw materials and products: the initial choice for the case study was to focus on companies that had oil and gas operations and who had an interest in cleaner energy production. A key criterion for the choice of the case study company was that they were one of the primary producers of energy in the world, as well as dealing in hazardous materials and pollutants, in this case, rich carbon dioxide producing operations, so that the application could be designed to eliminate waste. A further key criterion was the use of rich polluted material as the product of the company, which is also considered as a source of energy for a great number of countries around the world. The company operates in a conventional manner, with no involvement of quality management philosophies, i.e. lean six-sigma or lean applications. Thus, an attempt to merge the application of L&G with KOC's current style will demonstrate the elimination of waste during production. L&G will make operations more efficient and will allow for a use of mixed sources of energy. The attempt to merge L&G

within the company's strategy also has the potential to demonstrate the rewards of changing the current attitude towards the fossil fuel industry towards a greener industry, in the Middle East

The existence of advanced production operations in KOC's GCs and the production environments ensured that the company was ideal for cross case development within the framework of the research. Also, analysing and developing KOC's strategic plan by using a TOWS Matrix had the potential to return the benefit to the Kuwait's economy, rather than solely to KOC.

Furthermore, the organisation has played a significant part in the initial phase of the investigation. Kuwait Institution for Scientific Research (KISR) is an organisation that promotes scientific and applied research, particularly in matters related to industry, natural and food resources and other primary constituents of national economy, in an endeavour to serve the goals of economic, technological and scientific development. It also advises the government on scientific matters and scientific policy issues. It was important to identify issues relating to a new wave of manufacturing strategies and their use in the country through KISR, along with the orientation of the country toward mixing energy resources. The questions posed during the pilot interviews were general in nature, explored the types of current and potential energy resources in the country, along with a new type of organisational structure and the government's concerns with pollution and energy.

Furthermore, one interview during the initial phase was conducted with a manager of MEW. He was questioned about the efficiency of current power stations and asked whether it is possible to supply the country with energy and desalted water and whether the ministry is incurring further costs by taking on the role of providing conventional energy for the country. He was also questioned about the existence of a strategy (or project) to establish a clean source of energy to provide the country with energy and water.

3.6.2 Direct Observation

Babbie (2012) states that direct observation adds to the depth of research and enhances its reliability and validity. Observing an event is different than hearing it from the perspective of the responses of employees and provides clear insight and tangible feeling into the nature of work. Through directly observing operators and operations, the researcher can observe the ways in which this is reflected in their actions, and understand further details concerning the plant, machines and operations. The advantage of this direct observation is in supporting the researcher in understanding new dimensions, and to probe and be systematic. It is a research method that is straightforward to use and is the most powerful source of validation when employed as part of a methodological spectrum that includes member-articulated data gathering strategies (i.e. in-depth interviewing or participant observation) (Adler & Adler., 1994). The issue with direct observation is that observing the behaviour of employees or operations can be very time consuming, and is also the most uncontrollable form of field inquiry (Snow & Thomas, 1994).

Permission was sought from team leaders and operators to observe some of KOC's fields (i.e. GC and Water Handling Plant (WHP)), and the quality of the investigations on the shop floor was ensured when the training and development employer informed team leaders about the focus of the researcher's study. The researcher also took the opportunity to arrange for interviews with team leaders during the on-site period, particularly those difficult to reach since their workstations are sited inside prohibited areas.

Meetings on a one-to-one basis were arranged by the researcher with the training and development employer, to identify which area (or group) was essential for understanding the operations being observed, along with a number of interviews. This was particularly important due to time limitations. The training and development group has connections with the remainder of the groups within KOC, since the training group organises company training courses and placing new employees, and thus knows where (and how) to find the desired information.

A number of meetings were arranged by the researcher across the eight weeks with the training employer and operation's team leader, in order to discuss progress and the observations themselves. The researcher included the items for discussion, which were compiling an agenda: the observations made; further details concerning a number of processes in the GC and WHP; and, identifying those capable of providing information for future interviews, particularly once the potential stage of investigating company's strategy had begun.

Direct Observation of the shop floor provided discussions concerning working practices and changes due to the implementation of advanced technology and organisational arrangements with operators, along with responsibility for protecting the environment. Specific times were organised by the researcher to enable him to recollect his observations and the notes he had logged during the time spent with the operators' onsite. The use of a personal laptop (provided by Loughborough University) was vital during this time, enabling the researcher to note observations and investigate information to assist in an upcoming observation.

Employers, operators and team leaders responded generously to requests to provide the researcher with manual holding operations, official documents, and some archival and historical data. A sound understanding of each of the main processes needed to be obtained, in order to identify the levels of oil and gas production operations within all processes. On a daily basis (i.e. approximately four hours per day, five days a week) the researcher went to the company's main office, in order to use its private transportation to navigate between the company's sites.

In the GC, the researcher shadowed operators in order to understand the operations in more depth. During this time, the researcher took the opportunity to hold discussions with different groups of workers within KOC, particularly during break times in the canteen, with the aim of identifying the culture of the employees and the nature of their work. At each site, the team leader of the facility introduced the researcher to the operators in order for them to show the researcher the nature of the work. In GC, during an observation lasting a period of five days, close attention was paid specifically to the desaalter plant inside GC, along with the desalting process, since it forms the most significant stage of oil dehydration in the GC. The researcher stood by the side of operator paying close attention to the machines and screen monitors. GC operates by means of:

- One team leader (responsible for the entire territory, which generally includes a number of GCs).
- One supervisor (responsible for a number of GCs, but not of the entire territory).
- One controller (responsible for more than one GC).
- One operator (1) in a single GC.
- Four operators (2) in a single GC.
- One former (checking the status of the well) in a single GC.

The remainder of the observation was undertaken in order to view wells, reservoirs and WHP. However, the most important observation was that which gave the researcher the opportunity to access prohibited areas of KOC, allowing an opportunity to conduct a number of unstructured, and structured, interviews with team leaders. Observation was the only means of building friendly relationships with those working continuously in areas impossible for the public to access, and thus very difficult to meet. The following consists of a number of notes concerning the site observation:

1. The company received an official letter from Professor Stephen Emmitt requesting them to issue permission, if possible, for the researcher to visit the organisation's sites and oil fields. This was due to the fact that the required data was confidential and critical, in particular the historical data (i.e. archival data) concerning oil and gas production. At the same time, KOC's fields and oil wells are considered to be prohibited sites directly linked to the county's security. Thus the researcher needed to be provided with official documents from Loughborough University and the State of Kuwait Ministry of Higher Education. The primary condition for such permission being granted was that the researcher must be a Kuwaiti citizen, and must comply with any confidentiality conditions KOC needs to apply to such permission, should it be forthcoming. KOC management was informed that all data would be treated in the strictest of confidence, and all results would be reported anonymously.

2. Before the researcher travelled to visit the KOC sites, a risk assessment form was completed at Loughborough University with the research supervisor Mr Wayne Lord.

3. The employer of the training group introduced the researcher to every new group he needed to contact. The researcher was provided with an official letter and a temporary (eight week) permission to allow him access to the restricted plants, stations, and areas. To access the GC, or prohibited areas, the researcher needed to take a company car at specific times during the day. On the first day, KOC provided the researcher with a safety helmet, safety shoes and a work suit.
4. It was possible for the researcher to create friendships with the employees during these eight weeks, making it possible for the interviews to achieve a higher level of frankness, particularly in relation to questions concerning the actions of management. From middle managers, to supervisors, to operators, the majority expressed their opinions without reservation, and were mostly highly critical of management policies.

The observational study played a primary role in specifying the approach of the research, giving the researcher a clearer idea of where the focus of the research should be. The researcher was able to experience the nature of the work and operations of the company, by documenting all of the literature, pilot interviews and observations, and was able gain improved insight into what takes place in such prohibited areas of the fossil fuel industry around the world.

The observations provided the opportunity to gain valuable insights into the strategy and cultural aspects of the employers and operations the researcher perceived to be an indication of interest in pushing the company to operate in a cleaner manner. An analysis of the documented information related to KOC was conducted, including: training manuals; production processes; written rules and procedures; maintenance schedules; and group and department objectives.

3.6.3 Interviews

The motives behind the choice of interviews have been discussed earlier (see section 3.6 The Case Study Method in this Chapter). During the early stages of this study, the researcher conducted a number of pilot interviews. All pilot interviews, structured interviews and semi-structured interviews, were conducted primarily with managers and team leaders from KPC and KOC involved the research, in order to focus on the company’s strategic and managerial decisions (from strategy and planning groups, R&T group and operations group). Further interviews were conducted with: (1) researchers and senior-researchers from KISR; (2) a manager from MEW; (3) operators from KOC. Table 3.4, p.92, outlines the types of interview and the number of times they were conducted. Further details concerning the interview schedule section consist of the following:

- Kuwait’s Ministry of Electricity and Water (MEW) (Table 3.5, p. 97).
- Kuwait’s Institution for Scientific Research (KISR) (Table 3.6, p. 98).
- ‘Kuwait Oil Company’ (KOC) (Table 3.7, pp. 99-100).
- A Minister of the Ministry of Commerce and Industry (Table 3.8 pp. 100-101).
- The Kuwait Petroleum Corporation (KPC) (Table 3.9, p. 101).

Interviews were undertaken with four types of informants, eliciting their views concerning the potential strategies and their implementation in relation to mixing sources of energy in the country and KOC. Interviewees were as follows: (1) at the corporate level (including the manager of decision makers, such as the R&T group and the planning group in KOC and KPC); (2) the production group in KOC; (3) a manager in MEW; (4) five researchers in KISR; (5) a Minister of the Ministry of Commerce and Industry.

Interviews at the corporate level were helpful in two ways: firstly, as gatekeepers, these interviewees served as a stepping stone for further access and interviews with a wider cross section within the company. Secondly, they served to provide an insight into managerial perspectives and the associated meanings, patterns and themes being put forward by management. Interviews could generate in-depth conversations and add invaluable insights into identifying the corporation's future plans. The bases for choosing these participants were as follows:

Table 3.4 Number and types of the interviews

Interview type	Number of times
Pilot unstructured	1
Pilot semi-structure	3
Pilot structures	1
Semi-structured	8
Unstructured	2
Pilot online structured	1
Structured	6
Total	22

KOC and KPC

Interviews were undertaken with managers and team leaders of both KOC and KPC due to:

- Their experience of leading the company.
- Their position as decision makers.
- They are in depth knowledge of the future strategy of the company.

Production operators at KOC were also interviewed, due to the fact that their duties involve production and sending products to the export team. They work with the machines in the GC on a daily basis, twenty-four hours a day, seven days a week, and are thus in the best position to understand further details concerning oil and gas production operations.

Kuwait's Institution for Scientific Research KISR

KISR's researchers also hold responsibility for the development of KOC operations and strategy plans, and are thus aware of any possible future developments. Four researchers and senior-researchers from KISR were interviewed because they:

- Conduct scientific research and studies concerned with the progress of Kuwait's industry and facilitate the preservation of the environment.
- Explore and study natural resources and the means of exploiting them, i.e. energy and water resources.
- Render scientific, technological and research consultation services to the government and to national corporations.
- Follow up the development of scientific and technological progress, adapting it in ways that conform to the local environment.
- Participate in the study of ways to verify the resources of the national economy by investing the results of scientific and technological research in industry, and directing towards the services of the State's economic and social development goals.

State of Kuwait's Ministry of Water and Electricity (MEW)

MEW is included in the study due to being the only supplier of electricity and water resources in the State. It is also the central regulatory body that manages the supply/demand of these two resources in the country.

The Minister of the Ministry of Commerce and Industry

This interview was valuable to identify the approach of the State of Kuwait's government to the expansion of the country's industry and also to identify government strategy towards securing energy for the future.

Interview Procedures

1. Interviews were conducted with the various participants using the following formats: unstructured, semi-structured and structured. The informants were selected from a cross section of the KOC, KPC, KISR, and MEW to represent KOC's performance. This cross section was necessary in order to provide rich and deep information concerning the development of significant sources of global energy under discussion in this study, as well as to provide a mechanism for confirming the viewpoints of the respondents. Interviewing managers, engineers, supervisors, and operators, also helped to add variety to the process, as well as confidence in pinpointing the key issues related to KOC as a leader in the fossil fuel industry. The number of those interviewed for the study ranged between fifteen and seventeen. The number is not exact due to a number of operators simply attending some of the interviews and leaving before the end.

2. The first KISR interviewee was chosen due to a journal publication concerning the future of energy in Kuwait. It was not a simple matter to reach this individual, as his email was found only on the 'LinkedIn' website, and it took almost two weeks for him to reply to the request for an interview, followed by lengthy arrangements for the first interview. However, after the interview, the interviewee introduced the researcher to his colleagues in order to facilitate further interviews.
3. Interviews in MEW were conducted based on availability of the individual concerned, and only one interview was conducted with a single manager.
4. Interviews in KOC were conducted according to the availability of interviewees, and included: managers; team leaders; senior engineers; supervisor engineers; operators. The focus of the research concerned the development of a strategy leading to a green and sustainable fossil fuel industry through the mixing of sources of energy and developing efficient oil and gas production. Follow up interviews concentrated on the shop floor environment through interviews with operators and supervisors, focusing on: (1) oil and gas production operations in detail; (2) the environment in GC; (3) the tasks of supervisors and operators. Interviews were conducted in one GC in both the control room, and the GC field (shop floor). A further interview was conducted in the Water Handling System station's control room.
5. The interviews were based on a structured, semi-structured and unstructured interview process, primarily seeking to establish four perspectives: (1) Interviews were conducted with developers and researchers of energy in KISR and MEW, in relation to the energy strategy and development in Kuwait in relation to future energy supplies; (2) KOC 'the case study' focussed on the perspectives of managers, and environmental groups, along with production group and shop floor operators. Questions concerning the production process and the production environment of the company focussed particularly on oil and gas production operations and their impact upon the environment. There was also emphasis on the various macro and micro issues related to oil and gas production operations, and whether OC intends to begin adding clean sources of energy into its mix; (3) Interviews with both KISR and MEW focussed on questions concerning the country's strategy in relation to future energy supplies; the pilot project explored clean energy systems being introduced into both the country and KOC.

6. At the start of each interview, a brief overview of the research project was presented to the interviewee, who was assured of the confidentiality of all answers, and that the names of the company, business unit and individuals would be changed.
7. An attempt was made to cover all areas of questioning within the time constraints of the interview. As these interviews differed in structure, the discussion did not follow the same chronology as the interview question list. This led to issues at the heart of the dimensions being probed for further input, while other questions (particularly those relating to production-related facts) were left, and addressed during later interviews.
8. The questions related to the role of the individual within the company and his work duties, focussing on his views and comments, concerning whether oil and gas production operations had an impact upon the environment. Discussions also covered the idea of adopting of renewable energy in the country, and how the key dimensions of such a change would relate to the individual's specific area of work.
9. A smartphone voice recording application was used in some of the interviews, after gaining permission from the interviewee, substituted by handwritten notes when an interviewee was not comfortable with being recorded.
10. Questions that did not apply to the particular circumstances and position of the interviewee were not put. Factual questions concerning the processes were not repeated in questions to subsequent interviewees, unless they related to the discussion.
11. An attempt was made to cover all question areas within the time constraints of the interview. The semi-structured format allowed the discussion to focus on different aspects of the research issues relating specifically to the interviewee. Only a small number of formal structured interviews were undertaken, with these focusing on highly specific areas of the research. The unstructured interviews, on the other hand, were generic (i.e. closer to a 'chatting' style).
12. Interview times varied between interviewees and from visit to visit. The duration of each interview depended on the schedule of the interviewee, apart from operators, who were able to be more flexible. Some interviews were short (i.e. between thirty and ninety minutes) while others were longer, particularly as operators could be more flexible. An interview with an operator would usually begin on the GC where an observation of the machines, operations and operators was taking place. The operator

would explain each step of the machine process and operations, answering queries related to both the operation and the technology.

13. Some interviewees were unavailable for subsequent follow up interviews. This was particularly so for a number of the personnel interviewed in earlier visits. In these cases, follow up interviews were made with individuals working in the same area, and at the same level.
14. The initial visit for the pilot study in KOC took place in April 2012, in the company's main building. Only three pilot interviews were conducted at this time. The investigation was cut short and the focus remained at the macro level. Sufficient data was collected to contribute to the examination of the research questions of this study. Furthermore, the pilot visits, and interviews with KISR and MEW, contributed to setting the direction of this study. The decision was made to choose KOC as a single case for this study in August 2012. Paperwork was submitted in September 2012 for permission for the researcher to be present in OC's fields over five weeks. During the fourth week, it became clear that additional time was needed to accomplish the investigation. A further request was then placed requesting a three-week extension for the visit, which was approved.
15. Interviews were held internally at the respondent's normal place of work, apart from some of the interviews with operators, which were held in public places outside of their work, after a friendship had been established.
16. No permission was needed to conduct interviews in KISR and MEW, apart from or appointments made in advance for some of the interviews.
17. To minimise complexity in both the research and the process of analysis associated with the study of a GC plant, an examination of mixed manufacturing processes, and the general OC management approach to investigate the capability of L&G, was undertaken in a single case study.
18. Specific sites and fields were chosen by the OC training group, to allow the researcher access, in order to carry out his investigations. However, the majority of KOC's GCs and desalting stations have an identical design.
19. Further explanations were made concerning the meaning of each question, in order to ensure the interviewee has clearly understood what was meant by each question. This process was helpful to the research, as it clarified the different meanings associated with the concepts discussed at different levels within the organisation.

20. Notes were taken during the interviews, and some interviewees (i.e. at managerial level) handed the researcher notes or documents giving abstract explanations concerning the questions, and provided further information.
21. During some interviews, a number of the answers were too short, or not as expected. In most instances, the discussion did not follow the same chronology as the interview questions.

Issues concerning the Interview Process: from an ethical perspective, the intention was to ensure that all issues were clarified before the interview took place. The following issues were considered:

Anonymity: confidentiality agreements were made between the interviewees and the researcher.

Inconvenience experienced by the sample of the respondents interviewed: appointments were arranged and organised by the researcher. The interview procedure was explained to the interviewees before commencing the interview, along with an agreement reached with the interviewee concerning the concept and meaning of the questions before any documentation took place.

Bias: in order to avoid bias, the researcher remained neutral and did not interject opinions during the interview (Podsakoff et al., 2003).

Table 3.5 Kuwait Ministry of Electricity and Water (MEW)

No.	Visit Date	Informants	Nature of the Interview	Number of the interviewee	Average duration of the interview	Number of the interview at each position
1	March 2012	Director of mechanical works department, Power station project	Pilot/ Unstructured	1	45 minutes	1

Table 3.6 Kuwait Institution for Scientific Research (KISR)

No.	Visit Date	Informants	Nature of the Interview	Number of the interviewee	Average duration of the interview	Number of the interviews at each position
2	March 2012	Dr (SH) Head of energy research	Pilot/ Semi-Structured	1	45 minutes	1
3	April 2012	Dr (OS) Nuclear Energy researcher	Pilot structured	1	60 minutes	1
4	January 2013	Dr (OS) Nuclear Energy researcher	Semi-structured	1	60 minutes	1
5	January 2013	Dr (AG) Manager of Renewable Energy Program	Semi-structured	1	50 minutes	1
6	January 2013	Dr (OS) Nuclear Energy researcher	Un-structured	1	70 minutes	1

Table 3.7 Kuwait Oil Company' (KOC)

No.	Visit Date	Informants	Nature of the Interview	Number of the interviewee	Average duration of the interview	Number of interviews (at each position
1	March 2012	Dr (AA) R&T manager	Pilot/ semi-structured	1	40 minutes	1
2	March 2012	Engineer (DG) senior process engineer	Pilot/ Online/ structured	1	60 minutes	1
3	April 2012	Engineer (HZ) Team leader production group	Pilot/semi-structured	1	45 minutes	1
Second visit; Eight weeks past in the company's fields + site survey & observation, period between						
4	November 2012	Senior engineer (MK) R&T	Structured	1	60 minutes	1
5	November 2012	Senior engineer (MS) R&D	Unstructured	1	30 minutes	1
6	December 2012	Engineer (HZ) Team leader production group	Structured	1	60 minutes	1
7	December 2012	Senior Engineer (FS) production group	Semi-structured	1	40 minutes	3

8	December 2012	Senior Engineer (SA) HS&E	Semi-structured	1	50 minutes	1
9	January 2012	Engineer (KH) desalted waste water handling system	Semi-structured	1	30 minute's	1
10	January 2013	Expert engineer (M) field development	Structured interview	1	60 minutes	1
11	January 2013	Senior engineer (MZ) Planning Group	Semi-structured	1	60 minutes	2
12	November-December 2012/January 2013	Shop floor supervisors/ operators Group	Semi-structured	5-7	Varies	10/15
13	January 2014	Operator/operator (1)	Structured	2	120 minutes	1
14	Augusts 2014	Operator/operator (1)	Semi-structured	1	60 Minutes	1

Table 3.8 A Minister from the Ministry of Commerce and Industry

No.	Visit Date	Informants	Nature of the Interview	Number of the interviewee	Average duration of the interview	Number of interviews (at each position
1	April 2013	Minister Ministry of	structured	1	50 minutes	1

		Commerce and Industry				

Table 3.9: Kuwait Petroleum Corporation (KPC)

No.	Visit Date	Informants	Nature of the Interview	Number of the interviewee	Average duration of the interview	Number of interviews (at each position
1	December 2013	MS (SA) Planning and Strategy manager	structured	1	7minutes	1

3.7 Data Analysis

A number of researchers agree concerning the presence of standards for qualitative data analysis, and outline the ways in which qualitative data analysis can be conducted. A cannon of work is essential for qualitative data analysis to be presented in order to construct a platform for drawing conclusions and verifying the robustness of qualitative research (Miles & Huberman, 1994). Miles & Huberman (1994) state that while conducting a qualitative approach to analysis: "works that will produce clear, verifiable, credible meanings from a set of qualitative data are grist for their mill” (p.3). Other researchers claim that there are no absolute rules or principles, except to achieve the very best work and reasoning, in order to understand and communicate the data to give purpose of the study (Patton, 2002).

Miles & Huberman (1994) define analysis as "consisting of three concurrent flows of activity: data reduction, data display, and conclusion drawing and verification" (P. 10). In order to draw a conclusion from the data of a case study, a continuous process through each set of data must occur, as follows: selecting, focusing, simplifying, abstracting, and transforming the transcripts and written-up field notes. This leads to a recommendation that data display is employed, being a significant method of understanding and analysing data. This can be undertaken through different mechanisms, including: charts, matrices, diagram and networks aimed at assembling "organised information into an immediately accessible, compact form so that the analyst can see what is happening and either draw justified conclusions or move on to the next step of analysis" (p. 11). This is followed by the creation of flow to extract a conclusion and gain verification.

Shape and meaning begin to form during the early stages of data collection, however, a researcher must not take a specific curve with the data during the study, thus allowing themes or patterns to emerge to enable the final conclusion to be drawn and verified. Miles & Huberman (1994) state that these flows are "interwoven before, during, and after data collection in parallel form, to make up the general domain called ‘analysis’" (pp. 11-12).

3.7.1 Thematic Analysis

> Many ethnographers describe their analysis in somewhat mystical terms, suggesting that the theme and patterns emerge from the data as they read their field notes over and over again, somewhat as hikers emerge from mist on a foggy beach. Unfortunately, how these themes and pattern emerge, and what causes them to emerge, is left unclear. (Lofland & Lofland, 2006) (pp. 345-357).

Thematic analysis (see Chapter 5 for a detailed description) was employed at the fundamental level. Although widely used, thematic analysis can be viewed as an ineffective method of analysis. However, Braun & Clarke (2008) have argued that much of analysis is essentially thematic, but tends to be labelled as something else. A number of methods of analysis share a search for certain patterns, or themes, and holistic data, rather than within an item of data (e.g. an individual interview, or number of interviews, from one individual, as in the case-study forms of analysis). Thus, other methods overlap (more or less) with thematic analysis (Murray, 2003). Thematic analysis is not engaged with any specific theoretical framework, but is theoretically flexible and therefore compatible with a wider range of epistemological positions, thus allowing it to be used within various theoretical frameworks (Willig, 2001). Raskin & Neimeyer (2003) are of the opinion that thematic analysis can be an essential method in reporting experience and reality, categorising its methods as:

- Constructionist: examining the effects of events, realities, meanings, experiences, etc. on a range of discourses operating within society;
- Contextualising: sitting between the two poles of essentialism and constructionism, and characterised by theories.

3.7.2 Strategy Formulation of the SWOT Analysis

There are a number of participatory approaches that can be used to analyse and plan a new business strategy for a company. For example the Scenario Planning Tool simplifies the cluster of data into a limited number of possible states. The results of different scenarios show how several factors might interact under different conditions. Once the interactions between specific factors have been identified, a company can develop quantitative models to model these interactions (Shoemaker 1995). The Scenario Planning Tool has a number of advantages, which have been wildly discussed in the literature, but only little evidence is available about their actual implementation and the effects of the outcomes on company performance, (Varum & Melo 2010).

Another approach is the Participatory Modelling Methods, which is used to address issues and problems within a business. The approach is designed to include stakeholders' thoughts, their various perspectives and the empowerment of local communities and stakeholders. Therefore, participatory modelling requires stakeholder involvement in order to model the planning and decision making stages of a business plan. However, Participatory Modelling methods have been criticised due to their lack of structure and rigor (Mendoza & Prabhu 2006).

A study was undertaken that looked at 113 public limited companies in the UK in order to provide empirical evidence on the nature and practice of strategic planning. A SWOT analysis is a popular set of tools/techniques that is used by companies to analyse their strategy plans, (Glaister & Falshaw 1999). It is particularly useful for the development of strategies relating to the environment and energy management (Hill & Westbrook 1997). Further evidence of successful applications of SWOT analysis are available in (part 2 of literature review), (Nikolaou & Evangelinos 2010; Dyson 2004; Weihrich 1993). After conducting the thematic analysis, a SWOT analysis was conducted to provide an improved understanding of KOC's strategy. The SWOT analysis results and the TOWS Matrix will be used to apply a Strategy Analysis from a sub-theme 'Strategy and tactic internal and external' (for further description see Chapter 6, Section 6.1).

Organisational strategies deal with changing environments; such as changes can result in unexpected obstacles. Strategic decisions are related to the environment, and a changing of routine is considered sufficiently important to affect the overall welfare of the organisation.

The study of strategy includes the processes by which actions are decided and implemented concerning the content and action taken (Hambrick, 1980). Theorists agree that emergent and realised strategies may differ from one another: the organisation may have both a corporate strategy ("What businesses shall the authors be in?") and a business strategy ("How shall the authors compete in each business?"). Creating a strategy involves a number of different dimensions, both conceptual and analytical. Some authors consider the analytical dimension more than others, but most affirm that the heart of strategy making is formed by the conceptual work undertaken by leaders of the organisation (Chaffee, 1985).

For large businesses, it is essential to couple strategy plans with the business model. This has to be determined carefully, as it forces the business model to confront issues at which future managers can only guess, and it protects competitiveness. Choosing a strategy entails making decisions that explicitly cut off some possibilities and options (Teece, 2010). The strategy of any organisation is formed of strengths, weaknesses, opportunities and threats (SWOT) (Pickton & Wright, 1998). Chapter 6 refers to KOC's strategy in relation to a SWOT analysis. However, a traditional SWOT analysis identifies both internal and external factors without demonstrating the relationships between them. Weihrich (1982) has developed and tested the TOWS Matrix (a version of a SWOT analysis), which allows increased elaboration in identifying external factors and their integration into the resources of a business.

Weihrich (1982) states that the TOWS Matrix has been employed in a number of different countries and in a variety of situations and levels. These are reflected in his use of the matrix to analysis a number of automotive firms (e.g. Daimler and Volvo). The TOWS Matrix has been used on the macro level for industry analysis, as well as forming a conceptual framework at the micro level, in order to develop a career strategy. A number of studies have used the TOWS Matrix to develop strategy and strategic decision-making for a number of different large industries, thus demonstrating its validity (Proctor, 2000; Dyson, 2004; Ruocco & Proctor, 1994; Kurttila et al., 2000). The approach of situational analysis is to first analyse the external environment as list of threats and opportunities, with the second stage being to analyse the internal environment as a list of the company's weaknesses and strengths, before proceeding to the development of the strategic plan (Weihrich, 1982).

The conceptual strategy formulation is analysed in systematic order: the analysis begins with the current expected future of KOC, which consists of a complex process, particularly for a large company, such as KOC. However, a number of the leaders of KOC and KPC revealed their expectations concerning the corporation's direction, target and development. The strategy formulation process model (see Figure 3.3, p. 107) will aid this analysis and provide the framework for the discussion. Thus, the typical aims in strategic planning are as follows:

- To identify the inputs of the firm (e.g. employees, resources and skills) along with the goal input of stakeholders (e.g. government, individuals and customers).
- To identify the firm's profile.
- To identify the orientation of senior managers.
- To identify the firm's competitors.
- To clarify the objectives of the firm.
- To analyse threats and opportunities facing the company, in order to present a picture of the present external environment.
- To identify the weaknesses and strengths of the company, through establishing the availability of the firm's resources.
- To develop an alternative strategy.
- To evaluate a number of different strategies in order to make a choice.
- To test the strategy at various stages for consistency (recommended, but has not been carried out in this study).
- To prepare integrated plans.

The approach of the TOWS matrix at this point is to 'bottom-up' the gap in KOC's strategy and reveals potential solutions. The approach towards developing a solution will take the following order (Weihrich, 1999):

- Build on Strengths.
- Eliminate Weaknesses.
- Exploit Opportunities.
- Mitigate the effect of Threats.

Figure 3.3 (p. 107) shows the system inputs that must be considered to deliver an effective strategic plan. These inputs i.e. stakeholders knowledge, their skills, the company operations and the claimants culture are enclosed by arrows. Various strategies are proposed and then tested for congruency with the company's strategic approach, in order to formulate reasonable adjustments to the current strategy of the company and also to examine the feasibility of the recommended plans. In six steps (Grant, 1991; Weihrich, 1993; Weihrich, 1982), the model in Figure 3.3 (p. 107) demonstrates consistent testing of the steps in designing a strategic planning process. The formulated results are displayed in Table 6.1 TOWS Matrix, adopted from (Weihrich 1993; Weihrich 1999) Chapter 6, pp. 152-154). The six steps of strategy formulation are as following:

1. Understand the internal and external environment of the company.
2. Determine the external environment in relation to the future situation.
3. Identify the strengths and weaknesses of the company, in relation to its resources.
4. Identify and propose the potential threats and opportunities in relation to the market, environmental regulations and potential future demand.
5. Propose development strategies and actions in order to achieve the desired (future) goals of the company; consider the consistency of these decisions with the previous steps in the strategy formulation process.
6. Develop a plan that will work within the company's environment.

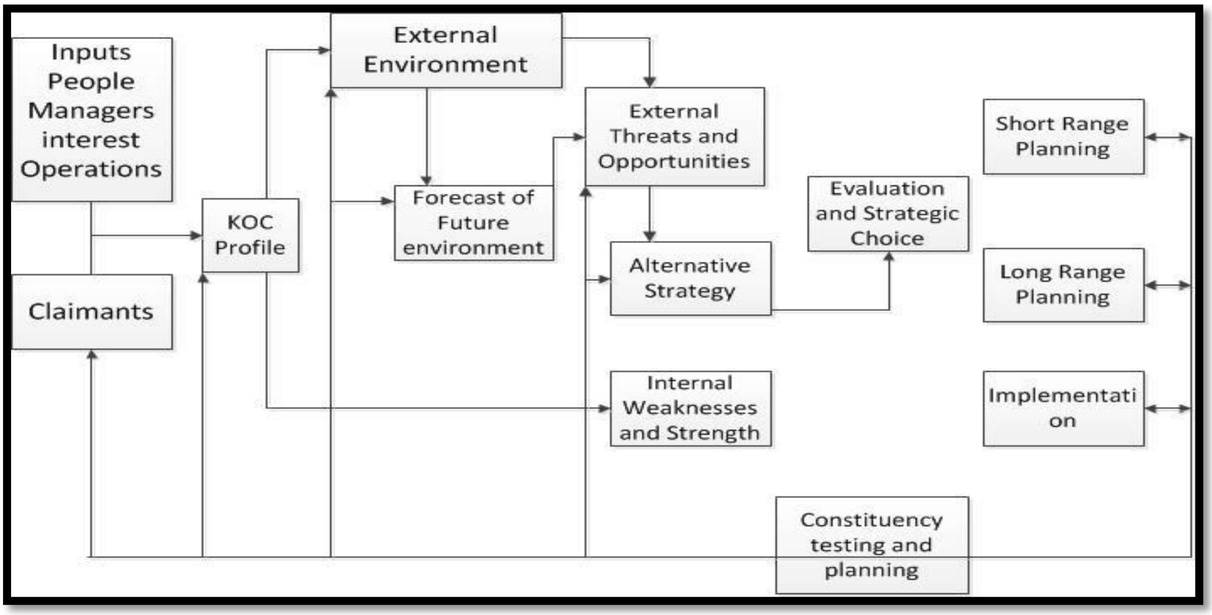

Figure 3.3 The strategy formulation process model (adopted from Grant, 1991; Weihrich, 1993; Weihrich, 1982)

3.8 Validity and Reliability of the Qualitative Aspect

In qualitative research, accuracy and validity are related to the relevance and reliability, of measurement, with researchers seeking to understand and explain, rather than measure, a fairly complex phenomenon. Despite the fact that the concept of validity does not sit well within the qualitative research paradigm (originating as it does from the positivist tradition (Krause & Denzin, 1989), qualitative researchers generally continue to support its relevance (Lincoln & Guba, 1985). Pluralist triangulation research uses quantitative research to assist in the understanding and validating of a number of aspects of qualitative research (or vice versa) (Pyett, 2003).

Works of science can, in part, be defined as a social process of validation. Mishler (1990) claims that different communities of researchers justify and evaluate claims in different ways to general rules, which can be provided for appraising validity in particular studies, or domains of enquiry. Validation is not so much a technical problem as a deeply theoretical issue, with no standard established for any specific procedure either for comparing different types of validity or for assigning weights to different threats to validity.

The goal in qualitative research is to achieve a coherent description of a situation based on (and consistent with) a detailed study of the situation itself, rather than to produce a set of results that any other researchers in the same study might have produced (Schofield, 1993). Patton (1990) is of the view that there are no ‘straightforward tests’ to ascertain that qualitative research is both reliable and valid: but that “this does not mean that there are no guidelines” (p. 372). Geertz (1973) recommends a number of approaches to gain validity and reliability, e.g. (1) rigor in data collection and analysis; (2) methods, differing data sources, and investigators; (3) the need to search for negative cases; (4) the use of ‘thick description’ and detailed reporting in writing up. As noted previously (Yin 2009; W. Tellis 1997), this research has benefitted from the collection of data from different approaches, helping to confront the issue of establishing the construct validity and reliability of a case study. The means of ensuring construct validity is considered to consist of multiple sources of evidence. This allows any potential problems of construct validity to be addressed, particularly in a case study, because multiple sources of evidence are able to provide multiple measures of the same phenomenon.

3.8.1 Validation Workshop

As a stage of the research, and in response to Wadsworth's (2005) recommendation to engage the stakeholders in validating the findings, the results of the research were discussed during a three-hour workshop held with the following four individuals:

- Two senior operators (Operator One) from the production group.
- Two senior engineers from the maintenance group.

These individuals were reached through a relationship developed with the researcher during the multiple interviews taking place over the past three years, beginning during the site operation period in 2012. However, gathering individuals from different groups in one place at the same time was not an easy task. In order to ensure that the data is reliable, and the data results are valid, two of the four individuals taking part in the workshop (one from production group, and one from maintenance group) were unaware of the research. Including such a diversity of experience in the workshop was important in guarding against researcher bias, and against the privileging of any one type of information or any one analytical perspective.

The criteria for participants’ eligibility for inclusion in the study were established by the data analysis, the applicability of the recommended solutions and the framework. However, the participants (stakeholders) and the researcher also checked the initial analysis and interpretations with each other, and the participants also undertook further discussions with their colleges work from different groups in order to assess the ways in which the solutions and results obtained could be beneficial or inapplicable

3.8.2 Reflexivity

Mishler (1990) suggests that the evaluation of trustworthiness in any single project is a matter of judgment. Every researcher uses their tactical understanding of actual practice in their field of investigation, in order to conduct their research, to make claims for it, and to evaluate the work of others: In the naturalistic/interpretive paradigm, reality is assumed to be multiple and constructed rather than singular and tangible. In the naturalistic/interpretive paradigm, reality can be logically treated as existing in a number of different scenarios, which may be intangible. Meanwhile, some ignore the transfer to interruptive research, on the assumption that valid work must be reliable, and thus qualitative research is as much art as it is science, and that the nature of the narrative data forming the mainstay of qualitative work is inherently revisionist (Sandelowski, 1993). In order to produce effective qualitative research, the researcher must understand that there is no way of avoiding the routine aspect of returning continuously to check the data. Pyett (2003) suggests that it can be a different definition of 'revisionist' to that claimed by Sandelowski (1993). Pyett, (2003) claims that the routine work of revising and double-checking is defined as 'reflexivity', which produces reliable and valid work.

Wadsworth (2005) is of the opinion that reflexivity is concerned with the politics of knowledge (i.e. production relation continued) to be foregrounded in participatory action research: "stakeholder-inclusive forms of collaborative inquiry or participatory action research were becoming commonplace" (p.276). Stakeholders can become commonplace in every location, including: community and higher education; human resources and organisational development; architecture and design. In business and industrial product-development, quality assurance offers, "total systems intervention and continuous improvement" (p.276) in relation to developmental evaluation, along with environmental and international development. Reflexivity can be achieved for qualitative research through checking method, analysis, and interpretation with the academic literature, as well as with the population included in the research, either by working collaboratively or by having a critical reference group, which should include a range of stakeholders critical to the study (Wadsworth, 2005; Pyett, 2003).

In order for the research to have a significant depth of analysis, reflexive processes were noted and comments that referred to the stakeholders, in addition to extra resources such as journals and books.

The researcher initially carried out primary coding of all available transcripts, for the purpose of aiding the choosing of the potentials themes. The researcher did not originally have the intention of referring to the stakeholders within this analysis stage. However, through the different stages of analysis the researcher became aware that the stakeholders' opinions were significant and should be included. Therefore a reflexive process was constantly undertaken during the data collection process, through transcription and backed up through literature review and journals and stockholders.

The reflexive process took place when analysing data during the following stages, conducting thematic analysis for the qualitative data (see Section 3.7.1 Thematic Analysis) during the literature review, through the processing of additional resources and also through contact with the stakeholders, who were constantly providing the researcher with more detailed background information, in order to develop suitable codes and themes. While the researcher was transcribing the interviews (see Section 3.6.3 Interviews), notes from site observation (see Section 3.6.2 Direct Observation) and additional transcribed documents provided by KOC/KPC and KISR software, i.e. (GC manual, R&T potential projects) were being analysed in Nvivo software, as well as the researcher referring to the existing literature. During this stage the researcher also needed to add to the existing literature review, by referring to additional journal papers and books from Loughborough University library, especially when further investigation and verification of data was needed.

The reflexive process took place during data analysis at different level including: writing notes on paper sheets during data collection and transcribing interviews in Nvivo, all the way through to the last stage in generating the final themes and results. The researcher faced particular difficulties in trying to understand how the contextual setting may have impacted the original interviews/notes of site observation. Therefore, working with a reflexive approach, the researcher allowed the data to dictate the analysis and this helped in the development of the research, thereby promoting objectivity through the reflexive stance.

3.8.3 Validation Conclusion

The complexity and depth of the research information generated by qualitative research makes it difficult to establish its true validity. Therefore, this current research follows the revisionist approach of Sandelowski (1993), along with Pyett's (2003) recommendation of revising and double checking. Wadsworth's (2005) recommendation of reflexivity has also been followed, leading to the inclusion of the opinions of stakeholders concerning the researcher's recombination and data analysis, and interpolation of results. Table 3.10 demonstrates all the approaches employed to confirm and support the reliability and the validity of the data and the research findings.

Finally, the write-up contains sufficient detail and reflexivity for the reader to assess whether the findings are valid. As a postmodern qualitative researcher, the current researcher acknowledges the presence of multiple realities and variables. In the research into the oil and gas industry, these might include efficiency at the GC, the operators at the GC, the company's management style, and environmental changes (e.g. climate). Each factor will have a very different impact upon the final result, thus ensuring a considerable division remains between the workshop arguments between stakeholders, leaving further possibilities for additional assumptions.

Table 3.10 steps undertaken to ensure research validity and reliability

Conducted Methods to support validity	References
Reflexivity	(Pyett 2003), (Sandelowski 1993), (Wadsworth 2005)
Multiple sources of data	(Greene & McClintock 1985), (W. Tellis 1997), (Yin 2009), (Adler & Adler. 1994), (Geertz 1973), (Goel & Dolan 2004)
Stakeholders engagement	(Wadsworth 2005), (Pyett 2003),
Triangulation	(Pyett 2003), (Creswell 2013), (Dainty 2008), (Greene et al. 1989), (Jick 1979), (Goel & Dolan 2004)
Direct Observation	(Babbie 2012)

3.9 Summary

The major philosophies involved for conducting this research have been addressed in this chapter. First, in the context of philosophical stance the research plan was described outlining the processes it is to take for conducting the action research process. It contained detailed description for the aim of the research in the context of research philosophy identified the research plan. Second, the research question and key questions was described every stage and illustrated the purpose of the choices made. Third, the research methods were described outlining the processes it is to take for conducting the action research process. The following chapter describes the case study company strategy and oil and gas production operations in details.

Chapter 4 The Case Study KOC

This chapter describes a primary study conducted at Kuwait Oil Company (KOC), and reports findings from interviews, observation process, archival records and physical artefacts.

4.1 The Enterprise Profile, Top Management Orientation and the Purpose of KOC (Strategy and Tactics)

In order to determine the current business profile of the company, and ascertain its ideal direction, identification of the company profile is essential. Company history has helped to determine top management style, the orientation and values of top managers, and the purpose of the business. To acquire a clear understanding of Kuwait Oil Company (KOC)'s profile, some fundamental questions were asked:

- What is this business?
- Who are its customers?
- What do those customers want?
- What should the business be?

These questions aim to provide a clear insight into the nature of the firm's business, about its activities, services, products and the significance of its geographical domain.

4.2 Ownership of Kuwait Petroleum Corporation (KPC)

Kuwait Petroleum Corporation (KPC) is fully owned by the State. of Kuwait, its diverse business interests range across a spectrum; this encompasses all aspects of the hydrocarbon industry, from onshore and offshore upstream exploration, through production and refining, marketing, retailing, petrochemicals, and marine transportation. KPC was founded in 1980 as an umbrella organisation to manage the country's diversified oil interests. As a group, KPC is actively involved in every aspect of the oil and gas industry. Through its 10 subsidiary companies, KPC engages itself in activities ranging from discovering new reservoirs to delivering clean and safe fuel for motor vehicles, aeroplanes, ships, agriculture and power stations. It also provides several base petrochemical products, which are essential for the industrial manufacture of several commonplace modern day amenities.

From its Head-Office, which is located in Kuwait's City, KPC strategically coordinates and supervises its various subsidiaries. It finances their operations and oversees the marketing of crude oil, refined products, and gas, in foreign markets. The Corporation also provides significant support to The Kuwait Ministry of Oil to support its dealings with other OPEC member countries. To support its international business interests, KPC has several Regional Marketing Offices, which are strategically located across the globe, from Houston to London, and Mumbai and Pakistan to Singapore and Tokyo. These offices effectively contribute to the sales and marketing operations of KPC and its subsidiaries, consistent with its short-term and long-term strategies. Their scope of work includes regional market analysis, establishing and maintaining relations with other key oil players, increasing KPC's share in existing markets, as well as, entering new ones.

KPC Upstream Vision:

KPC’s upstream vision (KOC vision) is to become “an integrated fossil fuel company, to achieve a leading global position in upstream oil and gas as an integrated, value-driven enterprise through the entrance into new fields, the company aims to get access to new information technologies, new materials, and systems knowledge” (KPC 2015).

KPC’s managers’ vision is to enable the company to contribute significantly to the support and development of the country’s economy to develop knowledge and education, and to deliver a world class performance driven by subsidiaries including KOC. This vision and the resulting related strategy have evolved thus far, to increase ways of protecting the company’s resources at a level limited to the hydrocarbon industry. The interviews conducted with KPC’s manager revealed a realisation of the importance of extending the lifetime of oil and gas production to underpin the country’s survival. Furthermore, they indicated the importance of managing research as an integral factor in the development of their enterprise.

KPC aims to make KOC a world class company, which retains the capacity to navigate dynamic variables successfully. In order to cope with emerging variables, KOC aims to realise value from technology; pursue a value-driven approach to research, identify, develop, and deploy appropriate core and enabling technology solutions through investments, partnerships and technology transfer mechanisms. Although its top priority will remain its role as a significant member of OPEC, by 2020 KOC’s plan is to play an important role in the natural gas market, and to secure qualified and skilled human resources.

KPC's Upstream Strategic Objectives

- Maximising the strategic value of oil;
- Realising the potential of gas;
- Growing reserves for a sustainable future;
- Being an employer of choice;
- Realising value from technology;
- Strengthening its commitment to HSSE (Health, Security, Safety & Environment);
- Striving for excellence in performance; and
- Contributing to the enterprise and state.

4.3 The profile of KOC

In 2009, KOC built two effluent water stations to handle the polluted water emulsion associated with oil; the ratio of associated water rises over time, which means increasing the threat from pollution and the resultant costs. In 2011, KOC achieved its goal of reducing gas flaring to approximately 1% by building of two gas booster stations. Flaring as high as 17% just a few years earlier, so this represented a major accomplishment for KOC.

The common threads integrating business units are expanding in parallel with the increased demand for oil and gas. Meanwhile, the risk of pollutants is also increasing as extra resources become essential to company operations. While it has been relatively easy to identify the primary customers for oil and gas, the task is increasingly complex, involving a requirement to satisfy all groups of customers, by sharing the need for resources, especially water and electricity derived from the same source.

Although, dealing with all groups of customers is not one of KOC's mission or objectives, it explores, develops and produces oil and gas, and via internal pipelines sends its products to the sister company (Kuwait National Petroleum Company (KNPC)) to serve all groups of customers; therefore, at the operations level, KOC is obliged to meet the demands of all groups. Satisfying global and local customers, and dealing with Ministry of Electricity and Water (MEW) as an official governmental authority required different approaches from KPC to limit MEW's needs, because it has to determine whether crude oil should be for export, or if it should be 'given' to local customers. Furthermore, KOC has to consider its need for resources, since KPC and all its subsidiaries, including KOC, and three groups of customers, are relying on a single source of crude oil and gas. However, in two separate interviews, two top managers claimed that KOC is not endangered by global competition; Kuwait is a leading country in the global oil market, a fact that has leant confidence to their enterprise.

Although the three different groups have to be treated as relatively autonomous, their very divergent organisational cultures and management systems do need to be integrated; this is a challenging task, as shown in Figure 4.1, which depicts KOC's assets up to 2013:

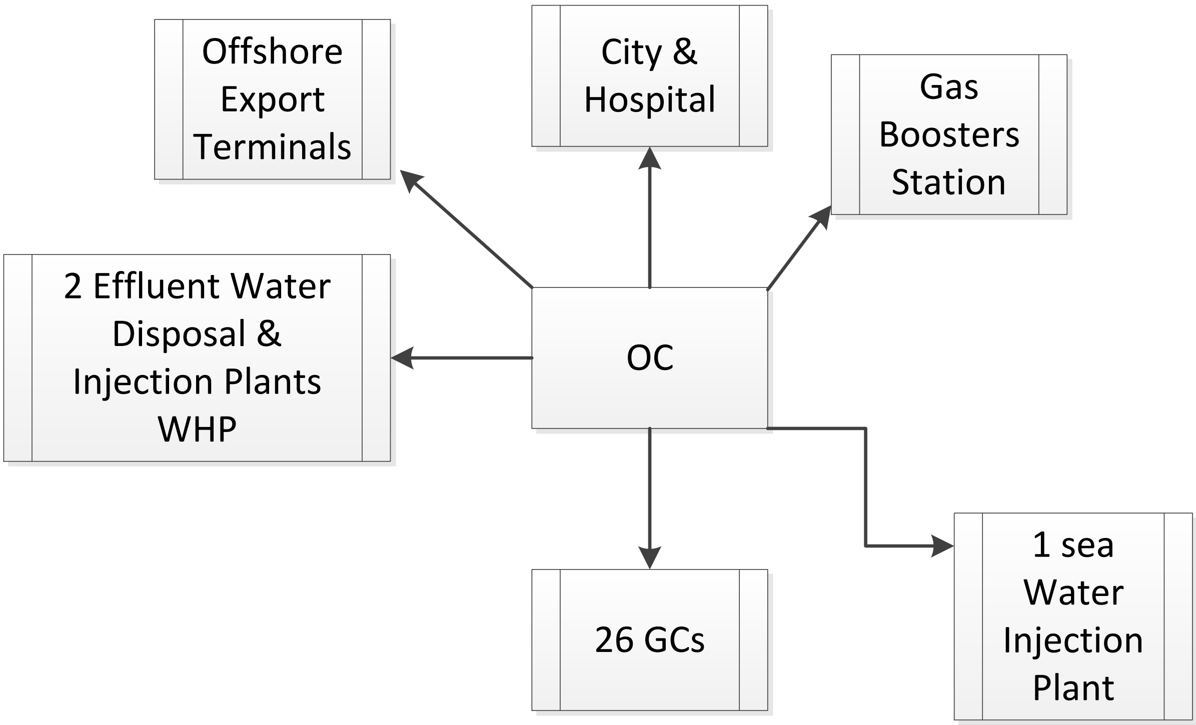

Figure 4.1 Chart showing KOC assets

4.4 Top management orientation and the values of KOC

KOC profile is shaped by KPC; the company's orientation is central to the formulation of its strategy. It determines the organizational climate, and the direction of KOC and its subsidies. Consequently, their values, preferences, and attitudes towards risk have to be carefully identified with reference to their strategic implications. A structured interview was conducted with one of KPC's managers, to attain greater clarity of understanding regarding its orientation.

In 2013, at KPC's building, a meeting was held between its top managers; at the meeting, the managers debated whether the corporation should expand its activities beyond the limitation of hydrocarbons. Subsequently, meetings were held to study the possibility of expanding KPC's activities to produce different forms of energy, such as uranium, renewables, or bioenergy. However, KPC's leaders agreed that the corporation should continue to focus exclusively on areas of current activity, which relate to oil and gas; diversification into other sources of energy was not included within KPC's strategy or its planning. However, KPC has made moves towards initiating some renewables projects for small-scale operational purposes only.

KOC had over 6000 employees in 2012, and large fields and facilities distributed throughout the entire country, at one point the very divergent organisational cultures and management systems needed to be integrated, which was a big task. 'Top managers' at KPC determine KOC's profile and direction. Both orientations involve the creation of a company strategy. Thus, KPC and top managers' values, preferences, and attitudes toward risk drive the company strategy, and examination of these elements is careful, to determine the implications of the strategy. KPC's predominant value is to instil entrepreneurial spirit into the firm's conservative organisational culture, and to make KOC a clean and a high performance company, the company values include emphasis on:

- Trust and ethics;
- Investment in people;
- Teamwork;
- Motivating environment;
- Honesty and integrity;
- Knowledge and knowledge sharing;
- Corporate citizenship;
- Quality and excellence;
- Innovation;

- Commitment to a health safety and environment; and
- Customer satisfaction.

One of KOC's main strategic objectives is to become employer of choice. Furthermore, KOC is very concerned with environmental aspects, advertising, producing brochures, enacting innovations to enhance the population's concerns about energy consumptions and environmental issues, to build an effective network with its partners and providers.

4.5 Purpose and mission of KOC

"To explore, develop and produce hydrocarbons within the State of Kuwait, the Divided Zone and internationally and so be a secure and reliable supplier to our customers, promote the care and development of our people and deliver on our commitments to our stakeholders in a compliant, profitable, safe and environmentally responsible manner"(KOC 2015).

An organisation's mission statement is a statement of purpose, intended to illustrate its reason to exist and to spell out the activities directing the enterprise (Ackoff 1990). In the past, it was relatively easy to identify KOC's purpose when the company's aim was to produce only oil.

When the company was first established in 1934, and from 1938, when oil was found in commercial quantities, KOC's fields were young and the oil was readily available and abundant. According to the interviewees from KOC, during the 1970s, gas flares were huge during oil production operations; the company just burned off the gas released with the oil without realising its vital value. Gradually, KOC began to recognise the value of the gas, and the company started to develop its facilities and operations to take advantage of the associated gas. Over time, KOC has worked hard to reduce flaring, in order to produce the largest possible amounts of associated gas.

Now, and with the increased demand from the three different groups (MEW, global market and domestic companies), KOC's strategy looking forward to 2020, is to raise its production of crude oil, which is aligned with the threat of transforming unconventional or difficult oil production operations, as these operations generate extra pollution and require additional efforts. Meanwhile, the global environmental regulations are being tightened to a more restricted level, as mentioned previously in the literature review, which makes the job of oil refining extraction more difficult.

At the moment, natural gas occupies a significant place in the hydrocarbon market (Homer 1993), as over time natural gas begins to take its place in the energy market at various levels (local/global) (IEA 2014). However, KOC is expanding its business by considering new targets in relation to oil and gas. KOC is expanding its gas business, with the aim of making it a new source of income generation. KOC set a target to achieving non-associated gas production of 2.1 billion standard cubic feet per day by 2020 within The State, which is considered a challenge; the interviewees stated that KPC currently lacks natural gas, and imports it from different countries, as it is essential to some of their operations. Gas studies involved 1% of KOC budget distribution by cluster in 2013-2014, and KPC is following through on its plans to increase its fuel mix by developing Liquefied Natural Gas (LNG) production.

Thus, recently KOC initiated intense exploitation operations for natural gas, according to the interviewee planning group. Now, with such obligations, the responsibilities, duties and operations divisions are involved in different kinds of business, complicating the task considerably. Developing and producing oil and associated gas will remain KOC’s focus; as the production and distribution of good quality oil is still its main purpose. In response to the global market’s rising demand for natural gas, KOC has already initiated natural gas exploration operations; however, KOC is unsure whether it will reach the commercial quantities of natural gas desired.

At the present time, it is vitally important that KOC focus on the development of un-associated gas industry. KOC managers believe they need to look toward the future, to develop gas resources that will meet both international and national needs, according to the planning manager interviewed. In particular, in the case of domestic consumption in the summer, to fulfil MEW’s needs for gas, this task is much more complex. Furthermore, KOC is intensively using liquefied gas to fuel parts of its own operations. According to EIA there has been growth in natural gas consumption especially in USA (EIA 2013a), which means there is a rise in demand for natural gas.

With natural gas, KOC will be assured an even more pronounced leadership role in the global market, as the interviewee from KPC stated. While this approach was recognised as a wise strategic move at the time, in view of the recent rise in the price of natural gas from Russia (the largest producer of natural gas in the world) (BBC 2014e; Uk.reuters.com 2014), this avenue of operational expansion is likely to be highly beneficial.

4.6 Purpose and mission of Research & Development

The mission of research and development (R&D) portions of the organisation is to conduct a strategically-focused, applied approach, in partnership with KPC subsidiaries, to make the best use of national and international technology partnerships, to create options for enabling fundamental research into KPC needs. The research and technology department's mission is to sustain KPC leadership in the country, to become a leader in the provision of upstream technology solutions in the GCC including;

- Developing and investing in KOC's people;
- Meeting the growth in data information and solutions; and
- Building an effective network with partners and providers.

4.7 KOC Projects

Today, KOC is continuing to live up to its stated mission of exploring, developing and producing The State's hydrocarbon resources to serve its customers around the world in a way that is environmentally sound and economically viable. As mentioned earlier, the external environment is the source of opportunities and threats facing the business. KOC has identified external challenges requiring indirect management:

- Oil price fluctuations;
- Complex and unconventional reservoirs;
- Renewable energy technologies competing with the oil industry; and
- Higher demand.

Research and technology group within KOC, believes in the lead up to 2025, its research projects are at high risk, marking a transition from low risk projects to high risk ones (see Figure 4.2 below). This particular point can explain the external threats KOC is encountering over its projected short/long-term future. It also demonstrates the potential weaknesses that KOC is struggling against; based on its short/long term future planning, a further explanation can be found in Chapter 6. For example, due to the global oil price fluctuations, in the fiscal year ending 31st March 2014 KPC had a post drop in profits of KD1.4 billion (£3.02 billion currency rate 16/9/2014) compared with the fiscal year ending 31st March 2013 (Kuna 2014).

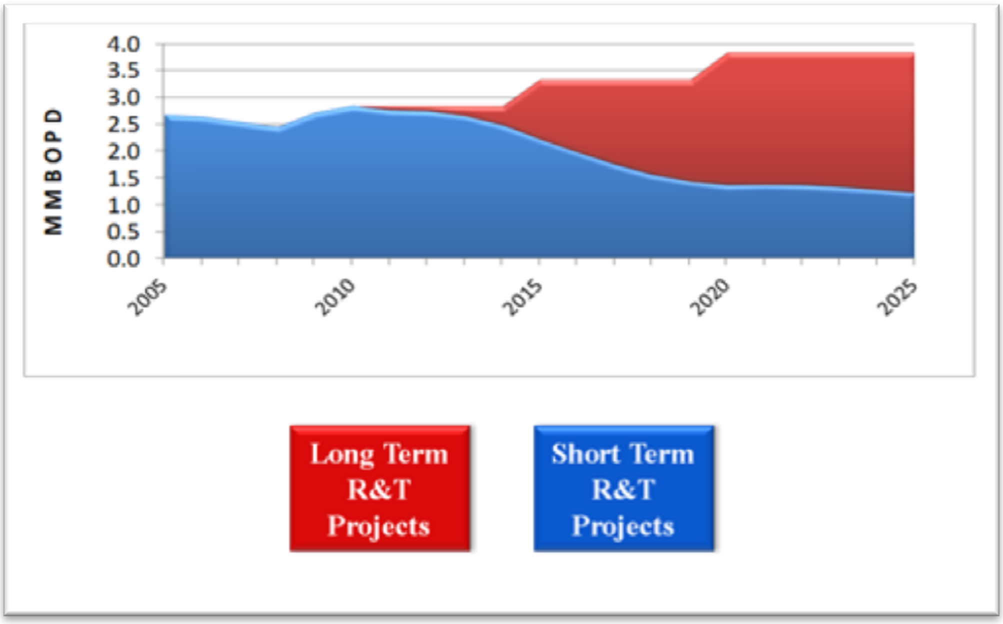

Figure 4.2 MOC Development and challenge, sourced (KOC document)

While is it clear to the company who its customers are; it is complex and aims to cover the needs of all customers, especially MEW. KNPC the sister company of KOC, and subsidiary of KPC is responsible for marketing customer goods and dealing with Kuwait's government and other countries, as well as large corporate customers, it aims to avoid leaving a gap in the supply chain at different levels, as any gap could result in severe consequences for the global market. At the level of the population, the lack of oil and gas supply directly influences water and electricity generation in the country. Although the satisfaction of these groups relies on delivering treated oil of good quality, the probability of a rising need to deal with more difficult oil (lower quality) is rising over time. This parallels the threat of developing alternative clean and cheap energy, which might affect the demand for oil and gas.

4.8 KOC's Production Operations and its GCs

KOC manages the production and export of oil and gas, and the associated facilities of more than twelve of the country's developed oil fields. The oilfields are spread throughout The State, and are split into four main territories (see Figure 2.4 Oil fields and Gathering Centres of KOC (KOC, 2014) Chapter 2, p. 34): the North Field, West Field, South Field, and East Field, and are locally administered at the site headquarters. At KOC fields there are 22 active Gathering Centres (GCs), which are operational and receive crude from various wellheads located in the producing oilfields. The GCs stabilise crude using a multi-stage stabilisation process, and separate gas and water from the crude to meet the required quality for downstream operations at the KNPC, and to supply market needs.

4.8.1 Plant Overviews

GCs are distributed across the country, which is divided in four different territories, as mentioned above, the majority of them are designed to receive both wet (three phase - gas, oil and water) and dry (two phase - gas and oil) reservoir fluids from oil wells. Incoming flow lines are 'manifold' to a number of production headers, and one test manifold header. The production manifold headers are segregated as either Wet, Dry, High Pressure (HP), or Low Pressure (LP), (see Figure 4 3, GC operations map, p. 127).

The production headers feed separation trains, each with three phases, and an LP and HP wet separator, which stabilises reservoir fluids to stock tank conditions by degassing, and wet systems, by dewatering. Dry crude and wet crude are stored in separate dedicated tanks, which is the final stage of separation. The wet crude is processed to reduce salt and water content, by three desalting trains. The treated crude is then routed to a dry tank. From the dry crude tanks, the crude is pumped to the export product pipeline. The test manifold is then routed to test separators. Liquid from the LP test separator passes to the test crude tank. Oil and oily water from the test tank are then pumped into the wet crude system, to the drain sump vessel (for tank capacities see Table 4.1).

Table 4.1: GC's tanks capacities

Tanks	No. of Tanks	Capacity (Barrel)	Fluid
Wet Tank	1	65,000	Wet Crude (Formation water and crude Oil)
Dual Tank	1	65,000	Wet/Dry Oil
Dry Tank	1	40,000	Dry Crude Oil
Test Tank	1	10,000	Wet/Dry Crude Oil

Drains from the LP wet Separator, and LP gas scrubber, 06-V-120 are connected to a drain flash vessel. The drain flash vessel gives sufficient resistance time for the gases in the liquids to flash off. The liquids then flow with gravity to the dedicated drain sump vessel, which is a horizontal vessel, which uses pumps to pump back the oil to the wet tank or the dual tank in cases of wet tank failure. Automatic diversion of liquids to the drain line, going to the drain sump, is possible by means of diverter valves provided at the inlet to the dedicated drain sump vessel.

Water produced from the LP wet separator is treated by the water treatment package, 006-Z-901. The treated water from the water treatment package is then connected to the effluent water inlet line going to Effluent Water Surge Tank, 06-D-801. Produced water/Oily water from the wet tank is treated in the effluent water Treatment unit, and off-spec water is diverted to the wet tank.

The facility is self-contained, with respect to plant and instrument air; with fresh water and diesel supplied by road tankers. To cover the increased capacity of the GC facilities, an additional diesel generator was installed. The Brackish water for the Desalter Dehydration Plant (DDP); known as a desalter train is provided from the brackish water tank.

The tank vapour flare header collects the vapours from the wet, dry, dual and test tanks. Normally these vapours are taken to the Condensate Recovery Unit (CRU), and compressed for further processing. In cases where the CRU is operating under part load or shutdown, the vapours are routed to the LP flare system. A control scheme for tanks, and for the tank vapour being sent to flare, ensures safe and reliable operation of the LP flare system. The pressure in the tank vapour header for vacuum blanketing is maintained by supplying fuel gas to wet, dry, and test tanks. Existing underground process piping is relocated to above ground on properly laid pipe racks, with appropriate access and operability for continued safe operations. In addition, the material for existing underground gravity drain piping is changed with RTRP material. A drip leg system, composed of a drip leg, on/ off level control valve, and level transmitter, is provided to eliminate liquid accumulation in the Pressure Safety Valve (PSV) discharge lines, where the elevation of PSVs is lower than the relief header.

Gas free liquids, such as off-spec crude from the desalter, oily water from the desalter, oily water from the dedicated drain sump, wet crude from the transfer pump, dry crude from the transit pump, and recovered oil from the effluent water surge tank are connected to the degassing boot outlet line of the wet tank, from the inlet of the wet crude line to the wet tank. This modification is applied to reduce the vibration at the riser piping of the wet tank, and to improve the two phase flow regime.

To monitor operational efficiency, new samples are collected and analysed at each point in the process. The detailed procedure for sampling includes gas sampling, oil and water sampling, oil sampling, condensate sampling, solid- water sampling, etc. Existing sampling systems have been changed to a closed sampling system (sample bottle in sample enclosure) to eliminate associated Health safety and Environment (HSE) risks, when liquid sample point outlets are collected at the closed drain system; in addition, the gas sample is flushed through the sample bottle for a set period of time. Similarly, all the instrument drains opened have been diverted to the closed drain system.

A sample is sent to the lab three to four times a day; the main sample is taken from the dry tank to ensure the quality of crude meets KOC's standards. Samples can also be taken from different places in the plant, such as during or after desalting process, to make sure that the level of chemical and other factors is sufficient to accomplish the crude recovery process.

GC's are designed to enable KOC to achieve its targeted 300,000 -500,000 Barrel of Oil per Day (BOPD), whereas the actual production of crude oil in a single GC is about 110,000 barrels/day. GC is designed to enhance production capacity and to achieve the target by utilising additional new facilities, and major items, and works as follows;

- One 3 Phase LP Wet Separator;
- One Water Treatment Package;
- One LP Gas Scrubber;
- Three Desalter Trains;
- Modifications/Replacement to the Tank Vapour Header and Control with Blanketing System;
- Two Condensate Recovery Unit (CRU) Packages;
- One Diesel Generator;
- Chemical Injection Package;

- Relocation of existing underground process piping to above ground on properly laid pipe tracks, with appropriate access and operability for safe continued operations; and

- Replacement of old electric cabling.

Production plant operation comprises the following six major steps:

1. Separation by gravity settling;
2. Chemical injection;
3. Heating;
4. Addition of fresh (less salty) water;
5. Mixing; and
6. Electrical coalescing.

4.9 Summary

This chapter provided a description of the KPC and KOC business structures and the amount of value that could potentially be added. It discussed the applicability and limitations of the approaches for constructing an operational, business-level strategy for KOC. The orientation and vision of KOC's leader in regards to business diversity and the need to fulfil the customers demand was illustrated. KOC's project assessment (from KOC perspective), the strategy and its strengths in oil and gas operations, were presented in this chapter. All the data and information provided in this chapter was obtained from the stakeholders, site survey and KOC's official documents.

The next chapter will analyse the data that has been collected, provide further description about the thematic analysis tool and demonstrate the steps that were followed to analyse the data provided in this chapter.

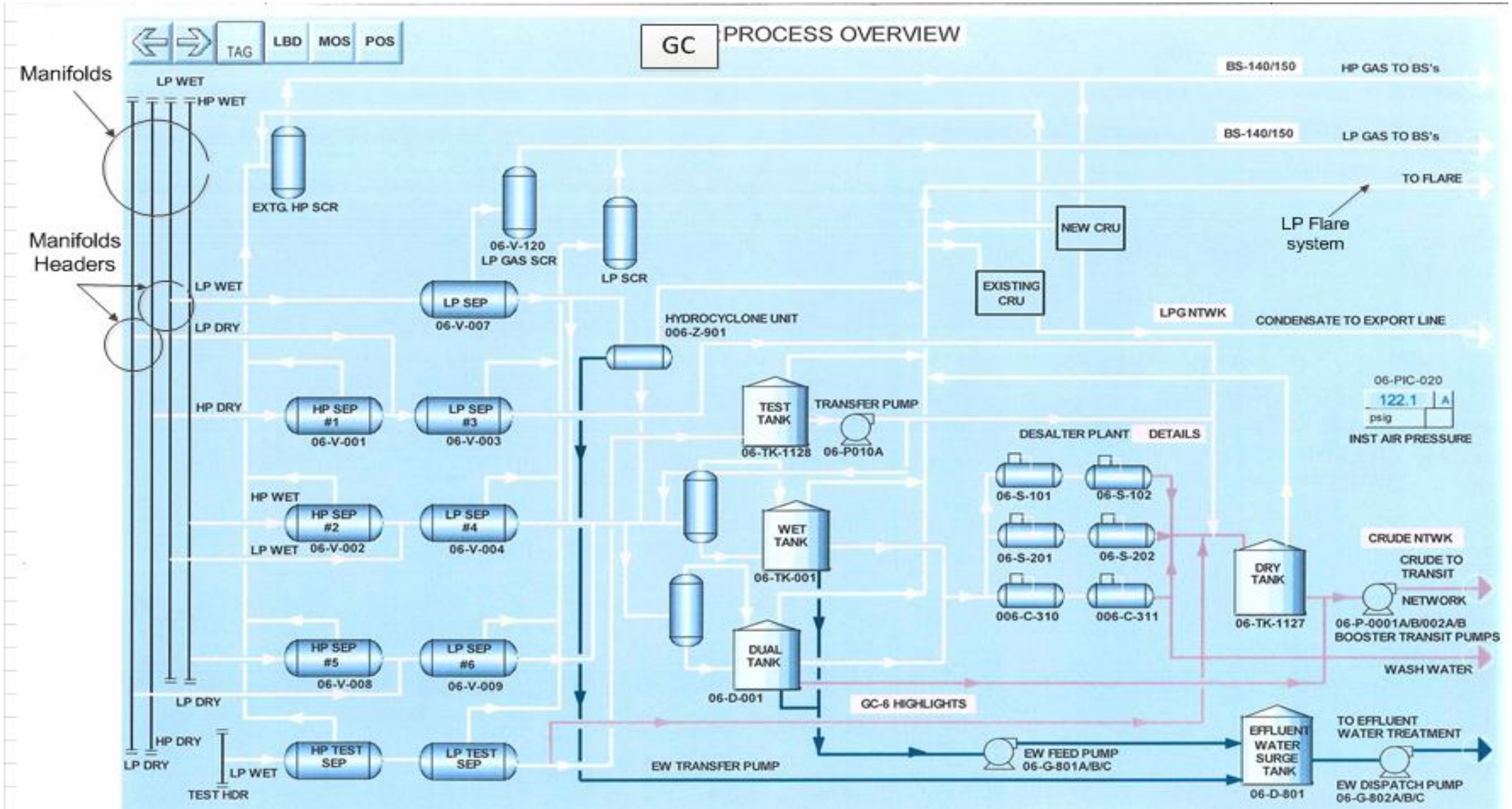

Figure 4 3 GC Overview, a capture screen from the control room, GC's operations map

Chapter 5 Thematic Analysis of Data

This chapter discusses the process of analysing the research data, comprised of company documents, observations of the company's fields, and interview responses. This chapter presents the fieldwork results and discusses the stages of its analysis when generating outcomes for fieldwork data and methods of thematic analysis.

5.1 Case Study Analysis

Qualitative research is varied and complicated and has various branches, (Holloway & Todres 2003). The fundamental method employed to address a case study is thematic analysis (Braun & Clarke 2008). Descriptions in the form of thematic analysis, or 'thematic coding' as a tool, can be applied across a number of methods, rather than as a method itself (Boyatzis 1998). However, Sue (2013) and Willig (2001) have claimed that thematic analysis should be considered a method in own right. Ultimately, thematic analysis is understood to be a flexible research tool capable of providing rich and detailed, yet complex, accounts of data (Braun & Clarke 2008; Bryman 2008). The preferred method of thematic analysis is to analyse, identify and create (themes) within the data. Themes resulting from describing and organising data in rich detail, can extend further to interpret various aspects of the research topic (Boyatzis 1998).

This chapter focuses on the constructionist method of thematic analysis. The aim of the data analysis was to generate comprehensive descriptions of intentions and to assess the meaning of critical and pragmatic processes. This information will form the basis for how the company, its operations, and its employees' are organised in the field. The reasons for a thematic analysis at this stage can be found in section 3.7.1 (in Chapter 3). Creating a theme means capturing important information from the data, in relation to the research question, to represent it at the level of meaning or as a pattern response within the data set. The key to devising a theme is to capture something within the data set that is related to the research question (Aronson 1994); this happens through coding, and building better search mechanisms for the main building blocks of local culture and themes. Therefore, the research question guides the coding and data analysis (Block et al., 2010; Holloway & Todres, 2003).

As mentioned previously, in section 3.4.4 (in Chapter 3), an inductive reasoning research strategy is central to this research, as it is a component of 'abductive' reasoning (see Figure 3.2 Research reasoning approach, Chapter 3, p. 75). A thematic analysis was conducted within a constructionist framework, due to the fact that it will not and cannot focus on motivation or individual perspectives. It instead seeks to theorise cultural contexts, operations, strategies, tactics and structural conditions. The thematic analysis in this chapter aims to analyse qualitative data only, quantitative information involves using different tools as follow:

- For the processing of production operations and lean value stream mapping (VSM).
- For electricity consumption, to build renewable system computer programme using software named "PV*Sol" version 7, developed by valentine software, and provided by KISR.

5.2 Starting the thematic analysis

The aim of conducting the thematic analysis was to create themes that help to explain how the data should be set up and any bottom up gaps. The analysis process was not linear, it jumped between one set of data and another, thus, the process was recursive. This section will outline the 'thematic analyses in five-stages (Bryman 2008; Pope et al. 2000; Lane et al. 2002; Short 2013; Braun & Clarke 2008; Willig 2001). Thematic analysis of the data was available from interviews, site observations, and officially collected documents.

Stage1: Familiarisation

The researcher began the data analysis with some prior of knowledge from the literature review. The researcher immersed himself in the data to familiarise himself with the depth of the data content, through repeated reading of the entire data set to deduce meaning and any pattern before coding. Taking notes and creating ideas to enhance understanding of the data set, and to prepare to start the coding process. At the stage before the researcher starts the coding process, identification of possible patterns is the principal aim to guarantee a detailed analysis.

Data provides a framework for investigation by firstly explaining the process of analysing the outcomes from the data overall. The first stages of data analysis involved the transcription of data using Nvivo 2010 software, provided by Loughborough University. The data from the official documents was inserted into Nvivo, and data from site observation was noted onsite and subsequently inserted into the Nvivo software. Verbal interviews were transcribed in Nvivo software also; (see Figure 5.1 insert data into Nvivo software p.132). Some interviews were recorded using smartphones, and some of them were noted on a sheet of paper before inserting them into Nvivo. Re-reading and transcription of the data was useful to further the interpretative qualitative methodology, each time it was given deeper meaning rather than merely being a preparation and organisational process.

Stage 2: Generating Codes

After intensive reading and familiarisation with the data, ideas about what is interesting about the data was generated; the aim of this step was to generate initial codes from the data. The definition of coding is: a summary of data achieved by creating a meaningful group to deliver information regarding the core of the data (semantic content or latent). Coding should deliver rich information about the data content, and develop and broaden themes to guide future steps when interpretive analysis occurs. Creating codes helps to identify potential themes, which are central to the task of building an understanding of the data. Codes help to conduct a thorough analysis of the data and pick out meaningful quotations. The coding process helped to identify particular points, rather than trying to describe an entire data set. No data set is completely without contradictions and for a satisfactory thematic ‘map’ to be produced, the overall conceptualisation of data patterns and relationships between them are not necessarily smooth. Inconsistencies and tensions can be ignored between or within data items, because the focus usually requires the researcher to tell the dominant story through analysis (Boyatzis 1998; Eisenhardt 2011; Bryman 2008; Helene & Lucy 2004).

Coded data offers broader interpretations for the unit of analysis (the case study). In the next stage (stage 3) themes will be developed and the interpretative analysis of the data performed, in relation to arguments about key phenomena. Coding has been conducted to the extent that themes are more theory-driven, aiming toward ‘developing a sustainable and green hydrocarbon company’. The coding approach in the set of data depends on the question of ‘how to reach greenness and sustainability within hydrocarbon firms’. Work was conducted systematically across the entire data set, giving equal and full attention to each item of data. Identifying interesting aspects from among the data items was achieved through repeatedly examining patterns from different sources (themes) across the data set. Coding was conducted using Nvivo software, and by tagging and naming selections of sets of data to create initial (Node) works as a code to describe each groups data (see Figure 5.2 p.133).

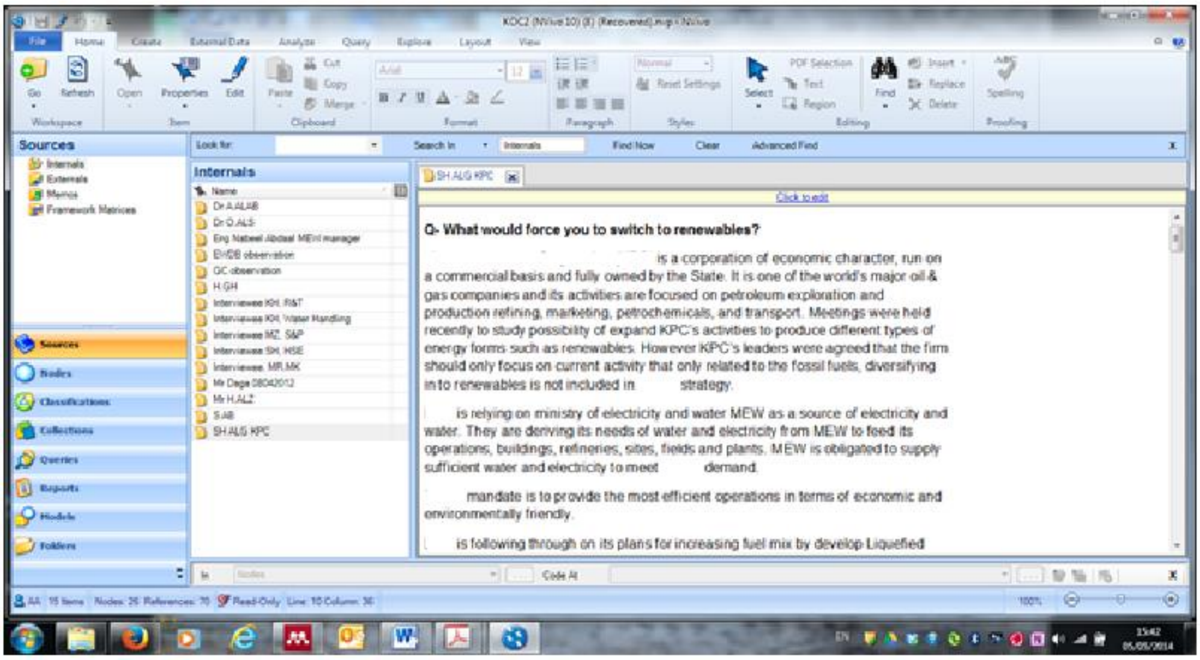

Figure 5.1 insert data into Nvivo software

Key coding processes engaged attention at this stage (Bryman 2008):

- Codes were created for each of the many potential themes;
- Codes were extracted inclusively from the data;
- Codes were applied across the many different themes they fitted; and
- Extracted data was introduced as a single code, or as many codes as were judged relevant.

See Figure 5.3, p 134, initial code (1), and Figure 5.4, p. 135 initial code (2); the initial codes (Nodes) are both related to the same stage (2); however, due to the page size the initial codes were presented in two separate figures.

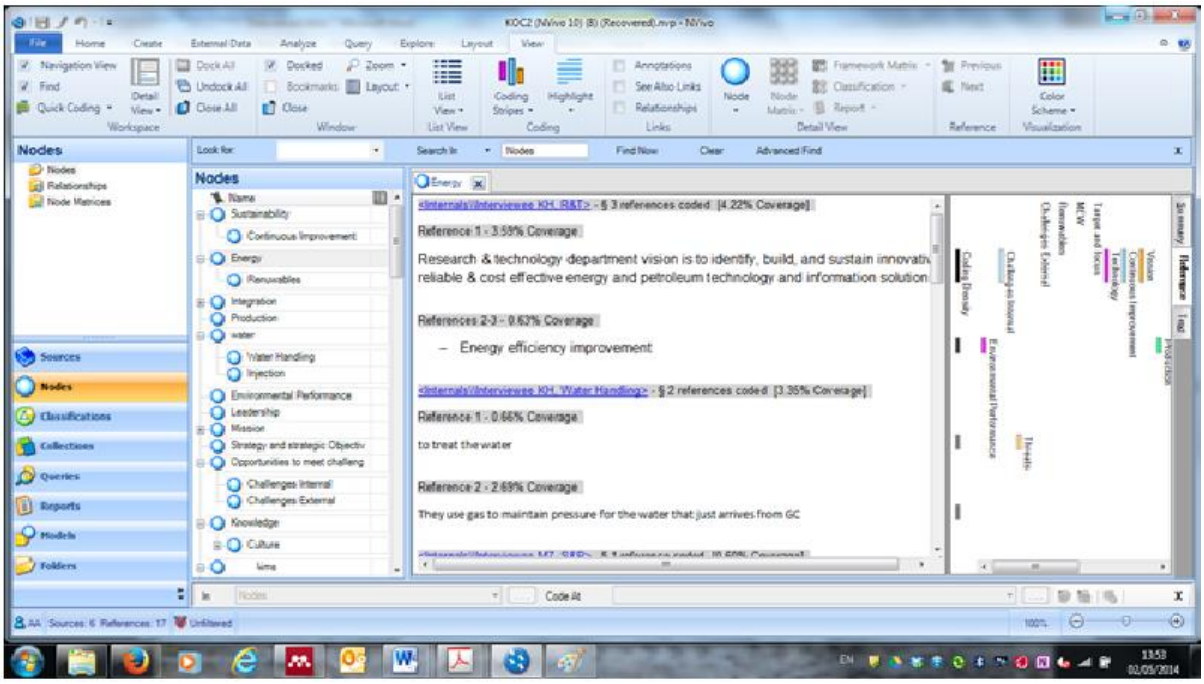

Figure 5.2 Coding process (creating Nodes) in Nvivo Software

Nodes

Name	Sources	References	Createc
Sustainability	4	9	19/03/
Continuous Improvement	4	10	19/03/20
Energy	6	17	19/03/
Renuwables	9	17	29/01/20
Integration	3	11	19/03/
initiatives	2	2	19/03/20
Development	3	9	29/01/20
Production	8	28	19/03/
water	5	7	19/03/
Water Handling	2	11	20/03/20
Injection	2	4	29/01/20
Environmental Performance	10	27	19/03/
Leadership	2	3	19/03/
Mission	2	3	22/03/
Vission	2	5	22/03/20
Value	2	2	22/03/20
Strategy and strategic Objective KOC	4	16	22/03/
Opportunities to meet challenges	3	6	22/03/
Challenges Internal	4	21	19/03/20
Challenges External	3	5	19/03/20
Knowledge	4	20	22/03/
Culture	7	30	19/03/20
Aims	1	3	22/03/
Assests	1	1	22/03/20
Business Security level	1	1	22/03/20
Target and focus	5	22	22/03/20
HSE	2	6	22/03/
International Organization for Standardization Curr	1	4	22/03/20
Streangth	2	6	20/03/
Threats	3	10	19/03/20
Weaknesses	4	7	20/03/20
Govenrment Strategy, Initiatives & duty	3	5	28/01/
Economic and benefit	2	4	28/01/20
Regulations	2	3	28/01/20
MEW	4	14	29/01/20
Global demand on oil	1	1	28/01/
Other energy resources (Fossels)	2	4	28/01/
Seasons (summer& Winter)	2	6	29/01/
Gas	2	2	29/01/

Figure 5.3 Initial code (1)

Nodes

Name	Sources	References	Created
Accened	1	1	29/01/2
Reservoir	3	6	29/01/2
Losses	1	1	29/01/20
Maximize reserve	4	5	28/01/20
GC	3	7	29/01/2
Dehydration Plant	2	10	29/01/20
Dehydration Desalting Train Capacity	1	1	29/01/20
Heat Exchanger	1	1	29/01/20
Heater	1	6	03/02/20
Other Sediments	1	1	29/01/20
Water in GC	1	9	29/01/20
Emulsion	1	2	31/01/20
Elictricity	1	6	29/01/20
Samping	1	7	29/01/20
Chimicals	1	10	29/01/20
Kaizen	1	4	28/01/20
Vesulization	1	1	29/01/20
Waste	2	9	30/01/20
Time	1	5	29/01/20
Commentment	1	3	03/02/2
Potential risk	4	5	04/02/2
Market competition	3	5	15/04/2
MArket Stabilization	1	1	15/04/20
benifit of potential market	4	4	15/04/20
Confidence	2	4	17/04/2
Technology	3	8	17/04/2
Stable supply chain	1	1	17/04/2
Efficiency	1	1	17/04/2
Obligations	3	3	17/04/2

Figure 5.4 Initial code (2)

Stage 3: Theming

This stage commences when all the data codes have been generated and collated. It refocuses the analysis at the broader thematic level, rather than that of codes, by merging and collating codes to produce potential themes (Short 2013; Braun & Clarke 2008; Willig 2001). According to Braun & Clarke (2008), it is helpful, in this phase, to use visual representations, such as mind maps, to gain a better understanding codes and generate themes (see Figure 5.5, p.137 Figure 5.6, p.138 Figure 5.7 p. 139, (these figures present stage (3) in the form a mind-map, but because of the constraints of page size there are three figures). Mind-mapping was a useful method by which to sort and re-sort the different codes into themes.

Some codes were developed further to form themes; however, some of the sub-themes were not included at this stage. Some codes did not seem to belong in any category, thus new themes were created to fit these codes. This stage involved coding (nodes) analysis, in order to create overarching themes; to simplify the codes; a visual representation was created, to develop the codes to themes. After which, a preliminary thematic map was developed to give a clear picture of the possible themes (see Figure 5.8, p.140). These provided guidance to begin generating relationships and linking codes, between themes, and at different thematic levels. Although the codes were merged to create themes, they were identified in the data set.

At this point, the researcher started to gain an understanding of the significance of the individual themes. No components of the data were abandoned; and investigations of the data remained very detailed at this point. In the next stage some themes were collapsed, merged, and discarded, and more themes permitted to emerge.

At this stage the researcher concentrated on the goal to be achieved, emphasising that it should be in parallel with company leaders' goals. KOC's leaders' desires were clear from the early stages of the study; i.e. take a "Leading global positioning in upstream oil and gas operations". Based on this initial aim, other candidate themes emerged:

- KOC;
- Sustainability;
- Gathering Centres (GCs); and
- Time.

Nodes

Name	Sources	References	Created On
Leading Global posision in Upstream Oil and Gas	0	0	04/05/2014 14
Sustainability	4	9	19/03/2013 14:4
Continuous Improvement	4	10	19/03/2013 14:5
Energy	6	17	19/03/2013 14:4
Integration	3	11	19/03/2013 14:4
water	5	7	19/03/2013 15:5
Environmental Performance	10	27	19/03/2013 15:5
Leadership	2	3	19/03/2013 16:0
Strategy and strategic Objective KOC	4	16	22/03/2013 09:5
Opportunities to meet challenges	3	6	22/03/2013 10:1
Knowledge	4	20	22/03/2013 10:3
HSE	2	6	22/03/2013 14:2
Streangth	2	6	20/03/2013 23:0
Govenrment Strategy, Initiatives & duty	3	5	28/01/2014 14:0
Global demand on oil	1	1	28/01/2014 14:5
Other energy resources (Fossels)	2	4	28/01/2014 15:1
Market competition	3	5	15/04/2014 12:2
Commentment	1	3	03/02/2014 14:0
Potential risk	4	5	04/02/2014 11:3
Confidence	2	4	17/04/2014 10:0
Stable supply chain	1	1	17/04/2014 10:2
Obligations	3	3	17/04/2014 11:4
Technology	3	8	17/04/2014 10:1
Gas	2	2	29/01/2014 11:3
Reservoir	3	6	29/01/2014 12:0
Accened	1	1	29/01/2014 12:1
	1	3	22/03/2013 10:3
Assests	1	1	22/03/2013 09:4
Business Security level	1	1	22/03/2013 10:3
Target and focus	5	22	22/03/2013 10:0
Mission	2	3	22/03/2013 09:4
GC	3	7	29/01/2014 14:2
Dehydration Plant	2	10	29/01/2014 12:0
Kaizen	1	4	28/01/2014 14:0
Waste	2	9	30/01/2014 11:5
Time	1	5	29/01/2014 15:1
Production	8	28	19/03/2013 15:4
Seasons (summer& Winter)	2	6	29/01/2014 11:3
Efficiency	1	1	17/04/2014 10:2

Figure 5.5: **Creating themes stage (3)/1**

Figure 5.6 Creating themes stage (3)/2

Nodes

Name	Sources	References	Created On
Losses	1	1	29/01/2014 13:59
Maximize reserve	4	5	28/01/2014 14:31
Accened	1	1	29/01/2014 12:10
Aims	1	3	22/03/2013 10:35
Assests	1	1	22/03/2013 09:45
Business Security level	1	1	22/03/2013 10:38
Target and focus	5	22	22/03/2013 10:06
Mission	2	3	22/03/2013 09:48
Vission	2	5	22/03/2013 09:47
Value	2	2	22/03/2013 09:51
GC	3	7	29/01/2014 14:23
Dehydration Plant	2	10	29/01/2014 12:00
Dehydration Desaltin	1	1	29/01/2014 16:45
Heat Exchanger	1	1	29/01/2014 17:02
Heater	1	6	03/02/2014 15:40
Other Sediments	1	1	29/01/2014 14:44
Water in GC	1	9	29/01/2014 14:44
Emulsion	1	2	31/01/2014 16:54
Elictricity	1	6	29/01/2014 14:43
Samping	1	7	29/01/2014 14:28
Chimicals	1	10	29/01/2014 14:42
Kaizen	1	4	28/01/2014 14:05
Vesulization	1	1	29/01/2014 14:25
Waste	2	9	30/01/2014 11:54
Time	1	5	29/01/2014 15:18
Production	8	28	19/03/2013 15:40
Seasons (summer& Wint	2	6	29/01/2014 11:37
Efficiency	1	1	17/04/2014 10:24

Figure 5.7 Creating themes stage (3)/3

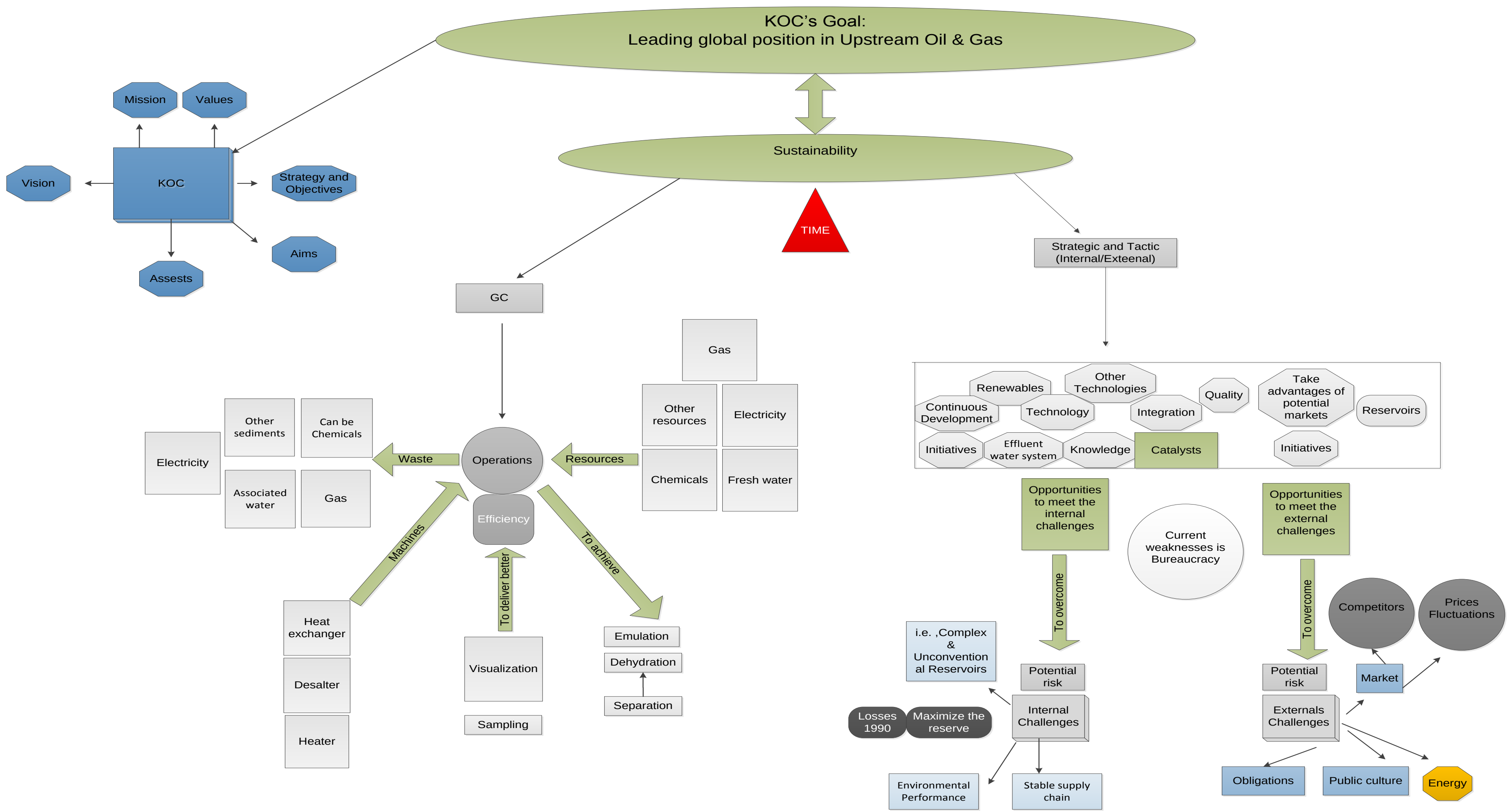

Figure 5.8 Preliminary thematic map showing the early stage of thematic development (Adapted from Short 2013; Braun & Clarke 2008; Willig 2001)

Stage 4: Reviewing

This stage involved conducting two levels of review according to recommendations by Patton (2002), and Braun & Clarke (2008). Level one, involved a review at the level of the coded data extracts. When themes appeared to form a coherent pattern, the researcher moved to the second level. If they did not form a coherent pattern, the case was considered problematic, and new themes created. Level one of stage four began after the candidate themes were formulated in stage three. The researcher started the process of refining the themes; this involved filtering the candidate themes. Some themes were deemed too diverse, and others were collapsed into each other, while others were broken down into separate themes. Ridged harmony between data themes is essential, as is clear identification of all candidate themes, "internal homogeneity and external heterogeneity" were carefully considered at this level, to ensure a coherent pattern emerged (Braun & Clarke 2008).

The candidate theme (KOC) was collapsed into the theme (Leading Global position in Upstream Oil and Gas), because the data related to the company mission, vision and values, while other sub-themes and codes were collapsed into each other, some codes can be refer to the same content. In addition, the (Leading global position in Upstream Oil and Gas) theme clearly explains the definition informing the suitability of a company's business. For this reason, both themes (sustainability and Leading global position in Upstream Oil and Gas) were merged (further description available in section 5.3 Concluding thematic Analysis Findings). The aim of this stage was to deliver themes and codes that were harmonious and cohered meaningfully, as well as being distinct from one another.

Level two focuses on to the validity of individual themes in relation to the entire data set. At this level, the candidate thematic map must accurately present the entire meaning present in the data set as a whole, providing an accurate representation that reflects the theoretical analytic approach. In order to achieve successful theme creation in level two, the researcher ensured that the theme worked in relation to the data set. It was also necessary to review 'reflexivity' in reference to the earlier stages of coding to ensure harmony with the theme (Pyett 2003; Sandelowski 1993; Wadsworth 2005). According to Hurley *et al.,* (2010), the researcher should not be inclined to be over enthusiastic with the coding and theming process, because this will influence the findings.

The thematic map shown in Figure 5.9 thematic map showing major themes illustrates how best to identify the possible (codes) associated with a specific event (theme), and the assumptions involved in reaching the desired outcomes. It is an important step in the analysis of events to develop solutions (Short 2013; Braun & Clarke 2008; Willig 2001). At this stage, the codes are properly identified and linked to the main themes, which are of central relevance to the task of building an understanding of the title theme. The researcher broke down the themes to illustrate the main areas of analysis, according to the recommendation of two interviewees and researchers from KISR, to integrate stakeholder engagement as a means to further reliability and the validation process (Wadsworth 2005; Pyett 2003). This process continued until the researcher believed that theoretical saturation had occurred and no new themes (index codes) emerged. By the end of this stage, it was apparent what the different themes were, the phenomenon they were indicating and how they relate to one another. At the end of this stage, it was apparent how the themes told a story about the data, and so the researcher moved to stage ‘five’.

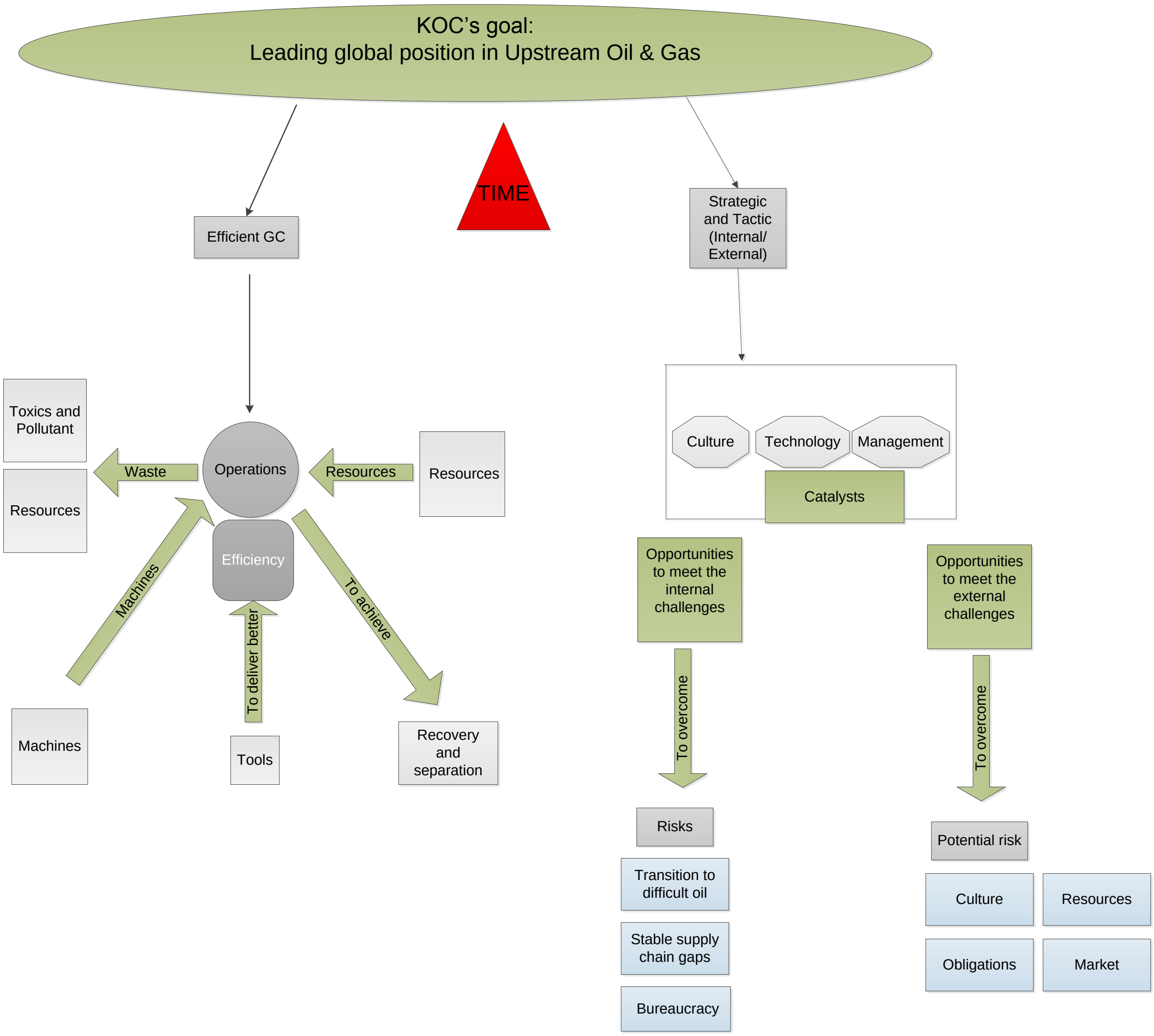

Figure 5.9 Thematic map showing major themes

Stage 5: Findings

After the thematic map produced was satisfactory the next stage five was the final refinement for KOC's thematic map, (see Figure 5.10, p. 147). At this point, a definition and further refinement was achieved, and the data analysis was presented thematically. For each individual theme and sub-theme, a description and a detailed analysis must be documented so that it tells a story about the data in relation to the research question; taking into account the need to avoid overlaps.

Further development of the thematic map aimed to identify the relationships between the codes and themes at different levels; focusing on the main overarching theme and the sub-themes. The sub-themes are themes-within-a-theme, and provide a structure to the main theme, also demonstrating any hierarchy of meaning present within the data. Defining, refining, and identifying the core themes and sub-themes was key, as was determining the aspects of each data set the theme and sub-themes contained. It is recommended to avoid too much diversity and complexity when generating themes and sub-themes (Braun & Clarke 2008). Therefore, emphasis was placed on identifying those that would be useful to describing the situation clearly.

5.3 Concluding Thematic Analysis Findings

Figure 5.10, (p. 147) shows the final thematic map, the main theme and both the sub-themes. Each one tells a story and by linking them together, it is possible to understand them and tell a bigger story. The relationship between the data, the themes, the sub-themes and the research questions provides potential for overlap. At this stage this should be avoided, and it should be possible to combine the main themes into a short paragraph to form a story (Short 2013; Braun & Clarke 2008; Willig 2001). A description of the main theme and the sub-themes, drawn from Figure 5.10, (p. 147) is given below:

- Main theme: 'leading global position in upstream oil and gas':

Through its 'upstream' operating segment KOC develops and produces hydrocarbons. Its goal is to be one of the world's top leading oil and gas companies. Thus, KOC is striving to become a world-class operator, a responsible corporate citizen and a good employer. However, the analysis revealed that current demand for crude oil and natural gas may reduce in the future for multiple reasons (see Chapter 6), despite the dominance of the oil and gas industry in today's energy market.

The theme sustainability (Figure 5.8 Preliminary thematic map showing the early stage of thematic development (Adapted **from Short 2013; Braun & Clarke 2008; Willig 2001)** 140) has been merged with both sub-themes, to create the final thematic map. To be leader in upstream oil and gas production operations KOC has to ensure sustainable resources, a sustainable product and sustainable production. Merging sustainability within the data set was done in order to manage, protect, and restore the countries' resources, as well as the ecosystem through sustainable management of natural resources.

Sustainability supports the development and conservation of strategies that help to protect the natural environment and make the Kuwaiti community, as well as the KOC's business more attractive and economically stronger. There are a number of ways to reduce the negative impacts of the hydrocarbon industry. This can be done, through environmentally-friendly oil and gas operations, environmental resource management and environmental protection. Sustainable management can take many forms, from reorganizing business conditions (e.g., green oil operations, and sustainable cities), using L&G oil and gas production operations to boost efficiency of new technologies such as renewables systems and supporting KOC's strength and conserve natural resources.

The development of KOC's strategy and operations are linked to global developments and demand, which may be subject to a decline or increase. In addition, oil is a finite resource; therefore, KOC's business is not compatible with sustainability over the long term for two main reasons (two sub-themes):

- Sub-theme (KOC's strategic and tactic, external/internal):

This goal requires focus on oil and gas and involves pursuing a strategy in response to limited priorities, focusing only on hydrocarbons and satisfying domestic demand; whereas, the global market is experiencing rapid development, constantly emerging needs and divisions (see discussion in Chapter 6).

- Sub-theme (operations):

Although KOC has initiated innovations to improve the environmental performance within its upstream operations; it aims to operate its upstream operations to maintain a specific daily target of production, rather than prioritising the environmental performance and GHGs emissions by considering sustainability and efficient development of its operations. In addition, KOC should consider options for potential primary sources of energy in the future to support its operations and enable it to compete with its peers (see discussion in Chapter 7).

5.4 Summary

This chapter presented the thematic analysis that offered an accessible and theoretically flexible approach to analysing qualitative data. The guidelines for conducting a thematic analysis were outlined and then the five steps of thematic analysis were analysed, to obtain quantitative data. These results were then presented. After the thematic analysis was accomplished the final results of the analysis was concluded, they are as follows: if KOC want to maintain their position as one of the global leaders in the oil and gas industry (main theme), it should reconsider its strategy (sub-theme) and develop efficient GCs (sub-theme).

Chapter 6 will provide a better understanding of KOC's strategy (sub-theme). By using the SWOT analysis and the TOWS Matrix as tools, chapter 6 will attempt to analyse and match the company's potential threats and opportunities, as well as its weaknesses and its strengths (Table 6.1 TOWS Matrix, adopted from (Weihrich 1993; Weihrich 1999) pp. 152-154) takes advantages of the positive issues to cover the negative gaps.

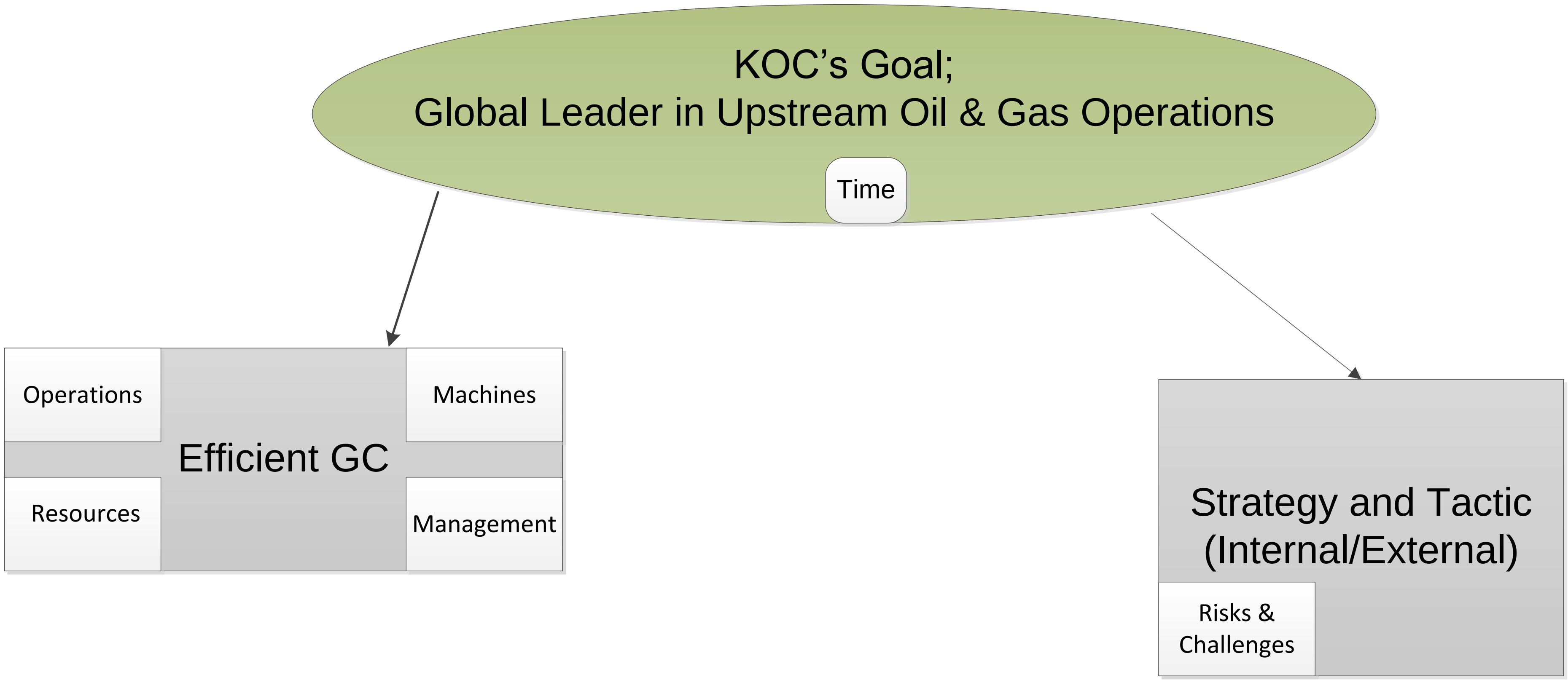

Figure 5.10: Final thematic map, showing final theme and two sub-themes main theme

Chapter 6 TOWS Matrix

This chapter presents a research analysis based on the case study presented in Chapter 4, specifically discussing the company's strategic situation. The first section relates to the interview results presented in relation to the strategic sub-themes (strategic tactic, external/internal) described in Chapter 5, and leads to the discussion of the main strategic model, based on Figure 3.3 (Chapter 3 p. 107), finally formulating a TOWS matrix for the company.

6.1 Introduction

In line with the Kuwait Oil Company's (KOC) determination to develop a sustainable strategy and efficient upstream oil and gas operations; the firm's key resources policy objective is to develop an efficient, cost-effective utilisation of resources, that will take due account of the security and flexibility of supply, and protect the ecosystem.

Although the Kuwait Petroleum Corporation (KPC) and KOC are both under pressure from MEW's (Ministry of Electricity and Water) high demand for oil and gas, the government has not yet adopted a serious national energy development strategy to raise the population's awareness about the value of energy. Furthermore, all five power plants, as overseen by MEW, rely on conventional operations and are so mature that they are not efficient. Some have been operating since 1954, and are the country's only source of electricity and fresh water. According to Al-bahou *et al.,* (2007) some power plants in the country are operating using old technology and that consumes larger amounts of energy than the more recently developed systems that exists in other countries. Thus, Kuwait power sector is not very efficient, and has a high heat rate of 10,536 Btus/KWh, which means that power generation overall has a low energy efficiency of 32%, compared to 35% for the world's average generating capacity (Boncourt 2012).

Managers at KPC are convinced that The State of Kuwait government, represented by MEW should seek out a serious solution to limit electricity consumption. KPC is aiming to persuade MEW and the government to find a solution to the current intemperate behaviour toward electricity and water consumption. KOC 2020 plan, states an aim to raise production from 2.8 million barrels per day, to 4 million barrels per day, which will be a challenge. Raising production demands extra facilities, and additional resources, human resources and funds. Meanwhile, KPC is struggling to manage domestic consumption, which is directly deducted from the share available for export. In addition, the recent oil crisis in 2014 (BBC 2014c), badly affected the company's income, causing losses of more than 40% of expected income.

Therefore, the policy maker, in this case ‘Kuwait government’ needs to take seriously the need to manage national oil consumption. However, KOC has the power to influence governmental decisions, if not to force them to seek a solution. This study focuses on developing a sustainable strategy and green operations in KOC.

This basic planning initiative at KOC is based on one core principle: operation of an integrated fossil fuel business. Indeed, KOC is one of the chief players involved in planning the national strategy and the country’s economy. KOC is involved in promoting environmental co-operation across a range of the national and international companies, as one interviewee manager from KPC claimed. The Counsel of Ministries, when articulating development policies regarding The State’s plans and projects, addressed six main areas holistically. These were: policy and legal framework, environment, energy, country development, social issues, and industry as a large enterprise.

Globally, KOC have a lot of power, and it will do so, as long as the world wants to ensure an efficient supply of oil, and OPEC remains a dominant player on the world’s oil market (Zietlow 2015; EIA 2015). However, at the level of the Middle East market KOC’s power might be expected to fluctuate due to the presence of large competing firms in the region, such as Aramco in the Kingdom of Saudi Arabia (KSA), or Qatar petroleum.

Thematic analysis was employed in chapter 5 for the purpose of data analysis, and a sub-theme emerged highlighting KOC’s current strategy and gaps. This section aims to discuss this sub-theme and analyse it in more depth with a thorough SWOT analysis. To understand the gaps in KOC’s strategy a SWOT analysis was deployed to examine the strengths, weaknesses, opportunities and threats for KOC, in order to develop better solutions to serve the company and the country. A SWOT analysis is widely accepted as an analysis method that can be used to develop a firm’s strategy (Glaister & Falshaw 1999). In order to link the available knowledge concerning the present circumstances at KOC with the potential market scenario, the SWOT in Table 6.1(pp. 152-154), reveals a potential need for KOC to cover the gaps in its strategy. It is suggested that use of the TOWS Matrix will help to develop a strategy that will systematically integrate threats and opportunities in the external environment with the internal weaknesses and strengths of KOC.

The next part of this chapter introduces a strategic planning model, and the TOWS Matrix as a solution, to address the critical issues KOC faces, due to overuse of its resources by MEW and the need to modernise the way it manages its resources.

6.2 TOWS Matrix

A TOWS Matrix was developed based on the aggregate results from the thematic analysis, the SWOT analysis, and the literature review (see Figure 6.1). The term 'strengths' encompasses the advantages facing the company, in particular concerning how it benefits from its power, as well as the adoption of environmentally friendly approaches. In order to understand its strengths, some typical questions need to be answered: what are the advantages of the practice of green thinking? How can it succeed? And, are there any potential benefits? Weaknesses are likely to relate to the resources, factors and items that impose obstacles to the company's attempts to be prepared for sustainable operations and a cleaner future. Some relevant questions might relate to, which components of the corporation's strategy should be developed, and which can remain as they are. Elsewhere, opportunities may include external benefits to the company, arising from the adoption of green thinking. This discussion would also seek to determine future benefits, and will also aim to detail any competitive advantages that KOC might expect to gain. Finally, threats show potential obstacles or problems KOC might face if it fails to implement a clean approach.

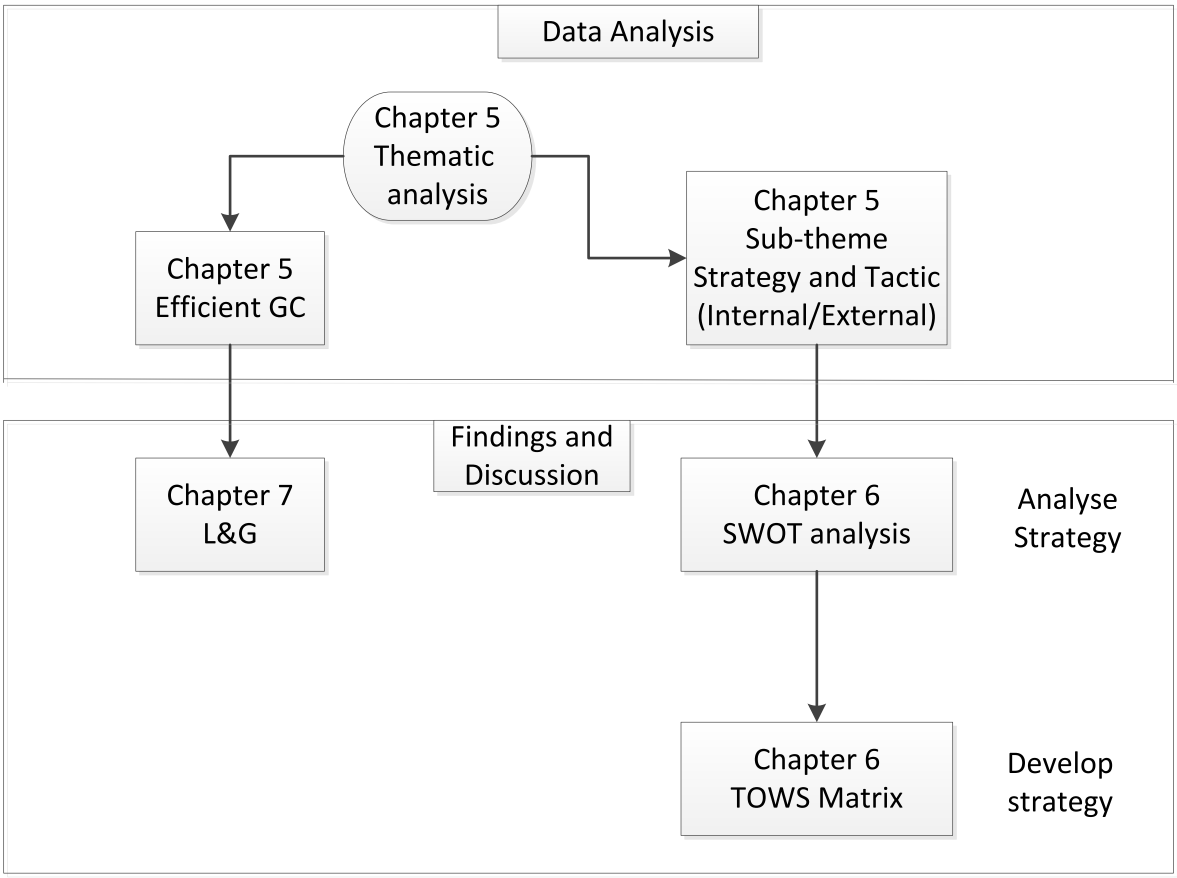

Figure 6.1: Analysis, findings and discussion map

In order to maintain KOC in a leading position, it is necessary to ensure the company's sustainability, and develop a green plan, as this is a factor of major importance according to the literature review (see section on 'energy outlook in the industry'). The TOWS Matrix presented in Table 6.1 (pp.152-154), and the associated analysis of KOC, are given in order to develop cleaner sustainable solutions. Interviews with participants from KOC, KPC, KISR and MEW provided the main sources of data from which to devise a TOWS matrix for a firm. The questions were based on a SWOT analysis, which enabled the researcher to understand the answers based on the processes informing the formulation of KOC's strategy. The TOWS matrix, addresses the present and long term future solutions included in KOC's long term plan for 2020. It will also generate determination at a different level, preparing for the longer term, and the future significance of operational factors and the strategic resources that the firm will need. Focus will be directed toward participation across a wide spectrum of energy related subjects: relevant ministries, regulations, electricity production, electricity distribution, heat generation, energy needs, chemicals required for oil recovery, oil and gas production, and reserves, reservoirs, public consumption, industry within Kuwait, responsibilities toward the environment, sustainability, the responsibilities of KOC toward the country and the public, and the present and future situation at the company.

The discussion aims to determine what developments are essential to the company's future, in order to withstand future changes to the fossil fuel industry. It will further explain the results of the analysis in chapter 5, and facilitate the findings and discussion regarding oil and gas production operations in Chapter 7. The parameters for the following TOWS Matrix have been separated into two general categories: external and internal factors. The former category involves threats and opportunities and the latter encompasses weaknesses and strengths. In this chapter the remote operating environment of KOC is identified, to help formulate a realistic picture of a future scenario.

Table 6.1 TOWS Matrix, adopted from (Weihrich 1993; Weihrich 1999)

Strategic Tactic Action	**Internal Strength**	**Internal weaknesses**
	1- Availability of easy oil and young fields 2- New facilities (poster stations, new pipeline network)	1- Retirement of experts 2- Bureaucracy 3- Lack of natural gas 4- High cost structure 5- Complex and

	3- Good quality crude oil characteristic 4- Effluent water handling system 5- Pilot sola projects 6- Availability of low cost research groups 7- Geographical location 8- Control over governmental decisions 9- Sun; hot climate	unconventional reservoirs 6- Lack of precision and certainty in some GC’s operations 7- Some mature and depleted reservoirs 8- Recruitments quotas 9- Large company (culture development)
External opportunities	**S-O strategy**	**W-O Strategy**
1- Emerge to carbon management business 2- Involve in renewables Market 3- Suspension of nuclear activities 4- Growth of energy demand 5- Create green jobs 6- MEW reduces the load, 7- Public and local industry aware of oil value	1- Harness the new facilities (EWB, Gas poster, new pipeline network) to emerge to the low carbon management market 2- Conduct more researches to develop more efficient operations and renewables (L&G operations in the oil and gas case)	1- Establish green-jobs to reduce high cost structure (L&G operations in the oil and gas case) 2- Expand renewables projects to cover lack of gas and reduce load upon local oil consumption (L&G operations in the oil and gas case)
External threats	**S-T strategy**	**W-T strategy**
1- Might struggle to meet Future demand of energy	1- Though availability of low cost research KOC can develop its	1- Use its power to persuade the government to set

(development required) 2- Awareness of public about energy value; Excessive consumption of energy 3- Pressure on MEW to satisfy all energy consumers including OC (Secure OC's needs of energy). 4- Oil prices fluctuations 5- Other hydrocarbons markets mainly shale gas 6- Surrounded crude oil produces 'competitors' 7- Other energy markets and technologies 8- Global legislations 9- Declining in economy growth	current pilot projects to supply MEW with clean energy instead of sending barrels of oil (L&G operations in the oil and gas case) 2- Establish green business in KSA lands due to geographical location and low wages in KSA (L&G operations in the oil and gas case)	more restricted strategy; reduce the subsidy on some of petroleum derivatives in the domestic market 2- Access to the unconventional wells 3- Apply developed management tools to avoid lack of information from experts retirements (L&G operations in the oil and gas case)

Strategic Planning Input

KOC is the most significant branch of KPC, and it plays a vital role in OPEC. KPC's competition is in the form of its huge neighbours, rendering competition significant, as it is necessary to find solutions to assure the firm's sustainability, by extending the lifetime of its resources and developing better solutions to minimise the effect of its activities on the environment. As well as marketing that is responsive to the competition, KOC production is governed by issues of humanity and political regulation. Therefore, as a priority, sustainability must be assured, in accordance with the requirements of team leaders from production and operations group at KOC. Furthermore, KOC’s managers are exploring advanced solutions in depth to ensure the sustainability of their business .A KPC manager defined sustainability in KPC terms as inextricably linked to the desire to develop its hydrocarbon industry. A question is asked about how it can compete in future, as a National Oil Corporation (NOC) focused on oil and gas. The foundations of the firm’s sustainability were examined to identify sources of sustainability advantages. All the information associated collected for the thematic analysis indicates the significance of assessing KOC’s position amongst its competitors, and the nature of its work. In attempt to develop KOC’s green strategy, it is significant to bring all this information together to provide a clear view of the firm’s position.

In order to produce an effective strategic plan, all the input into the system must be properly considered. Inputs include people, management and technical knowledge (operations), capital, and claimants’ needs. KOC has to deal with different groups of claimants who might come into conflict with each other, including employees.

As NOC, KOC has to meet a specified amount of daily production. It is critical for KOC to make sure there is no gap in the global fossil fuel supply chain, since Kuwait is a member of OPEC, any gap in the global supply chain would result in a fluctuation in oil and gas prices in the global markets. Suppliers, vendors and contractors are other groups of claimants comprising part of KOC business improvement model. Health Safety and Environment (HSE) group policy in KOC is encouraging and strengthens communication within the company, with its suppliers, and the community, advocating the adoption of all relevant HSE policies and requirements by contactors, vendors, suppliers, the public and environmental performance to minimise types of incidents, injuries, occupational illnesses and pollution.

KOC is the world's fourth-largest oil exporter, thus it is under pressure from government regulations. Since the company is a government-owned holding the corporation the Council of Ministers is involved in the company’s major decisions, the Council of Ministers plays a significant role within KOC’s strategy. The State of Kuwait government demand strategies result in the long-term success of the company, since it is directly linked to the country’s survival and budget. In addition, KOC is required to comply with the laws of The State Parliament; therefore, KPC’s management is governed by the country and shows long-term results. KOC also pursues a policy of corporate social responsibility; it is obliged to:

- Create job opportunities.

- Build the level of State manpower with relevant expertise as needed.
- Provide Healthcare Service via Ahmadi Hospital to its employees, the oil sector and the Public.
- Contribute to education (including scholarships).
- Contribute and support various initiatives, which improve the infrastructure and municipality services in the country.

It is clear, therefore, that many of these claims are incongruent, and that it is management's role to integrate the objectives of these claimants by developing green cultural initiatives as recommended in TOWS Matrix (Table 6.1, pp. 152-154)

6.2.1 The External Environment: Threats and Opportunities

This section considers the opportunities and threats arising in the external environment; such as political, economic, social, technological and competitive factors. The external environment challenges the business, and it is difficult to determine if an issue is an opportunity or a threat until a full picture of the business situation is understood.

Threats and opportunities assist in identifying the present and future external environment focusing on the evaluation of economic, social, political, legal, demographic and geographic factors. Investigating the environment is essential to the application of technological and production development. The TOWS matrix, shown in Table 6.1 (pp. 152-154), illustrates selected critical external factors influencing KOC.

External threats

Future Demand on Energy

Apparently, KOC is obliged to raise oil production in response to growing demand, locally and overseas. KOC's 2020 plan aims to raise the production of oil by about 40%. This will be essential if it is to cover the country's economic needs and ensure an efficient supply for the global supply chain, meeting such a target is not easy. According to a team leader from KOC, the company needs to achieve target production by 2020 of 4 million barrels per day of crude oil to avoid an economic crisis in the country (Al-qabas 2014; Oxfordbusinessgroup 2013)

However, at present KOC's daily production of natural gas is about 13.53 billion cu m, which is considered a very modest amount of gas compared with neighbouring producers. In addition, it is only producing shale gas. As mentioned above, the consequence of this is that the country currently is struggling from lack of natural gas production. As experts from KOC who were interviewed stated; in 2030 the demand on energy will rise, based on current energy growth demand, thus demand may not be met. From 1950 to 2005, human population growth in the world has more than doubled (PRB 2008), and the country's population also doubled between 1990 and 2014. Therefore, economic growth and industry expansion are the main drivers of global energy demand according to a manager from KPC. BP suggested that two main factors will drive increased energy consumption and demand. First the world's population is projected to grow by a huge increment between 2011 and 2030, second countries will double their income. BP expected demand for energy to increase by as much as 36% between 2011 and 2030, with nearly 93% of the growth expected to take place in non-OECD countries (BP 2014c).

Therefore, if KOC fails to develop its operations, by building more facilities and improving its efficiency through technological developments, it might struggle to export any crude oil after meeting local needs.

Current Domestic Energy Consumption

One of the greatest threats faces KOC is the domestic consumption of oil and gas for electricity generation and water desalination operations. The only source of electricity in the country is MEW conventional power plants fuelled by oil and gas. According to interviewee from KISR, MEW power plants are no longer efficient due to aging. Furthermore, the only source of fresh water is these power plants. Desalinated water provides more than 93% of potable water, with 7% coming from brackish water (Abdul-hamid 2009); Kuwait is a poor in natural water resources.

As number of interviewees from KOC stated that KPC in general is dissatisfied with the way MEW consumes oil and gas. It is very concerned about the domestic consumption of electricity and water, which is originally, produced using oil and gas reserves. Focusing on fulfilling domestic demand for oil and gas has a negative impact on the country's economy and its environmental performance. The rate of energy consumption is constantly rising in Kuwait, and its cost is directly deducted from the potential income raised by oil production. Kuwait's domestic consumption includes consumption in homes, commercial buildings, ministry buildings, government buildings, industry, streets, schools, offices, and shopping centres. KOC is obliged to fulfil the domestic demands of ‘MEW’ from its oil and gas resources, as MEW has the right to demand fuel.

KOC is disadvantaged by MEW’s demand for oil and gas; the country is among the highest electricity consumers per-capita worldwide (Al-Mumin *et al.*, 2003). High energy consumption in residential buildings is generally attributable to two main factors (KOC interviewee):

- Use of climatically incompatible buildings designs.
- Occupants’ energy-unconscious behaviour.

The government sets a low electricity tariff, which does not adequately reflect the true cost of providing the service to users; the per unit subsidy on electricity is around 94% (BuShehri & Wohlgenant 2012). Furthermore, the government provides a subsidy on petrol derivatives for the country’s residents, according to interviewees. Wood and Alsayegh, (2014) observe that one of the factors influencing unconscious energy consumption is random increases and changes to government salary cadres. More than 80% of the local labour force works for the government sector. A random rise in income after 2006 contributed to a change in consumption behaviour.

Electricity and water supply to KOC

It is unwise to rely entirely on MEW’s electricity and water, as its efficiency has been criticised (interviewees KISR), (Abdul-hamid 2009). However, the greatest likelihood of problems arises during the summer season, when the domestic consumption of oil and gas is highest, especially at peak times (i.e. between 11:00 and 16:00) when the outside temperature reaches almost 50C^{o}. The long summer season from May to October poses an extra threat to KOC; electricity consumption for air conditioning is high, as this is the only ventilation method used in every interior environment of every single building in the country. MEW is struggling to find alternative solutions to electricity consumption in the summer. Sometimes in the summer, MEW struggles to ensure a stable supply of electricity to the whole country, leading to power cuts.

To ensure a reliable electricity supply throughout the GCs, the company supplies diesel by road tankers and manages diesel generators, which create a small proportion of the electricity supply when needed.

Oil Price Fluctuations

One of the major external challenges to KOC, according to the R&T group, is the fluctuation in oil prices, as evidenced by the crises in 2014, when oil prices dropped from $110 to below $70 (BBC 2014c). The price of oil is of critical importance if oil export countries are to survive. In terms of both volume and value, oil and gas is currently a huge international trade commodity, and is often the only product of oil producing countries, due to the large market for hydrocarbon. Energy prices are dominated by energy-intensive goods and services, of which oil makes up the single most important share. Crude oil prices are directly linked to those of petroleum derivatives. Therefore, abrupt changes in the prices of oil have wide-ranging ramifications for both oil-producing and oil-consuming countries. Further, the main oil customer of the Middle East, the U.S.A. expects to be energy self-sufficient by 2035 by depending on its shale oil and gas. This expectation (alongside other political reasons) is one of the chief causes of the oil price collapse in 2014 (The Economist 2014).

A decline in oil prices will effect oil exporters, and benefit oil importing nations, especially in Kuwait and KOC, where the revenue from oil accounts for about 90% of all government income (Wood & Alsayegh 2014), and comprises nearly half the country's GDP. Energy is considered a prime agent in the generation of Kuwait's wealth, and a significant factor in its economic development.

On the other hand, higher oil prices could draw world attention to find alternative resources of energy instead of relying on just oil and gas. Sharp rises in the price of crude oil could prompt a search for better opportunities on the renewables market, and stabilise the cost of electricity generation, as well as offering environmental benefit. In addition, high oil prices are also likely to lead to a preference for nuclear generation, as it is more efficient than hydrocarbons. Sharply rising oil and gas prices might also prompt resurgence in the market for coal, and other hydrocarbon resources, that are not produced by KPC (interviewees KISR, R&T from KOC).

When oil and gas prices become unstable, both energy providers and customers are at risk of economic instability. Thus, fluctuations in oil and gas prices have negative consequences for Kuwait's economy in general, and KOC's business in particular.

Other Energy Resources

KOC's mission is to explore, develop and produce hydrocarbons; thus, it is evident that it is exclusively focusing its business interests within the oil and gas sector. As mentioned previously, in the literature review chapter, renewables are a potential source of future energy, especially for developed countries. The R&T group in KOC has identified that renewables represent an external challenge, which is likely to play a more significant role in the world's energy in future. Moreover, renewables offer a greater variety in methods of energy generation, and renewables that can be tailored to suit the economic, social, environmental and confederal climate of the region.

A key strength of renewables is that they have the potential to provide energy at zero or almost zero emissions, with no GHGs; whereas, the production of energy from fossil fuels generates emissions that incur penalty charges for the extra emission of carbon dioxide. In 2012 the UK achieved 4% of the energy to cover its domestic energy demand from renewable resources (DECC 2013). According to the BBC (2014a), by 2035, about 80% of energy use will be expected to come from gas, coal and renewables, with other resources accounting for the rest. Natural gas is the fastest growing hydrocarbon source for energy production, and shale gas is expected to account for more than 20% of world's gas production by 2035. If these figures are accurate, it can be concluded that by 2035, oil will be a less attractive resource on the global energy market.

Competitors

Another external threat is from regional competitors. As an interviewee from KOC claimed; other markets, especially local regional markets, represent a serious challenge to KOC. Each of the other members of OPEC is competitors aiming to sell to the global market. Of these the most important is Aramco. Some economists have suggested that in 2014 Saudi Arabia deliberately flooded the market with oil to gain longer term contracts in the Far East at lower prices (ABC 2015; Alakhbar 2014). Aramco's headquarters are situated several hundred km south of KOC's main office, in the neighbouring country of Saudi Arabia. Aramco's daily production of crude oil is almost four fold that of KOC. It is the world's top crude oil exporter and producer, owning the biggest easily accessible oil well in the world (Alghawar), Aramco produces about 11.730.000 million bpd and 103.2 billion cu m daily, according to CIA figures (CIA 2012c).

Another key competitor is Qatar Petroleum, which is located 770 km south of the country. It is a modest producer of oil compared to KOC, however, it is big gas producer, with daily production of 133.2 billion cu m, meaning it is ranked the sixth largest gas producer in the world (CIA 2012b).

Iran also plays a big role in the region, through the National Iranian Company. The National Iranian Company’s daily production of oil is 3.589 million bbl. /day, and it also produces 151.8 billion cu m of gas. Iran is ranked as the fourth largest gas producer in the world, and its sixth largest oil producer (CIA 2012a). Recently Iran has begun legal uranium enrichment operations in preparation to establish a nuclear reactor, which is the most efficient known source of energy. Figure 6 2 illustrates the level of activity in the fossil fuel industry along the Persian Gulf, which holds about 50% of the world’s oil reserves.

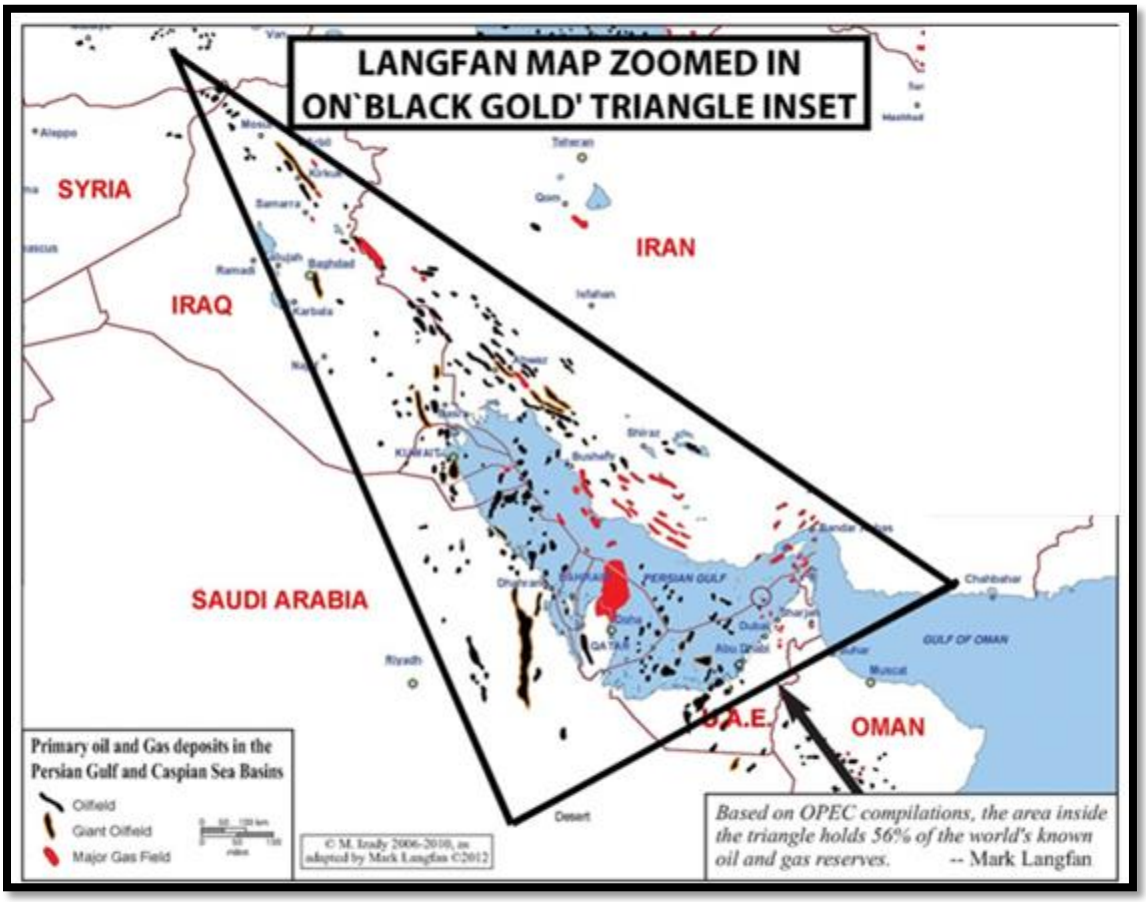

Figure 6 2 Oil reserves along the Persian Gulf , (JNS 2013)

Global legislation

Laws and regulations put in place to protect the global ecosystem are both increasingly essential and increasingly restrictive. Although KOC works within HSE policy, designing, managing, and operating its facilities to demonstrate effective health and safety management and promote pollution prevention, energy conservation, and optimisation, it has not committed to the Kyoto Protocol (interviewees KOC, KPC). The United Nations Framework Convention on Climate Change (UNFCCC) calls for the stabilisation of GHG emissions, so that they are concentrated in the atmosphere at a level that avoids dangerous anthropogenic interference with the climatic system. The Kyoto Protocol to the Convention commits its parties to binding targets, based on as a 'basket' of six GHGs, including carbon-dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs) , and sulphur hexafluoride (SF 6), (Rao & Riahi 2006).

The decision to commit to Kyoto would directly influence electricity and water consumption in the country, as it would impose major restrictions upon MEW.

External Opportunities

This section describes the opportunities gained by KOC to advance its capacity to expand its business alongside the development of tactical plans.

Carbon Management

New competitive advantages: KOC believes that environmentally responsible hydrocarbon refining and production operations can provide a competitive advantage, because they will meet the environmental needs of public and global regulators. They consider that holistic environmental commitments, such as to HSE, might assist the company to gain competitive advantages. However, KPC top management still questions the need to commit to global regulations such as the Kyoto Protocol, as many of its regional competitors have not done so. However, committing to global regulations will open new competitive market for the company.

By implementing globally recognised and holistic environmental management practices, KOC will gain easy access to additional markets. The majority of developed countries require the companies they deal with to be in receipt of accredited environmental status from global organisation such as the International Organisation of Standardisations (ISOs). Since 2011, KOC has committed to ISO 1400 for environmental management. Interviewees from the HES group claimed that it would be useful for OC to commit to more ISOs, such as ISO 15001 for energy management, and ISO 1800 for health and safety. However, another interviewee, a manager at KPC remains convinced that ISOs do not necessarily add value to the company.

Renewables Market

The Low Carbon market can be a gateway to new market renewables and vice versa. In order to support a business’s position, so that it can be a more distinctive member of the energy market, renewables are essential to survival, especially in the long term.

In the UK, the Government has committed to developing renewable resources and a secure energy mix. The UK Government believes that primary resources can ensure the security of future renewables, alongside natural gas, nuclear power and carbon capture storage (DECC 2013). Renewables are expected to help the UK meet its decarbonisation objectives and bring growth to all parts of the country. The Department of Energy and Climate Change in the UK has stated that since 2012 there has been good progression toward its 2020 renewables target to deliver 15% of energy demand from renewables.

BP has already established renewables projects, see literature review. Shell is also involved in eight wind based projects across North America and Europe. Shell has used its experience with oil and gas platforms to design wind farms that can withstand conditions in the North Sea. Offshore Wind farms are expected to survive for two decades, thus, their components are coated to protect them against corrosion for 20 years (Shell 2013).

In the Middle East, especially in the Arabian Gulf region, there are 365 sunny days each year; thus, there is huge potential to harness renewables. More information about renewables in the Persian Gulf and GCC countries can be found in the literature review. The opportunity to harness renewables is huge, and they offer sustainable, clean, reliable sources of energy. KOC, with its strong financial position, should be well placed to building sustainable stations.

According to an interviewee from KOC Planning Group, alternative sources of energy (i.e. solar, wind, geothermal, hydroelectric, nuclear, and biofuels) could become viable, although they should be explored case by case. However, top management at KOC are not pursuing such opportunities in their business, because they conflict with top management’s values, that fall outside the field of hydrocarbons. Furthermore, the influence of values associated with management’s commitment to socially responsible actions establishes that building renewables might benefit enterprises in the long run. MOC’s top management concern is focused on the hydrocarbon industry only, as other options are believed to be distractions.

Growth in Energy Demand

According to interviewees at KOC, global demand for energy will grow over the next two decades, with an intensive rise expected between 2012 and 2030. The rise in energy demand might be slower paced in OECD countries, because of increased fuel efficiency. However, in the non-OECD countries (KOC surrounding region) demand for energy could rise quickly. Meanwhile, in 2014 ,China's economic growth slowed to a more than five-year low influencing oil demand and prices (BBC 2014b). In the future, however, as the needs for energy resources increase, the demand for crude oil is also likely to increase. Emerging economies in developed countries, and industrial expansion are estimated to deliver a high share of the continuous growth of global energy demand. Population growth and industry development will increase the demand for energy resources, especially hydrocarbons (interviews planning group KOC).

Green Jobs

It might be rare to find green jobs in Kuwait or the Middle East, but they are very common in developed countries such as the UK. In the UK the Government continues to invest in green jobs in order to assure Britain's drive towards renewable energy (DECC 2013). OC as an enterprise is also taking responsibility for developing the preference of the people in its country. According to an interviewee from MOC, because it owns country's main resource it should have the strength to garner support from the government to establish unique green jobs.

GCC countries, except for Kuwait have heavily invested in a non-oil infrastructure, launching a number of ventures to encourage private sector involvement, Kuwait's policy system does not encourage entrepreneurial spirit and initiative, (Gulfbusiness 2014). Conversely, OC has the strength to pursue Kuwait's government, requiring it to set regulations to establish green jobs; since the strategic objectives of OC are to contribute to the enterprise and State. Furthermore, OC's values are:

- Invest in people;
- Provision of a motivating environment;
- Valuing knowledge;
- Corporate citizenship; and

- Innovation.

In January 2014, Kuwait government noted that the number of employees in the public sector was about 230,000 employees. This represented three times more than was needed. Moreover, there were in the region of just 61,000 workers in the private sector, largely because of the large increases public sector wages bill (Gulfbusiness 2014). This realisation has prompted The State's government to offer a salary subsidy for private sector employees.

Creating green jobs driven by renewables energy will generate economic growth. Creating new jobs opportunities will help to expand domestic income and establishing a renewables sector will support greater exports of spare of energy, establishing and operating a private system (interviewee from KISR). The public sector budget for wages or devours almost two thirds of the country's oil revenues. As mentioned earlier, current domestic demand for energy threatens the country's future, its economy, and the region's climate, and failure to benefit from oil revenues will adversely affect the country's economy. Heavy consumption of electricity and water also affects the country's economy.

Furthermore, Kuwait is unquestionably an attractive area in which to pursue utilisation of renewables, especially solar generation. If an Energy Counsel Office were established, one of its objectives would be to persuade individuals to install renewables in their houses, to mitigate the depletion of hydrocarbon resources, and to protect the environment from further damage. An Energy Counsel Office could play a major role in knowledge creation concerning the diverse impacts of efficient energy consumption. KOC as a hydrocarbon company has an opportunity, as well as the potential and strength to expand its business to create green jobs in the private sector. This could be done through investing in renewable electricity generation and through the use of advanced carbon management schemes. Applying lean and green (L&G) in their operations could improve the efficiency of oil and gas production operations. Further description of how this can be done is listed in Chapter 7. L&G could be deployed to provide an energy efficiency programme for KOC operations, the approach would eliminate waste. According to Zarnikau (2003) energy efficiency programs were already being expanded in some countries.

Such investment and approach might also provide work for the 19,000 Kuwait nationals who are on the waiting list for employment at the Civil Service Commission (Gulfbusiness 2014). This would allow the government to invest in meaningful, job-creating ventures. Meanwhile, KOC continues to provide a high level of public support, and is working tirelessly to encourage further investment in people, KPC has undertaken social responsibilities to:

- Create job opportunities;
- Build the level of State manpower by providing relevant and necessary expertise;
- Contribute to education;
- Contribute to and support various initiatives to improve the infrastructure & municipality services in Kuwait; and
- Corporate social responsibility

Therefore, creating green jobs driven by renewables generation and carbon management would create more opportunity for KOC to commit to global environmental regulations and guarantee that the nation maximises the opportunity to benefit from cost effective renewable energy; not only in terms of jobs and investment, but also to provide energy that will underpin the country's long term economic prosperity.

Public Awareness

Public awareness of efficient energy consumption in the country can provide a good opportunity for KOC to make extra profit. Public awareness concerning the value of energy is the main reason why KOC needs to extend the lifetime of its resources, make better profits, and implement environmental management practices to pressure the international community (interviewee from KOC). The public is not aware of how to progress toward efficient energy consumption, or how domestic consumption affects the country's economy. Interviewees from KPC suggested that an Energy Counsel Office should be established to educate the wider public about the high value of these limited resources. It cannot be assumed that public has a clear idea about the outcomes of energy consumption and high carbon emissions. A minority of the public are aware that air conditioning, TVs and lighting are the major causes of energy waste, threatening the stability and longevity of the country's economy and driving climate change.

MEW is the main authority responsible for generating, supplying, and dominating the water and electricity in the country. Thus, MEW is directly responsible for developing individuals' behaviours in terms of energy consumption; it has the power to force the public and industry to recognise the dangers of overconsumption. MEW has the power to ask Kuwait Parliament to issue laws regarding energy consumption, and to encourage individuals to consider installing renewables. Currently KPC is working together with MEW, conducting a public awareness about energy campaign (interviewee KPC). In 2013, KPC sent a strongly worded letter to MEW asking it to find a solution to its uncontrolled demands for oil and gas. If MEW continues its aggressive fuel consumption, the country will soon be unable to export any oil (interviewee KPC). In recent years, the situation has been exacerbated by the ever-increasing importance of access to Lean Natural Gas resources (LNG).

6.2.2 Internal Factors: Weaknesses and Strengths

Evaluation of the corporation's internal environment involves identifying its weaknesses and strengths in areas of production operations, research and technology, marketing, the products and services the corporation offers, human resources and culture, current strategy and planning approach, corporate image, and relations with customers.

Internal weaknesses:

Retirement of experts (organization experts' knowledge)

According to the interviewees from the production group in KOC, they experience issues associated with the retirement of experts. KOC spend considerable time finding and training the right employees, to meet its needs. The practice of profiling and maintaining an updated list of domain specific, technical employees has become a mantra for success. OC accrues benefits from the employment of experts organisation-wide, because of profiling initiatives.

The collaborative knowledge of its network of expert employees helps others to access important company information assisting further development. Some of the most important qualities for an expert are as follows:

- Comprehensiveness: the ability to capture all the information from across the company;
- Better search facility; knowledge of how to link new employees to the right information;
- Up-to-date: knowledge of how to maintain a high level of performance;
- Ownership: having the responsibility to create initiatives;

- Technology: able to easily direct the company to access the right technology; and
- Collaboration: knowledge of how to facilitate cooperation where necessary, such as with suppliers and customers.

There is a need for expert employees who can facilitate easy access and collaboration. Experts are of great interest to KOC, because they have the potential to direct knowledge seekers and knowledge sharers, and can drastically reduce the time it takes to do so. When experts retire or leave, KOC suffers an extensive loss of knowledge/ability within a particular area. This then creates obstacles to the continuation of experience through practice and education in different areas. Experts are important because the:

- Affect KOC's knowledge base;
- They have ability to reduce time spent identifying the right solutions to resolve any problems;
- They have a clear picture of "who's who" in the company and what their skill levels are, by group;
- They are able to select the right employees with the necessary skills;
- They easily recognise employee for their level of expertise and their contribution to knowledge sharing, and collaboration across teams, departments, and locations.

Bureaucracy and past success

There are several reasons for considering business diversification as it unfolds within KOC's business; one of these is bureaucracy, and this can be the main reason why the company is under threat, as it has budgetary implications. The fear is that the entire country's general budget rests on the company's shoulders.

According to one interviewee, who is a Minister; public sector salaries cost the country millions and millions each month, and these are directly paid from oil export revenue. It is feared that the country might face a budget deficit within a couple of decades if employment does not shift to the private sector, or if the government fails to find another source of income. The Minister stated that demand from public sector employees is placing the country's budget under serious pressure. The core component of the problem is that it should be the government's responsibility to maintain a healthy budget for the country, but in reality, the main responsibility resides with KOC. Again KOC and KPC managers operate as though oil supplies are everlasting and the demand for oil is strong and continuous; thus, they argue that economic diversification is pointless, or of no relevance to them. They are only interested in developing hydrocarbons to maintain good profits, and assure the distribution of oil revenues among the population. However, oil resources are finite and experience shows that both the price and demand for oil are subject to considerable fluctuation.

A manager from KPC, who was interviewed, claimed that the managers in the company "only want to think inside the box", as they are complacent and remain convinced that the main requirement of global heavy industry is liquid oil not gas. The size of the corporation and its bureaucratic structure are a potential weakness here, as it contributes to satisfaction with the status quo, and unwillingness to examine the possibility of turning to products other than conventional hydrocarbons, despite companies worldwide seeking to diversify their energy resources. The current and past successes of KOC mean that it sees no need to change. However, over the long term, claimants might demand energy companies to develop new, cleaner, or cheaper energy resources, such as shale gas.

Shifting Market Demand toward Natural Gas (lack of Natural Gas)

KOC is producing Associated Petroleum Gas (APG), or associated gas, and working on developing non-associated (isolated in natural gas fields) or LNG within its business; the interviewee at KPC is currently struggling to meet domestic demand for gas. Therefore, KPC is not in position to export gas; rather it is following through on its plans to increase its fuel mix by develop LNG production, and is also importing LNG to meet MEW demand. In 2011, about 42% of LNG was imported to meet demand from power stations. KOC has set a target to achieve non-associated gas production within The State of Kuwait of 2.1 billion standard cubic feet per day by 2020. According to the interviewee in the R&T group at KOC, one of the organisation's current opportunities is to meet the challenging target of meeting the need for non-associated gas production.

Worldwide, natural gas estimates are attaining an average rate of growth of 1.5-2.0%, (Vanguardngr 2014; Haziralngandport 2010), it is the fastest growing hydrocarbon used for energy within the hydrocarbon family. Natural gas is the bridge fuel between the dominant fossil fuels of today, and the renewable fuels of future. To produce energy, natural gas produces half the amount of carbon dioxide produced by coal. To generate electricity, desalinate water, and conduct the majority of KOC's operations, natural gas is the primary fuel. Furthermore, the fact that it is cleaner than oil is making it increasingly popular. The advantages of natural gas suggest it will emerge as a critical transition fuel in the battle against global warming.

Economists have suggested that the planetary reserves of natural gas are at least 50% higher than oil reserves at the current rate of consumption. This could indicate a serious threat for oil producers. Therefore, lack of natural gas as a component of KOC resources is a weak point that needs to be addressed. Natural gas is available regionally, and is frequently flared off in oil fields because it was thought to be of little use. This needs to be changes, as with the creation of pipelines to carry LNG, it is fast becoming a major international commodity (Vanguardngr 2014; Haziralngandport 2010; Ehow 2014; Entregapipeline 2014).

High Cost Structure

A further weakness of KOC is its high cost structure. The unstructured interviews, especially with operators and team leaders have shown their satisfaction of their very high wages structure. In KOC, the monthly average wage is £10223.47, compared with the other global companies and the remainder of Kuwait public sector is significantly high (see Table 6.2). comparing KOC average wages with other petroleum companes appeared KOC is payin more than double average wages of its peers. KOC wages data was sourced from interviews, Kuwait public sector from Aljarida.com (2014). Although, Kuwait public sector saw working hours lower than the working hours in KOC, but still KOC wages are considered high. In KOC's plants and field employees, including operators are working 24 hours/seven days, and in their offices they work eight hours/five days a week, whereas, in Kuwait public sectors the average working day is seven hours/five days a week. KOC's employees in the plants and the field work during holidays; but state public sector employees do not.

Table 6.2 salaries data, KPC data set from interviews, The State of Kuwait public sector salaries dataset collected in Jan 2014 from (Aljarida 2014), the rest of salaries data from (Glassdoor 2014).

	Average salary £/month
KPC	10223
Kuwait Public	2738

sector	
BP	4466
Schlumberger	3139
Shell Oil	3805

The size of KOC and its structure is also classified as a potential weakness; KOC with 10 sister companies (specialised subsidiaries of KPC) spread in country and across the world would demand great efforts to formulate and spread the ideal required culture across the corporation. In 2013, KOC had over 6000 employees, not including its sister companies. Another element of weakness is the corporation’s employment strategy; it has a recruitment obligation to meet in the form of a quota. In parallel with examining candidates’ capabilities, skilled and experience, KOC is obliged to meet specific quota; employees should be from various segments of society. A reflection of such an approach would critically change recruitment; it might turn the focus from ‘who’ is this rather than ‘how’ is this, it might also lead nepotism to take place. A further result of the quota is that employers in the corporation are dealing with each other, and with work in terms of family-ship rather than professional.

Mature, Complex and Unconventional Reservoirs

Some of KOC’s mature fields already suffer from too much water seepage into its oil deposits. A mature field is one where production has peaked and has begun to decline. Some of KOC’s reservoirs have already been depleted in the northern territories, making oil extraction difficult. However, there are currently a large number of young reservoirs (interviewees KOC, KPC).

Conventional reservoirs are those that produce at economic flow rates; they do not require further recovery or extra stimulation for treatment operations. Conventional reservoirs produce oil and gas with economic volume. High/medium permeability, drilling processes in these reservoirs is vertical, well at commercial flow rates and supporting recovery of economic volumes of oil and gas. On the contrary, unconventional reservoirs cannot produce at economic flow rates require assistance from extra stimulation treatments and further recovery operations, to produce economic volumes of oil and gas. To produce from unconventional reservoirs, use of technology is essential to fulfil the ejection (stream, water) process needed to extract the oil and gas. Unconventional reservoirs are a good source of emissions and pollutants. The best known unconventional reservoirs are coal bed methane, heavy oil, gas shale and tight gas sand.

Heavy oil also exists in KOC's reservoirs. This is a type of crude oil characterised by an asphaltic, dense, viscous nature (similar to molasses), and high asphalting content (very large molecules incorporating roughly 90 percent of the sulphur and metals in the oil). It also contains impurities, such as waxes and carbon residue that must be removed before it is refined. Although variously defined, the upper limit for heavy oil is 22° API gravity with a viscosity of 100 cp (centipoise), (Rigzone.com 2014).

Visibility within GCs operations

In order to save more time and operate with using fewer resources, advanced visibility is expected to take place on the shop-floor. More information is given about decisions relating to GCs oil and gas operations and L&G in chapter 7.

Water Injection

The Oil recovery method applied by KOC is water injection, as this maintains pressure in the reservoirs. The process involves injecting water into the oil reservoirs to increase pressure or displace oil from the reservoir, and thereby stimulate production. This can be considered a less than ideal method and classified as a weakness because water injection increases the water cut ratio in the crude oil, requiring additional oil recovery operations. Furthermore, one of the reasons for the low oil recovery efficiency obtained by the water injection flooding method is the high viscosity ratio of oil to water, caused by calculating the migration effect of oil in the reservoirs (Han *et al.*, 1999). Meanwhile a number of KOC interviewees disagreed that water injection affects oil recovery.

Another method of oil recovery, which can be deemed more efficient, is gas injection, or miscible flooding. The method involves injecting gases into the reservoir to maintain reservoir pressure and improve oil displacement, this allows for total displacement efficiency, but is not available to KOC (interviewee KOC).

Internal Strength

Availability of Resources

With the availability of abundant resources and easily retrievable oil, KPC is considered one of the strongest hydrocarbon corporations in the world, with a strong financial position. KPC owns the second largest oil well in the world and according to an interviewee from KOC, oil reserves in Kuwait are far from risk of depletion. The reason for this is because a large number of The State's oil wells are still young; also the constant exploration for new reserves hold the possibility of finding more oil and gas resources. Furthermore, because the country is a member of OPEC, the country is at risk of depletion according to a manager at KOC, non-OPEC countries are in a depletion curve; whereas some of non-OPEC member countries have already run out of oil. However, after 2014, when oil prices fall, OPEC will still have power over the global market.

New Pipeline Network

On this particular point, there was some debate regarding whether it was strength or a weakness; however, since it is more advantageous to apply better controls over oil transportation, a greater number of interviewees agreed it was strength. KOC has built new pipelines and networks for crude and gas transfer; new networks are allocated above ground, and the strategy of allocating a pipeline network that is visible above ground makes it possible to apply easy control, should any oil or gas spill.

Some interviewees criticised the new pipeline network project, suggesting that allocating a network above the ground would lead to a loss of underground, heat, which is essential to decrease oil viscosity and gas flow, in order to facilitate transfer operations. Ambient temperature is important, with respect to heat loss; ambient temperature beneath the ground is higher. Temperature and pressure are directly proportional to one another, as temperature increases, the pressure increases and vice versa. Operating pressure is important for all aspects of design. The higher the operations the better the light material that is retained in the pipeline oil and the higher its gravity. A lower viscosity of oil consumes less energy from transportation in the pipelines. Availability of underground temperature is essential to avoid heat consumption during desalination operations, and to avoid gas freezing in the pipe line and easier liquid transportation.

Oil's Characteristics

Kuwait's oil is characterised as an easy oil that is good for the marketplace. It is a typical medium-heavy, sour Middle East grade, its gravity is 30.5 API and sulphur content is 2.6%.

Its other exported crude is Eocene, 18 API and 4.6% sulphur; this is not considered as good quality as Kuwait's crude oil.

Water Handling Plants (WHP)

Effluent water handling is the process of removing as much material as possible from the contaminants of emulsified water (water cut) from the crude oil, as a second stage water treatment. To remove biological, chemical, and physical contaminants, several processes are applied. The aim of treatment is to produce an environmentally safe water waste. After this stage the water is ready for disposal or re-injected inside oil reservoirs, as part of water injection operations, as mentioned earlier. This water is not suitable for drinking or agriculture. In 2011, OC built two water treatments stations (EWB1, 2) to handle cut water. KOC was able to achieve environmentally friendly disposal or re-injection of 97% of produced water.

New Gas Booster Station

In order to achieve lower gas emissions, KOC has built a Booster Station. The station can utilise the gas separated from the GCs, which reduces wastage through flaring. Typically, a Booster Station has the following functions:

- Receives the gas from various GCs and compresses it.
- Separates the condensate from the gas stream.
- Dehydrates (removes water) from both compressed gas and condensate.
- Receives and dehydrates condensates from the GCs.

Gas booster stations are a new strength for KOC, and demonstrate that it has recognised the benefit of reducing of gas flaring. Although KOC is not in a position to sell the gas, rising buyer preference for Methane gas offers hope to the company if it continues to develop this line of production.

Pilot Solar Projects

KOC has conducted a number of initial pilot mobile solar panels projects. These projects have identified, prioritised and appraised the impact of KOC's operation in order to benefit MEW and reduce the risk of demand over load.

In 2013, KOC and KISR pulled together to conduct a tender study to build 5 MW, PV solar stations. According to interviewees from KISR, this project aims to cover a large portion of KOC's GCs and its operations.

Developed R&T and R&D Group and KISR

Major research, development and technology projects, which have a huge impact on the oil industry in country, are being conducted by researchers in the area of technology, in collaboration with assessment of the assets of the world's leading technology providers and research centres. Without extra cost KOC has gained considerable benefits from investing in R&T and R&D groups alongside KISR: Unique operations can offer KOC a unique resources saving. They can then acquire a cleaner image as a hydrocarbon company:

- Competitive advantage; through R&T and R&D groups and KISR, KOC is able to build an advantage over its competitors by bringing innovative operation to the industry.
- Long term income; once unique operations have been developed, KOC can generate a strong stream of profits over many years.
- Ongoing research also leads to new opportunities; researchers cannot always anticipate what the results of their research will be. Often chance discoveries open up entirely new channels of research.
- Enhanced reputation; engaging in research helps to KOC to build on history. The public and the government are more likely to trust a company with a strong scientific R&D base.

One way in which KOC managers can reduce the costs of operating the company and its GCs is to use its R&T group and R&D group, in cooperation with KISR, to uncover cost-effective operations. Applying advanced methods to operate existing operations would allow KOC to realise the full revenue associated with developed operations, but reduce the costs resulting from getting useless resource.

Geographical Location

Location is a key strength of KOC; the Middle East's geographical location means it is well located to deliver products to the west and the Far East. Kuwait is at the junction of trade routes connecting Europe, China, India and Africa, and all the cultures of the Mediterranean basin.

KOC is also located close to Saudi Arabia, which is one of the world's most vital chemicals suppliers (interviewee operator). OC imports chemicals that are essential for its operations and so proximity to Saudi Arabia results in relatively low transportation costs.

Ruling

The firm owns the oil and with sufficient time it can develop its fields and operations comfortably. KOC has the luxury of time to develop its reservoirs comfortably, which is a good position (according to interviewee from KPC). The situation faced by International Oil Companies (IOC), such as BP and Shell, is different, because they operate in tougher conditions where stakeholders closely monitor them; they are also subject to the pressure of the market competition.

In Kuwait, oil is a part of the constitution. Therefore, KOC is relaxed about oil ownership; they have the option to put the right developments in place, to maximise the output from their reservoirs without damaging them, and to choose a suitable method for production to apply. KOC as a large business at the global level has certain inherent advantages over the country government and parliament. It is strongly established, and has a huge amount of funding and resources. KOC also has established customers, although it is looking to penetrate other markets, especially in the Middle East (interviewee KOC). It is confident that it will not struggle to sell any of its products.

KOC enjoys more repeat business, which produces higher sales and profits. There are also several additional key advantages, as the company is one of the largest businesses in the country. KOC is capable of influencing the government through campaign contributions, lobbying, and mainly because it owns the majority of land in the country. This is not always emphasised in Kuwait government texts and in Parliament; although, this influence is certainly a common theme in many political discussions. KOC has the power to influence the government. For Kuwait to survive and grow it will need to see KOC's business expand. With the rise of such a big business, there is no question that the company is in a position to manipulate the country's budget.

The Climate

The geographical conditions in Kuwait are well-suited to renewable energy options. The State of Kuwait has the potential to also generate wind energy (Al-Nassar *et al.*, 2005). In addition, because the climate is sunny, with almost 80% clear skies, it offers ideal conditions for harnessing solar energy (Doukas *et al.,* 2006).

Furthermore, because of the long and extreme hot summer season, KOC gains some advantages from the extreme heat, as it is able to avoid some energy expenditure on heating processes during oil desalting operations. High ambient temperatures contribute to reduce the viscosity of the crude oil, and increase the pressure and speed of gas flow in the pipeline network, which is then directly proportional with the ratio energy consumption.

6.2.3 Developing a Strategic Plan

Based on the discussion of the internal and external environment, strategic planning is then developed as given in the findings. As shown in the TOWS Matrix; see Table 6.1, (pp. 152-154), four rather distinct strategies are available:

The W-T strategy (mini-mini), the aim of this approach is minimise internal weaknesses and external threats; this position is an unfavourable position for a company.

The W-O strategy (mini-max), this aims to minimise weaknesses and maximise opportunities. It might be there are opportunities the company is aware of, but cannot take advantages of because of the internal weaknesses. However, in this sense the company takes steps to transform weaknesses into strengths.

The S-T strategy (maxi-mini), this is about taking advantages of the strengths of an organisation, to deal with the surrounding threats, the aim is minimise the latter through maximising the former. However, this approach is not guaranteed to succeed even if a big company can meet the surrounding threats head-on.

The S-O strategy (maxi-maxi), aims to maximise both strengths and opportunities. When a company is in a position where it can maximise its strengths and opportunities.to take advantage of the market, companies can utilise resources by leading with strength, to take advantage of the market.

S-O strategy would enable KPC to develop a cleaner business model. The company already has several new facilities, and has used strengths associated with its power and size and availability of time and resources. The company can increase net profits by pursuing a greener model to satisfy other global organisations, and meet legislative requirements for the reduction in gas emissions. As global regulations become tighter and more restricted, it will be necessary to sell extra carbon units to other industrial countries that might need them. Furthermore, the expected inefficient energy consumption by non-OECD countries led by China and India has increased the demand for carbon units.

The hot climate and sun shine almost 365 days a year can be engineered into efficient operations for efficient fuel consumption (e.g. reduce oil viscosity, abundant heaters) and be used as a source of clean power. These developments can be facilitated free of charge to developers such as KISR in R&D, R&T groups in the company; a further explanation about how to develop efficiency of operations is given in the next chapter (L&G).

Government of Kuwait encourage investment in the private sector, the government has an ensured salary subsidy for the private sectors employees to attract them to work in the private sector. KPC has the power and the potential to increase its activities and attract qualified employees with wages subsided to generate new green jobs. Thus, the corporation would achieve social objectives, while at the same time it may gain some cost advantages, and reduce pressure upon MEW.

Since Kuwait population is small, about 1.3 million (only citizens), and currently, KOC’s employees number over 6000 and live in small country, expansion of corporate activities would result in the spread of a green culture that KPC can completely dominate.

The S-T strategy builds on the company’s strengths to cope with external threats. One of the threats to KOC is enormous local consumption, as one interviewee stated. Thus, the company may use its engineering strengths and ruling power to transform its conventional supply of MEW know-how into unlimited clean products or non-hydrocarbon projects. As one interviewee stated, KOC operations consume less energy than residential areas; thus, if KOC develops and switches its renewables to the residential sector (that can be done after L&G and efficient oil and gas production operation are being developed), the costs would be lower than just keep sending barrels of crude oil to MEW.

The company already has certain strengths in these areas, through its building of a new solar PV station, and it has already installed some mobile PV solar panels. However, this strategy would require shifting more resources from the oil and gas to clean projects. In this way, KOC's bureaucratic structure, and complacency may be overcome.

The new-model strategy mentioned above in the discussion regarding the SO strategy will also help to address competitive threats in the hydrocarbon sector worldwide. Specifically, KOC can maintain its competitive edge with surrounding firms in Iran, KSA, Qatar and the ADNOC Group in Abu-Dhabi, by insuring a clean supply of abundant energy sources to satisfy domestic demand and maintain delivery of hydrocarbon products for export purposes. Moreover, rapid model-development will gain in importance when competing with the ADNOC Group, as Abu-Dhabi is now involved in generating clean energy as a supplement to cover part of Kuwait's demands for energy. Masdar City in Abu-Dhabi can be a potential competitor to establish long term strategy, and consequently will pose a major future threat to KOC business.

By contrast, if KOC extends its land area by looking to abundant and cheap lands in KSA and urging its business to construct renewables, it might encounter political resistance. Owning lands in competitors' area has numbers of benefits:

- Lower cost land;
- Land location will be close to the home country (possibly less than 100 miles)
- Cheaper labour, Table 6.3 shows the average monthly wages in Kuwait and KSA; and
- Be in a position to compete with the strongest oil and gas producer in the world

Table 6.3 shows that the average wages in Kuwait are almost 90% higher than the wages in KSA. The wages for KSA are the aggregate of all sectors including (private and public), whereas in Kuwait, as Table 6.3 shows the average wages of the public sector are lower compared with governmental institutions and the private sector. Saudi Arabia's weighted Average monthly Salaries in private Sector and public sector, 2010, (1.00 GBP=6.272 SAR, 28th May 2014).

Table 6.3 Average wages in KSA and Kuwait, KSA wages adopted from (Sheikh & Erbas 2011), average wage in KSA adopted from (payscale.com 2014)

	KSA	Kuwait lowest average
Average Monthly Salary £/month	Private sector 559	2738
	Public 1.810	
	Average 1500	

The *W-O strategy* aims to transform the company's weaknesses into strengths, to take advantage of opportunities. A high cost structure, partly resulting from high labour costs, may be alleviated to some extent through investments in new projects under new categories. The main reason for high wages is the nature of the work in KOC, which have been categorised as high risk jobs. Thus, the company is obliged to pay such wages. Potential clean projects are not categorised as high risk jobs, and so wages for green jobs will not cost the company as much as current wages.

Moreover, costs may also be reduced by satisfying part of the self-feed need for energy. As illustrated in SO strategies, KOC has the resources to attract the necessary qualified skills. KOC's bureaucratic structure, and the complacency caused by its past successes may be overcome, in part, through expanding their operations. New facilities, poster stations, and effluent water handling systems in KOC are accountable for its performance. This, in turn, should result in greater responsiveness to global demand. Moreover, centralised R&T, R&D and KISR should result in cost reductions.

The WT strategy aims to minimise internal weaknesses and external threats. KPC could use its power to enforce the government to bottom-up the necessity of establishing solutions in parallel with campaigns in orders find solutions of domestic energy consumption.

KOC should convince The State government to stop subsides for some of petroleum derivatives and electricity. In the second half of 2014, Kuwait's government started reducing some state subsidy payments, being at an advanced stage in preparing the plan to cut subsidies for kerosene and electricity. This approach was pursued by the government, after it emerged smugglers were selling diesel to the neighbouring countries at full price. However, such an approach much affects electricity also, in order to reduce non-rational electricity consumption. Subsidy cuts are an anticipated important economic reform for the country because lavish subsidies, spent mostly on energy, swallow about 5.1 billion dinars (£11 billion) annually, or roughly a quarter of the government's projected spending this fiscal year, according to government figures.

On the other hand, KOC can come overcome its relative weaknesses through applying L&G to keep operators up to date, as they will be able to develop a data warehouse and apply lean tools, such as: Gemba, Kaizen, standardised work, total productive maintenance and visual factory, offering a further explanation in detail about these tools, as can be found in the next chapter. In this way, KOC will not only become more able to compete with surrounding firms, but also with its competitors in the global marketplace. Through this flexibility and the availability of information, and through the possibility of achieving reduction in local consumption, KOC, in turn, would gain time to operate, eliminate further waste on the shop floor and gain more barrels for crude oil export.

From these illustrations, it is evident that KOC can pursue a combination of strategies, drawing on the strengths and weaknesses of the company, to take advantage of opportunities and to cope with external threats.

6.3 Evaluation and Choice of Strategy

After the development of various strategies, they have to be carefully evaluated before a choice is made. Strategic decisions should be considered in light of the risk involved.

Despite The State of Kuwait’s vast oil wealth, spending threatens to push its budget into deficit later this decade, (IMF 2013). Local consumption of energy is extreme and it must be an absolute priority to maintain the oil export share. Venturing into the renewables sector might involve some risks for KPC, since this business is outside the hydrocarbons field, which the company knows best. However, fulfilling local demand for oil and gas would involve certain risks, especially in the long term future. Thus, in hindsight, with the rapid construction of renewables in developed countries as well as neighbouring countries advocating mixing sources of energy by developed countries about 92% of Kuwait’s economy relies on exporting oil it is clear that the risk of entirely depending on oil can be great, especially with the lack of natural gas availability in the country.

It is true that some of the technologies linked to renewables may lack efficiency, but it remains to be seen whether the benefits will outweigh the disadvantages. Another critical element when choosing a strategy is timing, even the best product might fail if it is introduced at an inappropriate time. Moreover, the reaction of competitors should be taken into consideration. KOC has been taken a long time, in fact too long; almost five years 2009-2013 for a tender study to build the potential 5 MW, PV solar station before it gets approved (interviewee from KISR).

As mentioned earlier, neighbouring countries such as: UAE, KSA and Iran, and large National Oil firms (NOC) such as: Statoil in Norway (Statoil 2014), Nunaoil in Greenland (Laboratoriet 2014) have a much shorter strategic development cycle, and many petroleum firms can be heralded as examples of companies developing renewables businesses. Comparison with NOC would be more appropriate for KPC since it is a NOC corporation, and it is not as reasonable to compare MOC with international companies (ION) such as BP.

To remain competitive in its long term strategy, KOC has no choice but to shorten the model development strategy cycle. Clearly, competitors, world circumstances, regulations and demand often force companies to adopt certain strategies. The smart oil and gas NOC may do just that. These heightened alert and competitive threats may give KPC the impetus to reinvigorate its organisational culture, and lift their approach beyond their mission.

6.3.1 Consistency Testing and Preparation of Contingency Plans

The final key aspects of the strategic planning process, as shown in Figure 3.3 (see Chapter 3, p. 107) are testing for consistency and preparation for contingency plans. Researchers question KPC’s philosophy for not venturing outside the traditional hydrocarbon business and expanding into the carbon management market and renewables projects. In the future, expansion might be essential to support the country. The orderly state bureaucratic organization structure appears to be inconsistent with the potential market requirement from enterprise to operate highly efficiently. It is not clear if KOC has prepared contingency plans in the event that an efficient source of energy comes into the market or even to cope with the rapid growth of the domestic population.

Apparently, none of Kuwait organisations including the government have seriously taken into account the potential risk of a lack of energy supply and budget deficit.

In September 2014, the Diplomatic Centre for Strategic Studies (DCSS 2014) warned Kuwait's government about the rapid incremental rise in governmental expenses. It was advocated to rein in expenses by reducing expenses (ongoing) and by adjusting growth in wages and supporting rationalisation, while also strengthening capital investment as well as increasing non-oil revenues. DCSS pointed out that the State's budget is losing the tools to ensure stability because of its heavy dependence on oil revenues. The centre claimed that a fiscal deficit in the budget for 2013/2014 emerged due to a rise in expenditure, and failure to invest in non-oil revenues, thereby aggravating structural imbalances.

The report claimed that many people did not notice the high non-oil deficit in the budget because of increased oil revenues and huge financial surpluses. The surge in the non-oil fiscal deficit may reveal the national economy is at risk, and the huge deficit reflects a weakness in the foundation of current revenue sources, and confirms that the fiscal approach is unsustainable.

One of the most prevalent risks to Kuwait is its tendency to look at the significant growth in oil revenues as though it is eternal, the report advocated the need to restructure public finances in order to increase the volume of non-oil revenues and curb current expenditure. The unstable crude oil price, the negative impact on the public finances, and occurrence of a deficit in the public budget, especially in light of economic conditions and volatile political, DCSS insisted that the government has to hedge the deficit.

In January 2015, The State of Kuwait Finance Ministry announced a deficit in the 2015/2016 budget. This deficit mainly resulted from the large drop in oil prices and the huge number of state employees (Gulfbusiness 2015).

6.4 Summary

This chapter presented a strategic plan that recommended new approaches that could be employed to create an economic advantage against its competitive rivals. It has showed; that although KOC has had a long experience in creating strategic plans, it has still not implemented the modern green strategies, that are used by its competitors in other developed countries. The main concern against the green policies was the deployment of the resources in an efficient way, which would still serve Kuwait's economy. This chapter presented green strategic solutions to serve the main theme of the data analysis (Global leader on upstream oil and gas operations).

The next chapter firstly applies L&G to developing lean & green oil and gas production operations. The implementation is discussed at the micro level, focusing on the conventional lean production system tools, mainly drawing on the lean values stream mapping. Secondly a PV solar system model is developed to supply a single CG with clean energy, initially to be shown as a proof a concept in the production of oil and gas and then to show that even in heavy continuous production, these methods can be used with renewable resources.

Chapter 7 L&G Operations in the Oil and Gas Case

The sub-theme of Chapter 5 (i.e. the efficiency of GCs) resulted from the process of analysing the research data derived from direct observations and interviews in the company's fields. Both qualitative and quantitative data have been used in this chapter, which focuses on the findings of the fieldwork (including the stages of its analysis from Chapter 5 and findings from Chapter 6), in order to generate the outcomes of the fieldwork data using lean and green (L&G) on the Gathering Centre (GC).

7.1 Introduction

Chapter 6 discussed the findings of the strategic level of the case study. The research question, 'What benefits would Kuwait Oil Company (KOC) gain if it adopted a green strategy?', together with the findings from Chapter 6 established that if Kuwait Oil Company (KOC) developed a green strategy it would maintain its position as a high-ranking global hydrocarbon company. The findings from the previous chapter have demonstrated that large competitors have begun merging their businesses in order to prepare for 2030. KOC is of the opinion that oil will remain the primary source of energy and that its price will consistently increase. The findings of the TOWS Matrix, along with the results of the data analysis process, indicate further improvements could be made to improve productivity and efficiency in KOC's oil and gas upstream operations. This will form the subject of this chapter. Efficiency improvements have a butterfly effect on an operation, eventually improving the image of a country within the world's economy, while also improving the economy and the ecosystem. This is demonstrated by the fact that if Kuwait, represented by KPC and MEW, followed other OECD countries and increased their operational efficiency, then they (KOC, MEW) would consume fewer resources, while also having lower levels of GHG emissions (Filippini & Hunt, 2011; Asif & Muneer, 2007; BP, 2010a).

This chapter examines a number of key factors critical to the implementation of lean and green (L&G) within KOC's production plants, including the fact that 'leadership' by senior management is essential to the development of a new culture, and therefore a new roadmap. From the interviews, it has been hypothesised that the commitment of senior management is the most critical factor for the success of any project in KOC. Senior management is the only authority in the company able to influence the company's decisions, being a source of inspiration, motivation, and providing support for each member of the organisation (Vera & Crossan, 2004).

The decision makers are KOC's senior management and the planning group, particularly the latter, as it is engaged in designing plans and drawing up the company's strategy. Thus, convincing the planning group to adopt L&G within the company's strategy would result in significant influence on each department and employee in the company. The following section discusses the relevant factors in more detail.

The basis of establishing the operation and success of any project consists of finance, which can only become available with the agreement of senior management. Finance could play a significant part in training, consultancy, and developing L&G culture. Finance can also prove to be a major obstacle in the establishment of L&G within KOC, raising fears that its adoption demands additional expense, including the additional improvements, such as hiring consultancies, training courses for employees or the re-arrangement of the existing machines to aid implementation.. This chapter will illustrate the ways in which considerable improvement can be achieved if KOC adopts L&G for its operations.

7.2 Lean production

The concept of lean production has been developed by the Toyota Production System (TPS), to develop tools that focus on waste elimination in parallel with meeting customer satisfaction (Hines *et al*., 2004). Lean production has been criticised as being incapable of resolving environmental issues within plants. However, a number of researchers have suggested that lean production has the potential to influence environmental management and improve the use of resources, even though it might not have the capacity to address all environmental issues (Rothenberg *et al*., 2009; Florida, 1996; Andrew & Michael, 2009). For this reason, the research in Chapter 6 utilised the TOWS Matrix to address these issues and develop additional solutions to reduce environmental pollutants within the hydrocarbon company.

The findings from Chapter 6 demonstrate that the company is under pressure to satisfy the demands of a number of different groups. Although strategic solutions were developed in the course of the chapter, there are still a number of operational gaps that need to be covered. One part of the recommendations from Chapter 6 concerned the need for the company to redefine and redesign its oil and gas production operations, in order to tackle the competitiveness of peer markets, particularly those immediately surrounding the company. A number of the findings in Chapter 6 (as well as part of the data analysis in Chapter 5 (i.e. GC efficiency)) conclude that it is necessary to be in possession of practical tools to support the redesigning process and the operations in the GC-floor. A number of the concepts and theories in operations management (i.e. from lean production to manufacturing strategies), have been developed through the case study in the field, a method of investigation that enriches both the theories and the research (Voss *et al.*, 2002).

Thus the lean manufacturing approach (Womack & Jones, 1996) or L&G (EPA, 2003), was conducted and developed primarily by the use of a Value Stream Mapping (VSM) tool (Rother & Shook, 2003) as a method of displaying the production line with a lean vision. A number of cases have demonstrated the validity and success of the application of this tool, particularly to enable continuous and complex production lines to deliver more efficient operations (Abdulmalek & Rajgopal, 2007; Braglia et al., 2006; GSN, 2012). The application of lean production has been widely employed in different sectors of industry, i.e. white goods, and automotive electrics. Some authors have argued that there might be difficulties in using lean in the continuous production sector, (Abdulmalek & Rajgopal, 2007), while others have established that lean is an effective application for the delivery of a green industry (Andrew & Michael, 2009; Simons & Mason, 2003; Miller et al., 2010).

Through the use of lean, this chapter illustrates the specification of the factors creating value for the end customer driven by an ‘environmental demand’. The analysis values stream map is used to identify the ‘value’ offered by lean production, including both value added and non-value added activities taking place in the plant to accomplish production operations. Value stream mapping introduces the production flow in detail, in order to identify and eliminate as many of non-value added activities within the production line as is practical, and improve as many value-added processes as possible (Womack & Jones, 1996). The literature review has previously revealed how VSM, as a tool of lean production, is effective in delivering an efficient production plant, particularly after recommendations from EPA (2005). A number of further lean techniques are also employed in this chapter.

7.3 Value Stream Mapping

This section focuses on VSM, along with a number of lean tools and techniques employed in this study to enhance GC efficiency and deliver cleaner operations. VSM is a tool that can be used to map production processes, as well as the entire supply-chain network. In the current study, VSM focuses on mapping oil and gas production processes in KOC’s GC-floor. Alongside the processes, VSM contains further details of control production, material flow and the time consuming, step-by-step procedure to facilitate the analysis (Braglia *et al.*, 2006). VSM presents the action and activities of value- added and non-value-added aspects essential to bringing a product (or product family) using the same resources, and sharing the same flow start from wells (the source of raw material), to the final point in the production line (Rother & Shook, 2003). This flow contains both material and information. All the data used in this chapter were sourced by site survey, historical data of production and the GC manuals.

The aim of using VSM is to eliminate all types of waste in the production line, through the displaying of the flow of materials and information concerning production operations. Lean VSM is a pencil and paper tool, and taking the value stream viewpoint means working on the big picture and not each individual process (McDonald et al., 2002), by using a predefined set of standardised icons (see Figure 7.1 Value stream mapping icons (source Rother & Shook, 2003). In order to develop green production operations in GG, the VSM is used to source non-value added time and material, along with investigating opportunities to increase the efficiency of operations and develop plans for implementing improvement. VSM is a tool employed to review processes and reveal substantial opportunities to reduce cost, improve production flow, save time, reduce inventory and improve environmental performance. Conventional VSM can oversee environmental waste in order to:

- Identify waste of raw materials.
- Identify material waste and pollutants released into the environment, i.e. flaring, disposable water, and hazardous waste.
- Identify hazardous substances during production with the ability to harm human health or the environment.

Green production has been developed to include L&G features into its mapping techniques, in order to:

- Understand where an environmental impact is taking place in the production line.
- Quantify chemicals used by processes, and compare this to the precise need.
- Identify pollution and waste generated by operations, i.e. reduce electricity consumption and machines breakdowns results reduce gases emission,
- Identify root causes of waste and inefficiencies.
- Understand waste of energy and water.

Eight lean questions were used as guidelines to construct the lean VSM (McDonald *et al.*, 2002) (see Table 7.1 The eight Lean questions (source McDonald *et al.*, 2002) p. 192) as a platform on which to deploy development in the plant, on issues related to efficiency, and technical applications linked to the use of lean tools. This map then became the basis for implementing the necessary changes in the shop-floor.

The researcher monitored the mechanism of the GC's operation to understand the effectiveness of using lean production VSM and determine its correct application. The primary approach to understanding the GC operators consisted of specific figures to manage the VSM process. VSM is based on five phases put into practice by a specialised team created for such a purpose (Rother & Shook, 2003). These phases consist of:

1. Selection of a product family;
2. Current state mapping;
3. Future state mapping;
4. Defining a working plan; and
5. Achieving the working plan.

The first step was to choose a family of products as targets for improvement. In GC, the single source 'liquid oil' produces both crude oil and associated gas. The next step is to draw up a current VSM that demonstrates the current sequence of operations. This can be established while walking through the plant, providing a basis for analysing the production line and identifying its weaknesses. The third step is to create a future VSM, i.e. a picture of how the operation should look after the Kaizen has been applied.

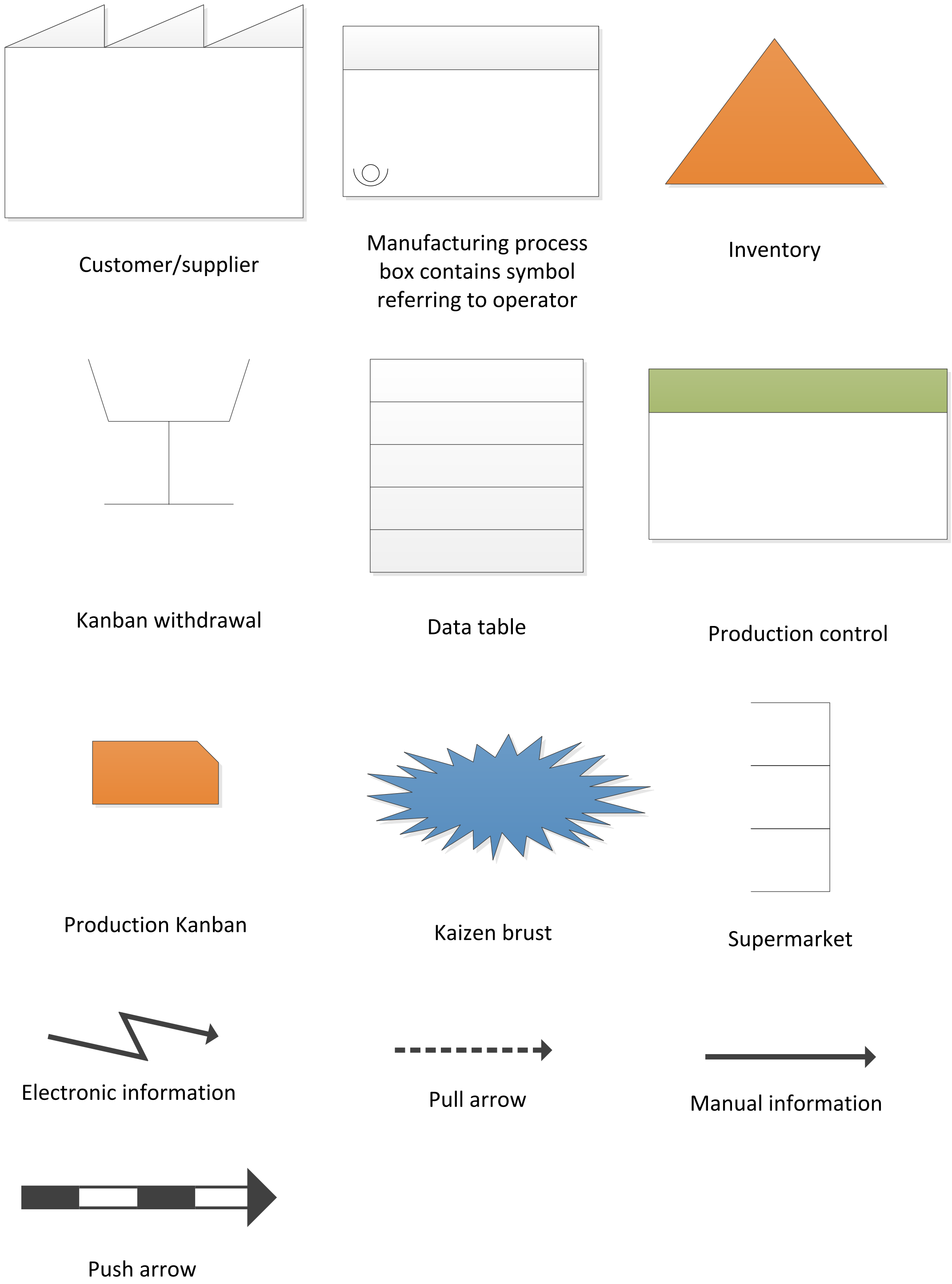

Figure 7.1 Value stream mapping icons (source Rother & Shook, 2003)

Table 7.1 The eight Lean questions (source McDonald et al., 2002)

Future-state questions	
Basic	1. What is the takt time? 2. Will production produce to a finished goods supermarket or directly to shipping? 3. Where continuous flow processing can be utilised? 4. Is there a need for a supermarket pull system within the value stream? 5. What single point in the production chain will be used to schedule production?
Heijunka	6. How will the production mix be levelled at the pacemaker process? 7. What increment of work will be consistently released from the pacemaker process?
Kaizen	8. What process improvements will be necessary?

All data for VSM data was collected according to the approach of Sayer & Williams (2012), and Rother & Shook (2003). Data collection for the oil and gas flow was collected in a single plant, starting from inlet headers ending in final pumps, after the effluent water surge tank for oil and outlet points for gas, and gathering snapshot data, i.e. daily production (see Figure 4 3 GC Overview, **a capture screen from the control room, GC's operations map**, p 127 .in Chapter 4). It should be noted that this data was collected whilst walking through in the shop floor, while one operator described all the process in the plant, including the provision of historical data, GC's manual and the manual for the machines. After all the information related to the machines, processes, material flow and energy consumption have been collected, they are connected as indicated by the arrows in the map, representing the way in which each process receives and processes liquid oil. The production data used in the VSM is completely based on the average of the historical data of 2012, (see Figure 7.3 Liquid oil production historical data 2012 (source KOC). It should be noted that there are four tanks in the map, (see Figure 4 3 GC Overview, a capture screen from the control room, Chapter 4, p. 127), with only one tank (i.e. the dry tank) considered the final product. The dual tank is a standby, in case of the wet tank experiencing a failure, in which case the dual tank takes its place. The wet and test tanks contain water/oily water that cannot be considered as the final product. In this current study, the wet tank inside the GC floor has been treated as part of the inventory. Data collection for the material flow began at the Inlet Headers (Manifolds), and worked forward to:

- The dry tank for the crude oil;
- The wet tank for the wet crude oil (i.e. to complete the oil-water separation process);
- The effluent Surge Tank for the Water; and
- Outlet points for the gas via two CRUs to the flaring or gas booster station.

Data appears in the VSM processes as the waiting time and cycle time. In the GC, all machines operate 24 hours/seven days a week, including being on standby and therefore no change needs to be considered.

Operators in the GC-floor operate and monitor all operations from the control room (see Figure 7.2 below). Apart from any failure (when operators might need to restart the machines from the control room) there are no physical attachments to the machines in the GC. Should advance failure occur, operators need to call upon the maintenance group to resolve the problem, for this reason, operators are not considered for VSM.

Figure 7.2 Control room (source Kashagan.today, 2015)

7.3.1 VSM: current state map

GC does not produce a wide variety of product configurations, which are specified by KOC's managers, despite the fact that they are focusing on a variety of markets, particularly competition within local regional markets.

KOC needs to meet a daily oil production target of approximately 2.8 million barrels/day across 22 GCs, with the average capacity of each GC designed to be approximately 300,000-500,000 barrels/day. The quantity of gas produced is linked to that of oil, as the gas is extracted from oil. GC produces a specific amount of crude oil on a daily basis, based on its location and the number of reservoirs to which it is connected. The average daily amount of oil delivered to the case study (GC-floor) in 2012 was 118,869.46 barrel/day, containing 56,266.12 60 MMcf gas per day. The distribution of outputs by product is as follows:

- 104,854.26 barrels of crude oil per day (product).
- 56,131.60 MMcf gas per day (product).

- 143.17 MMcf gas flaring loss/ day (average) equalling an average of 3.17% /day.
- 13,987.05 bbl./day water cut.
- Electricity consumption 22.03 MW/h.

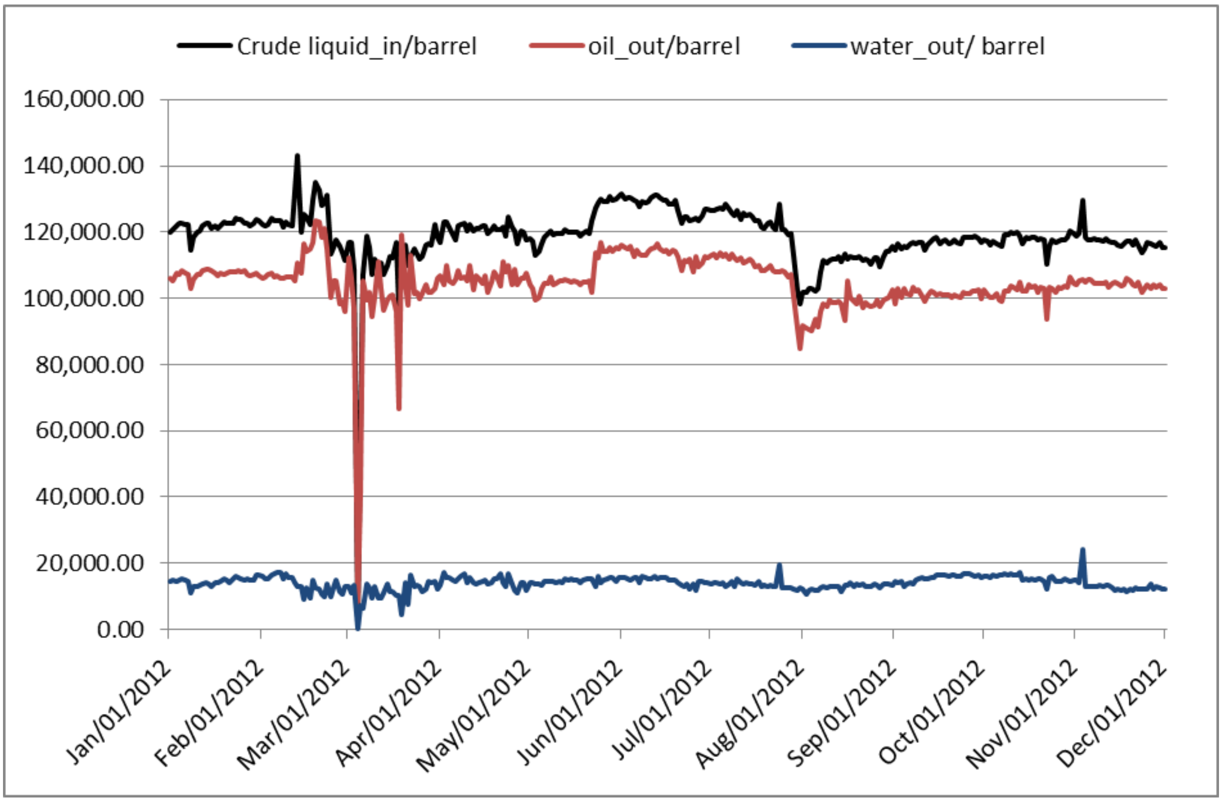

Figure 7.3 Liquid oil production historical data 2012 (source KOC)

Figure 7.3 above reveals the production of GC during 2012 (gas is not included). Within only one year, the average production of crude oil liquid and oil is slightly decreased, whereas the water cut is fixed, leading to a possible indication that the percentage of waste increases. In order to establish a clearer overview of the history of oil production at this GC, Figure 7.4 gives results over five years, i.e. from 1st December 2007 to 1st December 2012. It reveals liquid in, oil out and water cut, establishing that in 2012 the amount of liquid was higher than in 2008.

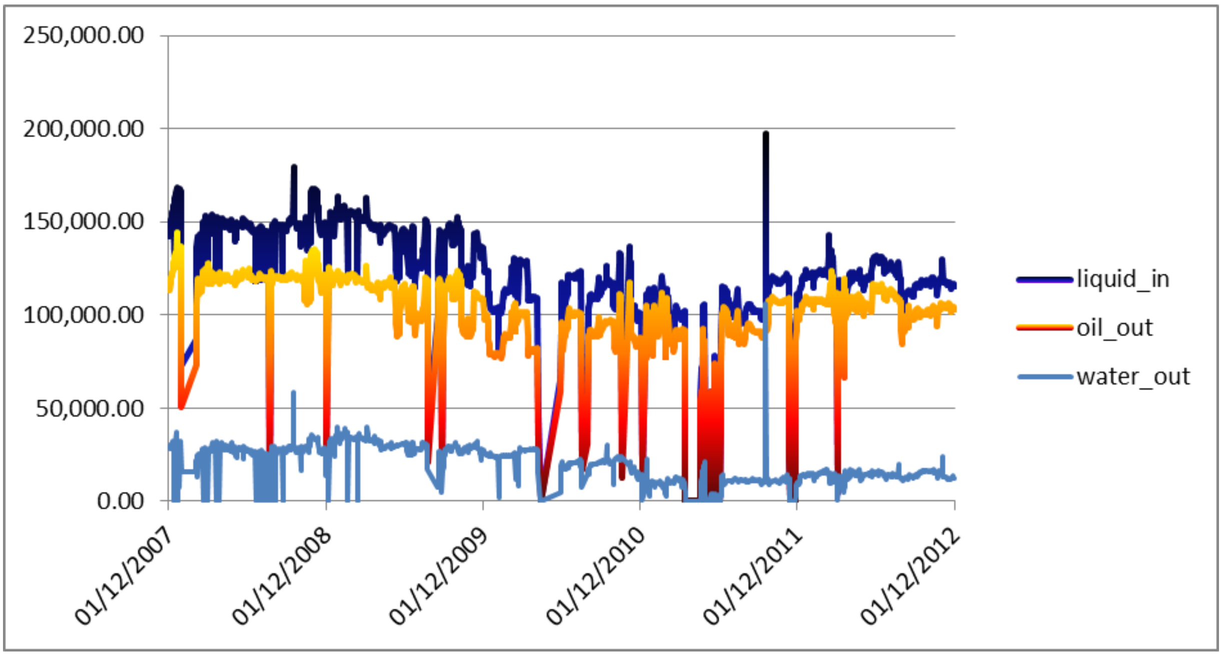

Figure 7.4 Five years' production (2007-2012), (source OC)

The fall in each point on the chart indicates shutdowns in the GC, either planned (i.e. due to scheduled preventive maintenance) or unplanned (i.e. due to a breakdown of machines). In Figure 7.3, on 3rd and 4th March, the fall was due to an unscheduled shutdown occurring in the GC. In Figure 7.4, the liquid line demonstrates a decline between 2007-2012. The production group state that this can be for the following reasons:

- Geological issues;
- Some reservoirs ageing;
- Machine efficiency.

This research (and particularly that in the current chapter) aims to address the above issues by identifying alternative clean energy resources to reduce the load on oil, and enhance the efficiency of these operations. Efficiency can be addressed with advanced management tools; however, the operators are of the opinion that this does not imply that some machines should be replaced. On the other hand, any rises in the water cut ratio within liquid oil requires increased resources and time within oil recovery operations in the GC floor, hence the focus on potential improvement to deliver quality while saving on time and resources. Daily production is constant, and sent continuously to Kuwait National Petroleum Company (KNPC) through the connected pipeline network, 24 hours/seven days a week. KOC does not deal with customers directly, but sends the production to its sister company, KNPC, which acts as a dealer, selling, distributing and refining the production.

Figure 7.5 Current value stream map, (p. 200), demonstrates HP and LP off-gases from the separators passing through both HP and LP scrubbers to remove entrained liquids. Vented gases from the wet, dual and dry crude tanks are compressed by means of the tank vapour compressor in the CRU, before entering the export HP gas system. The products from the CRU are lean gas and condensate, both of which are routed to the company's gas and condensate networks. As part of this production, it is important to stabilise the pressures and liquid levels in the tanks. In order to maintain constant production from the wells, there needs to be an estimation of the production target, through which the production team estimate they can achieve the daily target, and thorough-schedule operations on the production units on daily basis (i.e. the morning shift). This is followed by the next production team (i.e. the night shift) possibly adjusting a routing of production, including raw materials required for production on the order, and then assigning a plan for the following 24 hours.

This schedule on the operating side becomes the basis of the monitoring of day-by-day changes of output levels against how closely they accord with the schedule. The schedules can then be further updated, on an as-needed basis, to daily (or even bi-daily) schedules. The production team employs two types of transportation methods to transfer the production of crude oil, gas and waste water: (1) Pump (electricity); (2) Ruston gas turbine ta 1500.

As noted previously, liquid oil arrives at the GC in a number of different forms: HP, LP, wet and dry. The dry crude is constantly sent to dry tank then to the farm tank, while high pressure gas is transferred to the gas poster station and low pressure gas is transferred to the export line. The plant works on a continuous basis, 24 hours a day throughout the year (apart from major shutdowns) and runs a two-shift operation for the GC. Conventional VSM examines the time it takes to produce a product in order to present the proportion of that time that is value-added, or non-value-added. The timeline forms a graphic representation of a comparison of both, but without focussing on the resources consumed, and waste generated, during production.

Figure 7.5 (p. 200) demonstrates one day (i.e. 24 hours) of a value stream manager, with the timeline at the bottom of the current state map including two components. One production day lead-time was established to work on the stages of the process as a whole. The assigned time was integrated into the 24 hours period the team considered correct. The total observed value can be gained for the waiting time, including settling and separation in the wet tank, and sampling and testing.

The first component concerns the production waiting time required to accomplish the separation and settling process in the wet tank, which is primarily undertaken by a gravitational method (i.e. time and gravity). Free water carried in the crude can be easily separated when given sufficient space and time (i.e. between 25 and 120 minutes for the gases and combined water in the liquids to flash off, with operators stating that, at times, they leave it as long as possible in order to gain the best results. It was therefore assumed that, on average, this process takes 90 minutes after the validation of the operator. Reduced waiting time at this stage leads to eliminating the inventory in the GC-floor.

Next, the new sample is collected. This is primarily from the dry tank, as well as from other random locations within the GC, and can also be taken from the pipelines and machines (including the tanks) to test the quality of the crude. The sample goes to the laboratory, where, if the test result does not meet KOC's quality standards, operators are obliged to re-process the batch. Taking further action to adjust the quality of the crude oil by injecting an additional dosage of chemicals, or an additional wash with water, might needed, or the heat increased. Alternatively, it can be achieved through increased settling time in the wet time (depending on the test result). Washing with water (Agitation/Dilute salt) refers to wash water being injected into the crude to dilute highly concentrated salt water.

The distance between the GC and the laboratory is approximately five miles, and workers are not available to transfer the sample themselves, and waiting for the driver would cost the GC operations additional non-value added time. The sample therefore takes a considerable length of time to reach to the laboratory, with the results also taking time to appear: a total of between 100 to 140 minutes. Thus, it is assumed that waiting time at this stage is 120 minutes.

The longer waiting time keeps operators processing the same crude in the GC until the results of the test on the sample appears. This is known as work in process (WIP). Therefore, the investigation considers the amount of raw material consumed along the production line during such waiting times, due to the fact that the raw materials are hazardous and of high cost, in particular the chemical 'demulsifier' used to treat the oil. The value added can be achieved during this stage through reducing the lead time, which would result in a reduced inventory and the consumption of other resources, e.g. chemicals, and energy. Waiting time is considered to be:

- Waiting for settling and separation in the wet tank:

    - 90 minutes = 0.0625 day

- Waiting for sampling: delivery of samples and test results:

    - 120 minutes = 0.083 day

- Total waiting time:

    - 0.146 day

As GC's machines are operating constantly, the CT for the plant is 86400 sec, undertaken in two shifts, including a number of machine breakdowns (although KOC does not preserve the historical data). For the desalter and dehydration trains, CT was estimated for a single batch of wet oil according to the operators. Although the desalter deals with the batches system, its actual processing time remains 24/7 (there is no standby-mode, apart from when case pumps require cleaning). The desalter's manual states that its capacity is 150,000 barrels of oil, thus it is able to handle more than the daily production in single batch. However, multiple batches of wet oil are sent to the desalter trains during a single production day, due to multiple factors, including: waiting for other machines; waiting for sampling tests; to ensure efficient processing. The desalter and dehydration (i.e. desalter trains) plant is the main treatment stage, and forms the main stage in which treatments are added to the wet crude oil (i.e. washed water and chemicals). The operators noted that the desalter and dehydration plant requires 180 to 360 minutes to process a single batch, with processing assumed to be 300 minutes.

Thus, the desalter dehydration plant can form the optimal process to achieve added-value to the production line. Each batch of wet crude oil desalting operation consumes around 18000 sec. Test results of the sampling is the parameter to assign the time required for wet crude oil desalting in the desalter. Operators were not able to provide more accurate times for the desalter processing, as they claim it varies and is uncertain.

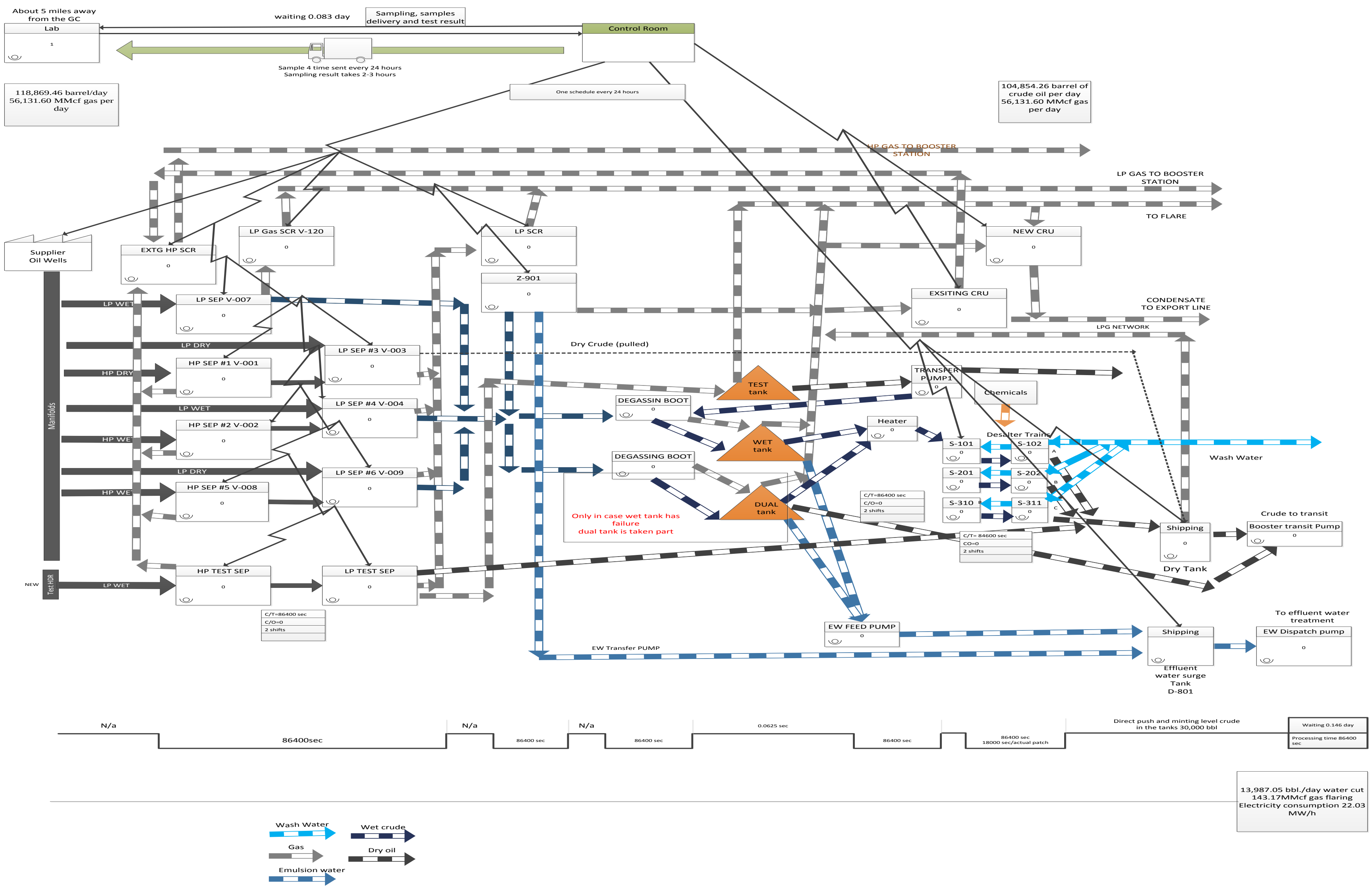

Figure 7.5 Current value stream map

7.3.2 Future VSM

Rother & Shook (2003) advise “don’t get hung up trying to make all the details on the future state map perfectly correct. Fine tunes the future state map as implementation progresses”.

The future VSM is a developed version of the existing one, and demonstrates the current VSM; it shows the type of improvements that can be undertaken to enhance the production flow, and in which areas within the operations. A future state map was developed to demonstrate what production line would be like after the implementation of the recommendations, with the future state map developed to be green, based on current VSM. The focus is to deliver green GC to demonstrate to KOC’s stakeholders, areas of waste, where environmental improvements can take place. The aim of future VSM in this study is to position renewables as a source of energy, in order to produce oil and gas. Future VSM focuses on the improvement of processes. Opportunities for process improvement can be demonstrated in the future VSM with a Kaizen burst (see Figure 7.24 Future VSM, p.243), with Kaizen able to identify the processes requiring improvement. Future state maps should represent a highly efficient operational optimisation. The line of the materials in both current/future VSM is an indicator of where opportunities for improvement exist. From the current VSM (see Figure 7.5 Current value stream map, p. 200), a number of gaps stand out:

- The considerable variation in inventory time in the wet tank (settling time).
- Sampling and testing processes are time consuming.
- More energy can be saved.
- There is a large variation in desalting time processes.

The inventory in the wet tank is strongly related to time, viscosity and gravity, along with other chemical resources needed to accomplish the settling process. Operators assume that the longer the time required completing settling, the fewer barrels of oil produced, along with increased pollution generated on the GC-floor. In order to create L&G in the future VSM, a number of tools must be identified to reduce waiting time, alongside the consumption of resources for crude oil and gas production processes. Answering the eight lean questions assists in the development of the ideal future VSM, primarily due to the fact that it will reveal less waste appearing within GC’s operations (McDonald *et al.*, 2002).

Question 1: What is the takt time?

'Takt time' refers to the rate at which customers purchase products from the production line, i.e. the unit production rate required to match customer requirements.

Takt Time = Available Minutes for Production / Required Units of Production.

The throughput required for the processed crude oil product at the GC averages at 104,854 barrel of crude oil per day. GC continuously runs two shifts per day, which translates to 1440 working minutes per day. Thus the takt time is 1440 / 104,854.26 = 0.014 minute per barrel of crude oil.

Available time is to take the total shift minute(s), without counting breaks (in the GC operation there are no breaks), shutdown events, and other non-working time. According to the operators, in a normal day (i.e. with no machine malfunction) GC operates 24 hours.

Question 2: Will production go directly to shipping or to a finished goods supermarket?

A 'supermarket' is a buffer, or storage, area located at the end of the production process for products ready to be shipped (Rother & Shook, 2003). Production that is directly shipped refers to when it is only products that are ready to be shipped that are produced. From liquid oil, GC produces crude oil, gas and water, sending them to different locations within the GC, where they are stored to be sent to different destinations.

Crude oil: the treated crude is then routed to the dry tanks, from where it is pumped into the export product pipeline. Operators need to maintain a level of crude inside the dry tank of approximately 11 feet, or 30,000 barrels, before it is pushed into the tank farm of KOC (see Figure 7.6 Crude tank specifications (source KOC) p. 205). GC production is based on continuous flow rather than the batches system; (see Table 4.1: GC's tanks capacities for all tank capacities, Chapter 4, p. 123).

Gases: the Tank Vapour Flare Header collects the vapours from the wet, dry, dual and test tanks, which are normally taken to the Condensate Recovery Unit (CRU). Should CRU be operating on part load, or is on shutdown, the vapours are routed to the LP Flare system. The products from the CRU are lean gas and condensate, both of which are routed to the existing gas and condensate networks of the company.

Emulsion water: the treated water from the water treatment package is connected to the effluent water inlet line going to effluent water surge tank, 06-D-80.

Therefore, in this application, as the production lines are based on continuous flow rather than a batches system, and this is done based on a push system, the product is pushed directly from GC, and thus a supermarket is not needed for the finished goods.

Question 3: Where can continuous flow processing be utilised?

As noted in Question 2, the holistic production in GC is continuous flow style, but a number of stations in GC operate on a batches system. This is only for wet crude oil production operations in GC, due to the fact that they cannot be easily moved into the classical continuous flow style, as the dry crude production line consists of continuous flow and (at least until 2020) the daily production of crude oil in the GC must be fixed, no matter how much water cut is processed within the daily operations.

In general, oil recovery and gas separation processes have a significant amount of continuous flow, in particular dry crude oil production and associated gas production, which already uses the continuous flow design, apart from wet crude oil production. By passing through different stations, dry oil is sent directly to the dry tanks after the gas separation process, and is then sent to the export tank farm. In the dry tank (i.e. the final product) operators apply a push system in order to maintain the level of crude oil in the dry tank, i.e. 11 feet, which is equivalent to 30,000 barrels.

In the case of the wet oil, it is difficult to introduce continuous flow between the stations of the wet tank and desalter trains, and a feed pump applies a hybrid pull/push to take the crude from the wet tank to the desalter. Operators establish a set point for the interface level in the wet tank between the crude oil and water (i.e. there is a crude level set point and an interface set point). If the interface set point becomes low and the valve (LCV) closes, this indicates that the settling process is not processing well, leading to the operators decreasing the flow rate of the feed pump for the desalter. Thus, if the feed pump pulls 40,000 m3/h, and the operator notices that the set point of the interface is becoming lower, and the valve LCV controlling the interface is closed (i.e. no water discharge to surge tank), operators will decrease the flow rate of the feed pump in order to give more time for settling and raise the water set point to the desired level. Operators claim the process is not precise.

Therefore, in order to improve continuous flow at this point, 'Kaizen' focuses on the wet crude, and particularly those two workstations (i.e. the wet tank and desalter trains). At this station, one 'Kanban/pull' is applied to stabilise the feed pump flow rate pull by the desalter and provide a history of the pump flow rate (which reflects the interface set point in the wet tank) rather than waiting for the LCV to close. However, at this stage continuous flow is still not possible, due to the time required to accomplish settling operations. A Just-In-Time (JIT) Kanban/Pull system will play a significant role in the wet tanks' ability to eliminate the inventory on the GC shop floor, and will also help to consume less of the essential resources to accomplish oil recovery operations (see question 4 for further details). The time required for the separation of water from the crude in the wet tank ranges between 25 to 120 minutes, while leaving the wet crude in wet tank for longer means a greater consumption of raw material. Thus any reduction in the time variation at this station is value added time. The connection between wet tanks and the desalter is manipulated by the following: tank pressure; the temperature of the crude; chemical injection; the nature of the crude; quantity; gravity; time. The method of identifying the status of the wet crude oil consists of sampling, establishing whether it is ready to be transferred (for additional details see Quality-at-the-source).

In order to achieve Kaizen, it is recommended to allocate the laboratory testing the samples inside the GC–floor to establish the Kanban/pull and thus create a smoother flow for the wet crude oil. Current procedure is that the main samples are taken from the dry tank twice during each shift, after all operations have been completed, to ensure that the quality of the crude oil meets KOC's quality standards. The water carried in the crude is normally salty, and mostly in the form of emulsion (i.e. droplets of water dispersed throughout the crude oil). The desalter treats the wet crude to the required specifications of 5 Pounds per Thousand Barrel (PTB) (Pounds/1000 barrel of oil BBL) Salt and 0.1% Basic Sediment and Water (BS&W).

Wet tanks are designed to reduce the crude water cut from 25% to 10% at the outlet, and the desalter plants are designed for a maximum of 10% water in the crude water cut at the inlet. Thus, the introduction of the wet tank controlled by a Kanban system forces the entire wet crude to keep pace with the desalter at the speed of the bottleneck (see question 4 for further details). The desalter takes on the characteristics of an assembly line, where wet oil begins flow more smoothly from the wet tanks, rather than a stop and start system controlled by vague waiting.

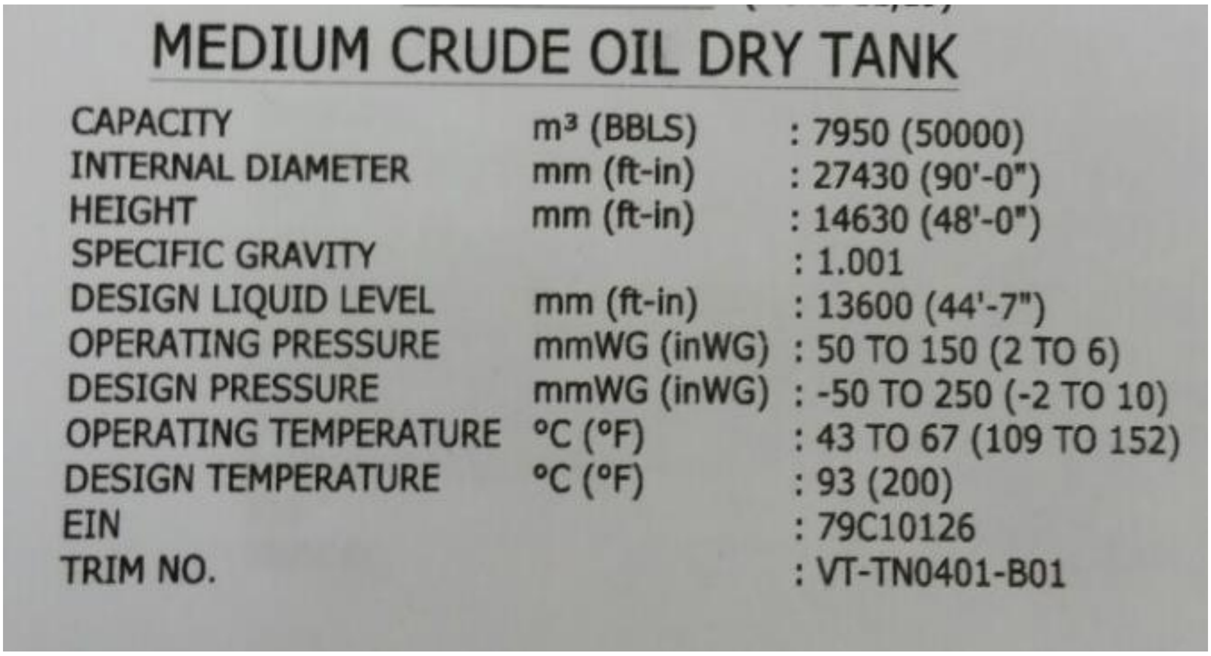

Figure 7.6 Crude tank specifications (source KOC)

Question 4: Where will KOC need to use the pull system of supermarkets inside the value stream?

A pull supermarket works as an interface between processes in the production line, in order to create continuous flow material required for production.

The dry crude oil production line is designed to be a continuous flow process, and therefore it does not make sense to position a supermarket in any station within this line. The introduction of supermarkets is highly beneficial, and necessary only at the finishing end, where amounts of inventory exist between different workstations. This is what is occurring within wet crude operations, particularly in the stations containing the wet tank and desalter trains. According to the GC's manual:

> *Settling time can be a costly factor because operators may need to reduce the flow rate through the Desalter to increase the settling time. If production cut back is allowed, it may be possible to reduce the flow rate to rebalance the equation. Otherwise, balance other factors, 'little here'; 'little there'* (GC manual).

This is where the supermarket will play a vital role, by providing sufficient space and increased control over the crude flow rate. At this stage, the pull method from the desalter can be exponentially enhanced, in order to give the desalter the advantage of pulling more smoothly from the supermarket and reaching continuous flow. When this recommendation was presented to the stakeholders, they agreed that at this stage the supermarket would generate a third stage of separation, leading to:

- Changing waiting times in at this stage from an average of 90 minutes to almost zero (i.e. from the perspective of the desalter), while in the supermarket the new stage of available settled crude will omit any need for waiting.
- Making the desalter work more flexibly and comfortably, as verified by the operators.
- Saving chemical injection for when operators judge it is needed, as a result of clarity provided for the process.

Therefore, one supermarket is needed to create a smoother flow (if not a continues flow) within the wet crude production line, i.e. between the wet tank and desalter trains (see Figure 7.24 Future VSM, p.243). The availability of a supermarket between these stations will provide:

- Crude ready to be processed to the desalter;
- A clear idea concerning the status of the crude;
- The reduction of waiting time;
- Conservation of an injection of an additional dosage chemical required for oil treatment (i.e. the injection of the demulsifier chemical is a primary factor in the completion of the emulation and desalting processes in the desalter trains.

To achieve Just-In-Time (JIT) Kanban/pull (i.e. the same Kanban as in question 3) a further pump should be installed between the wet tank and the supermarket. JIT Kanban pull adjusts the pump flow rate from the wet tank to the supermarket after the crude has been separated, when given sufficient space and residence. The end result is typically a significantly unnecessary inventory inside the GC where the Kaizen takes place. The GC manual states that this stage of separation is primarily affected by time, gravity and demulsifier dosage. Thus, a supermarket is recommended to enhance the pull system and the pump flow rate to the desalter. The JIT Kanban/pull should contain:

1- The level of interface of crude oil in the wet tank;

2- Crude oil quality specification API;

3- The quantity of the chemical dosage injected into the crude oil;

4- Time taken to accomplish the settlement process.

Kanban is a prime example of a pull system. It is ‘single-peace-flow’, which increases continuously, eliminating an unnecessary Work In Process (WIP) inventory (Rother & Shook, 2003). The traditional pull method currently applied at this stage is based on time estimation. The JIT Kanban/pull would create greater flexibility on the GC floor.

However, in the GC, the Kanban is not a card that travels between stations as a typical Kanban: it either will either travel as a t-cards travel in dashboard (see Figure 7.10 Crude Oil Quality Manual (COQM) board, p. 222, for further details), or it can be a computer command created through the use of scheduling software (Scheduleit.co.uk, 2014) to provide a history of the oil and water interface. Thus, Kanban serves to ultimately eliminate any waste of time and treatment methods, and is known as ‘in-production Kanban’ (i.e. used between processes in a plant). This is the point at which ‘poka yoke’ can be can developed with time, and increased description of lean tools for improvement of the sections processes.

JIT/production Kanban systems will reduce the amount of necessary in-process and post-process inventory in the wet tank. It will typically allow additional available space in the tanks (i.e. eliminating the inventory), as the GC is a plant rather than a warehouse. Reduction in square footage on the shop-floor is significant in reducing energy use for additional processing, and to reduce chemical consumption and the waste associated with maintaining of the unneeded space in the wet tanks. Even more significantly, reducing the spatial footprint will reduce environmental impact, sending polluted water in a more rapid manner to the water handling stations. Thus it is necessary to set up a supermarket to accommodate crude ready for the desalter, and the JIT/Kanban pull system can be used to regulate the replenishment of this supermarket, as well as to establish a pacemaker. This new stage is to deliver quality through ensuring that:

- The crude contains no gases.
- It is maintained constantly by means of a put through the system.
- Sufficient residence time is provided for the free water to separate and settle down.
- Sufficient reaction time is allowed for chemicals to be added to all wet headers.

Question 5: What single point in the production chain (the ‘pacemaker’ process) should GC schedule?

The pacemaker process is a point at which the production is scheduled at any workstation in the value stream map, in order to avoid overproduction. A further Kaizen is applied at this point, in order to tie both upstream and downstream together, sending the pull signal from the downstream station to the upstream station, and material flows from upstream to the downstream stations, in a continuous manner. The typical pacemaker is a continuous flow process, which requires no supermarket between stations. The pacemaker process is one in which production is scheduled, i.e. everything before is pulled from the pacemaker process and everything after is continuous flow (Rother & Shook, 2003).

The pacemaker process at the GC production line will consist of the desalter trains regulating the demulsifier chemical injection at this stage. The operators state that the demulsifier dosage injection is inaccurate for the majority of the time. At this station, the pacemaker will assist in preventing overconsumption of significant resources, or a shortage of the dosage in the value stream map, thus reducing the impact upon the ecosystem. The main processes occur in the dehydration desalter:

- Electric shock: the use of the electric grid (electro-static) to coalesce the droplets as a final polish to the oil.
- Chemical injection (demulsifier).
- Washing with fresh water to reduce salt concentration.

At this stage of the desalter process, the injection of the demulsifier chemical is generally based on the estimation of the operators, who admit that this can frequently consist of an over dosage of demulsifier chemical injection, which is difficult to identify before the result of the sampling appears. Thus, the introduction of the pacemaker at this stage will adjust the amount, and space, of the demulsifier chemical to keep pace in the desalter with the speed and amount of the bottleneck.

Again this concerns the sample test process. Due to the laboratory being currently located in a different facility to the GC, the scheduling of the demulsifier chemical injection, (along with the scheduling of the amount of wash water that is paced to the desalter) is a challenging process. If testing of the samples were to take place inside the GC-floor, one schedule would be released to the continuous demulsifier chemical injection to set the pace for the final station treatment of the wet crude. This is the final process, and sets the base for the entire production stage at the wet crude production line in the GC. Although the demulsifier chemical injection takes place across the entire number of stations, starting from the manifolds, this stage is the most critical in the obtaining of the KOC's desired crude oil quality. A further Kanban between the desalter and demulsifier tanks would assist in scheduling the pacemaker process of the stations, with the Kanban to be introduced by the operators in the production system. Before running the Kanban, operators will be able to check for the status (or quality) of the wet crude in the desalter, which can be achieved by developing charts (or data history) to aid the production data by using schedule software (Scheduleit.co.uk, 2014).

Question 6: How will the production mix be levelled at the pacemaker process?

This question will be addressed through an examination of a single resource in one process over the production time during the pacemaker process, i.e. the adding of a chemical demulsifier to desalter trains. This will consolidate the scheduling dosage of the demulsifier for the wet crude, so that at this stage operators are dealing with only one criteria, i.e. chemical dosages that can be adjusted as required within the product specification (the dosage rate for chemical demulsifier is 10 ppm on total wet fluid).

The key concept is for GC to send a schedule to the pacemaker process to ensure that each of chemical dosages is given at a required rate, and synchronised with each batch of wet crude in the desalter. This means that several dosages of chemicals need to be scheduled, but it might be not at the same sequence, depending on the status of the wet crude. This will allow KOC to avoid over-consumption of chemicals that are both hazardous and expensive, by ensuring the quality of the crude at an earlier stage. This is a step towards being green, and avoiding waste related to other resources, along with time and pollution, and cost saving.

Focusing on efficiency, as well as the reduction of CO_2, Toyota has implemented delivery schedules of hourly shipments for the raw materials (Honeycutt, 2013). Lean addresses the issue of waste by delivering in small increments (Poppendieck, 2011). The lean approach is for some processes to flow into the production in very small amounts for the processing batches (Smalley, 2006). Rother & Shook (2003) state that an even production creates a predictable production flow, enabling operators to take rapid corrective action by releasing small (but consistent) amounts of production during the pacemaker process synchronised with the amount of finished goods (i.e. crude ready to leave the desalter).

The recommendation is therefore to establish pulling small batches from the supermarket to the desalter pacemaker, in order to regulate the release of demulsifier from the upstream station. The calculation of the number of batches of wet crude per 24 hours is as follows:

Wet Tank capacity = 65,000 barrels for quality purposes, due to:

- The need to set the interface level in the wet tank;
- The wet tank being the first stage of water/oil separation.

It is therefore recommended that small batches are created, with the interface point being at the level of 12% of wet tank full capacity, approximately equalling 7560 barrels for each batch. The reason for recommending 12% is to enable the delivery of 10 batches of wet crude per day. Total production is 104,854.26 barrels of crude oil per day, of which (according to the production group) approximately 70% is from wet crude, i.e. approximately 73,000 barrels per day.

- A demulsifier is injected into the wet crude oil to dissolve (or weaken) the film of the emulsifying agents around the water droplets.
- The demulsifier chemical makes contact with the emulsifying agents, reacting with them and weakening (or breaking) the film, so allowing the droplets to move closer to each order, forming large droplets which are easily separated from the crude oil.
- Chemical demulsifier dosing systems are provided for the desalter trains.
- The demulsifier is injected into the desalter feed pump suction line.
- The dosing rate of the demulsifying chemical is controlled by the demulsifying effect within the desalter.

Question 7: What increment of work (the 'pitch') will be consistently released to the pacemaker process?

The guidelines are to release and withdraw small increments (known as the 'pitch') of production within the pacemaker process, leading to the question of how often the pitch should be released from the pacemaker process. The pitch is calculated by multiplying the takt time by the transfer quantity of the finished goods during the pacemaker process, in order to regulate the injection of demulsifier. The pitch thus becomes the basic unit of the production schedule for a product family. In the case of oil recovery, the takt time to produce a single barrel of oil is 0.014 minute per barrel of oil.

The dosage of demulsifier for the desalter = 10 ppm on total wet crude (i.e. each batch of wet crude in the desalter). Given a takt time of 0.014 minutes, and assuming the batch in the desalter is 7560 barrels, then the pitch (i.e. 10 ppm of demulsifier) should be every 106 minutes for each desalter train (three trains are available within the GC).

Question 8: What process improvements will be necessary?

The operators state there is no specific timing for the wet crude oil to be settled in the wet tank, and the GC manual notes that (when given sufficient space and residence time in the wet tanks) free water is carried in the crude separates (20-30 minutes), therefore, JIT oil releases are inefficiently met. A development of precision in developing the clarity for settling process in wet tank could be a solution to evolving the JIT approach.

Thus, the recommendation is to introduce a laboratory onto the shop-floor of the GC, as beneficial in reducing time wasted by the testing the samples. It is clear that the sampling process has an impact upon the environment, and thus the longer the journey between GC and the laboratory, the higher the potential pollution. Availability of a laboratory would provide cleaner and improved opportunities for more frequent testing, resulting in:

- Decreased energy use associated with the need to transport the sample to a laboratory located in a separate building;
- Reduce delivery time;
- Provide faster test results concerning the status of the crude;
- Reduce the danger of pollution.

More rapid availability of the status of the crude leads to avoiding the WIP and over-consumption of resources. The introduction of a laboratory would facilitate the flow of the wet crude keeping pace in the desalter and wet tanks with the speed of the bottleneck. Thus, oil and gas recovery would begin to take on the characteristics of a smoother flow, in which each process is able to operate in a smoother manner, as opposed to waiting for an unspecified length of time.

If improvement of action takes place in the future state map, this would result in the enhancement of the flow of both information and materials. In order to gain the benefit of continuous improvement, the following should also improve: the production Kanban(s); the supermarket; the pitch; takt time; and other medium step changes involving specific lean tools of processes. Further details are outlined in the following section.

The Desalter's Heater

According to the GC manual, in order to enhance the desalting operation, and reduce the viscosity to a suitable level, the crude feed temperature to a desalter's feed heater should be raised to either 76.7 °C (170°F), or 63.8 °C (145). The temperature indicator controller is located in the control room. If the temperature is reduced (e.g. due to an issue with the heater), it is generally necessary to increase the chemical dosage and/or settling time. The primary function of preheating is to reduce the load on the desalter's feed heater (GC manual). The heater is gas powered, with the gas arriving through internal pipelines from SPC. Due to the hot climate, in the summer operators can run a single, rather than a double, burner in the heater, in order to save the cost of potential maintenance, fuel, and keep one burner spare in case of failure. Only after the sample is taken from the second stage desalter, or the dry tank, can operators establish the temperature. A high temperature affects the quality of the crude, and also disrupts oil production operations that might appear from the pressure in the dry tank (i.e. high pressure = high temperature)

The operators note that it is possible to switch off the heater during the summer season, when the temperature of the crude oil is naturally over 145F. During the site observation, the recorded temperature of the crude oil at this stage was 124.3F in December, when the external temperature was approximately 50F (see Figure 7.7 Heater screen snapshot (source KOC), below). During the summer season, the external temperature easily reaches 122F, and crude acquires its temperature from deep underground, where it is always at a higher temperature than above ground. According to the operators, the process of switching the heater on and off during summer months is based on the judgement of the operators, rather than any specific rules. Thus, if the heater is turned off for six months (i.e. during the height of summer) and taking into consideration the difference in temperature between day and night time (particularly during September, October, March and April) then six months of value-added can be gained from the heater's gas consumption, i.e. at least 50% of the total gas consumption from the heater, which is the main consumer of gas in the GC. Harnessing natural temperatures would further add value by saving the burning of gases for the heater for the desalter, which would also lead to a reduction in pollutants.

Thus it can be concluded there are no specific rules in relation to the heater, which is not given sufficient attention by the operators. Paying more attention for the operating times of the heater would save time and resources, while also improving quality.

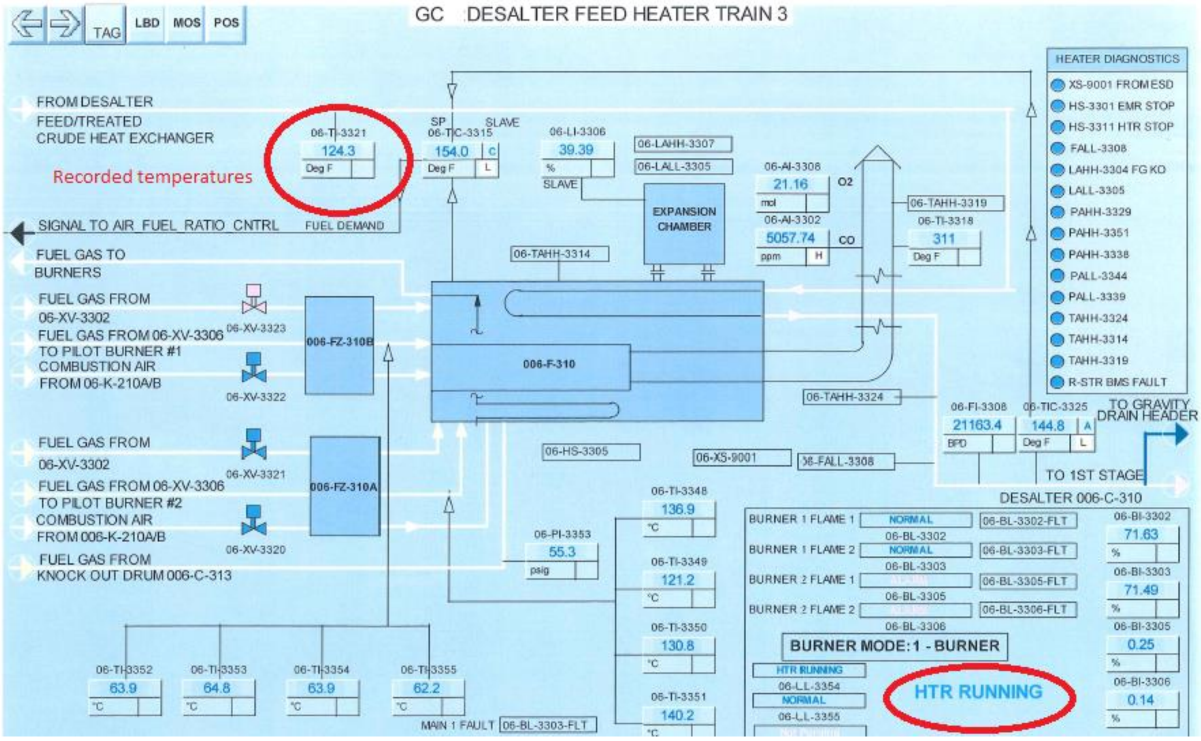

Figure 7.7 Heater screen snapshot (source KOC)

7.3.3 Quality-at-Source

Quality-at-the-source concerns the building of quality into the product. This is achieved through systems that identify and resolve quality issues at source. Widely employed techniques include an inspection system that provides immediate feedback (e.g. self- and successor-inspection strategies), monitoring and control of factors that cause quality issues and error-proofing (i.e. poka-yoke) mechanisms. As noted previously, a sampling process takes place on the GC-floor, while the recommendation is to apply sampling from the source, i.e. from the wells. Samples taken from the well should give a clear idea concerning the nature of the liquid oil before it arrives at the GC, i.e. what is known as quality-at-the source.

7.3.5 Total Quality Management (TQM)

Quality is the responsibility of every one however it can be influences by senior managers. This is the perspective shared by lean and TQM, although with a number of differences. TQM needs to create structures that support employees in the production of high quality (Pettersen, 2009). KOC understands that quality of production within products is the means of raising and maintaining a competitive edge in the global marketplace. The recommendation is to implement TQM in order to achieve the highest quality work. The model of lean TQM strategies (see Figure 7.8 Lean TQM strategic model) align the goals of the organisation's managers (Strategy), with the strategy and planning goals (Tactics) and the work performed on GC (Action) as a comprehensive approach representing TQM.

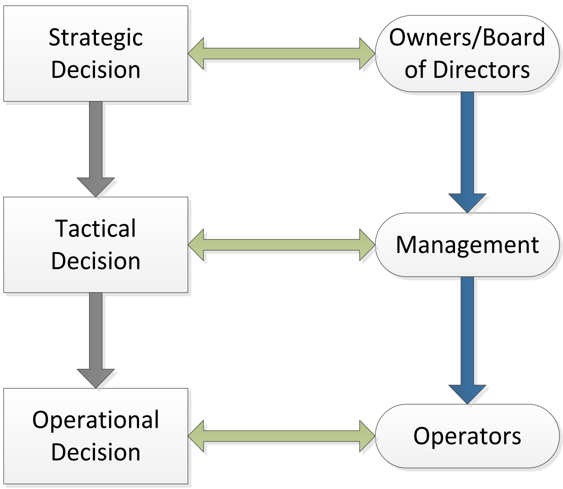

Figure 7.8 Lean TQM strategic model

Developing a structured (factual) data approach to problem solving derived from TQM philosophy, is to provide a means of assessing the quality of organisation in various aspects of their internal processes. It has been established that the measurements of TQM philosophy and core concepts (which form critical factors for success) reflect the performance of an organisation (Kanji et al., 1999). Any change in the performance of the critical success factors affects the organisation's excellence in business. It also provides information to the organisation's senior management on its performance over time, and in comparison with other institutions.

The measurement method can be employed by the quality assurer's shop-floor to inspection production quality. However, this can lead to a number of issues. This recommendation was negotiated with the stakeholders during the validation workshop, resulting in their agreement that they have a major problem to overcome in order to deploy TQM. The issue arose with the workers, due to the fact that they depend on each other to resolve problems, and this culture (or behaviour) has developed laziness, and a lack of trust, along with a dependency between workers, leading them to fail to take any job seriously. It is therefore clear that there is an issue of culture within the internal environment. Stakeholders claim that the structure currently in place creates the pattern of work, but rarely allows for a flow of personnel. Therefore, the TQM approach is to change the way in which workers interact and work on the shop-floor (Tata & Prasad, 1998). As such, it is a context-dependent programme, the success of which depends to a large extent on a culture of sharing knowledge and structural factors.

On the other hand, the future VSM is a model that will create connections between the success of TQM implementation, and organisational culture and structure. The importance of these connections has been illustrated for both theoretical and practical reasons, particularly when the focus is on the operators and the control room. On the practical side, the future VSM can help operators assess the probable success of their shop-floor's TQM philosophy, along with the extent of the necessary organisational change required for success (e.g. extending the duties of testing the quality of the product). It should be noted that the operators are considered to be the focus of the company's work and (according to the maintenance and operators) are a cross-functional team, a point confirmed during the workshop.

TQM philosophy can create management derived vision to incorporate quality as integral to the business, as well as to establish the structure, practices and policies consistent with that vision (Porter & Parker, 1993; Tata & Prasad, 1998). TQM encourages a company with control-oriented cultures, and mechanistic structures, to focus on stability, increasing predictability, which, in turn, increases control. Thus, with a 'Kaizen' philosophy, TQM will find an improved match in a company with flexibility-oriented cultures and organic structures. A number of operations are conducted under the assumption that learning and adapting to change are essential for survival, particularly on the GC-floor.

7.3.6 Lean Tools and strategies to gain Kaizen

The goal of this section is to identify the potential dynamic gains from implementing lean and integrating future VSM. It focuses on lean manufacturing tools that can be quantified and modelled objectively: a modified pull type production system that can be applied to set up the quality.

By using a number of lean tools a strategic solution can be developed to address the issues of time and quality within the oil and gas production operations and product. There are a number of complex processes in the GC-floor that operators find difficult to adjust according to their need for time, resources and raw materials. In order to achieve value-added, it is necessary to develop a work environment that is self-explanatory, self-ordering, self-regulating and self-improving, i.e. where what is supposed to happen does happen, on time, every time. Lean production has developed useful improvement strategies to simplify complex production operations.

- **Production system**

In the future VSM, the two levels for comparison recommended for the production system factor are a push system, along with a hybrid push–pull system. Although a hybrid push/pull system represents the current situation in GC's operations, the hybrid system is improved in the future state map. In this system, work will continue to be pushed and 'drained' and pulled by pumps, but should result in a smoother system that consumes fewer resources and less time. When it comes to the wet crude oil, from the buffer 'supermarket' area after wet tank and all the way to the dry tank, the system will be based on a JIT Kanban/pull, where the settled crude oil will be pulled, while another Kanban will be used to pull chemicals from the upstream station to the pacemaker 'desalter'. The junction area is between the wet tank and the dry tank, thus forming the push 'drain'–pull boundary.

- **Understanding Muda**

Processes involved in understanding Muda on the shop-floor consist of using a number of lean tools. The philosophy focuses on effective workplace organisation, along with standardised work procedures, to deliver efficient and cleaner operations, as well as ensuring the highest quality. The benefits demonstrated by Figure 7. 9 below (p. 217) are as follows: simplifying the work environment; reducing waste; reducing non-value added activity; improving quality; improving efficiency and safety. Lean visual tools drive operations and processes in real time. These systems act as an extension to metrics, and may be considered a dynamic system of measurement. The issue does not concern the availability of information, but the scientific communication of this information is essential to demonstrate its effectiveness. The gaining of additional scientific information is likely to be effective in influencing the evolution of uncovering developed solutions, while credibility involves the scientific adequacy of the technical evidence and arguments. Salience deals with the relevance of the assessment to the needs of decision makers, proving crucial to systems that mobilise knowledge regarded as salient (Cash *et al.*, 2003). The model contains a number of steps to develop L&G in GC, in order to:

- Eliminate waste;
- Reduce consumption of resources, waiting times, processing time to the bottleneck;
- Ensure quality;
- Improve efficiency of operations;
- Enhance the behaviour of stakeholders in order to protect environmental performance (i.e. culture development);
- Be prepared to mix sources of energy with renewables.

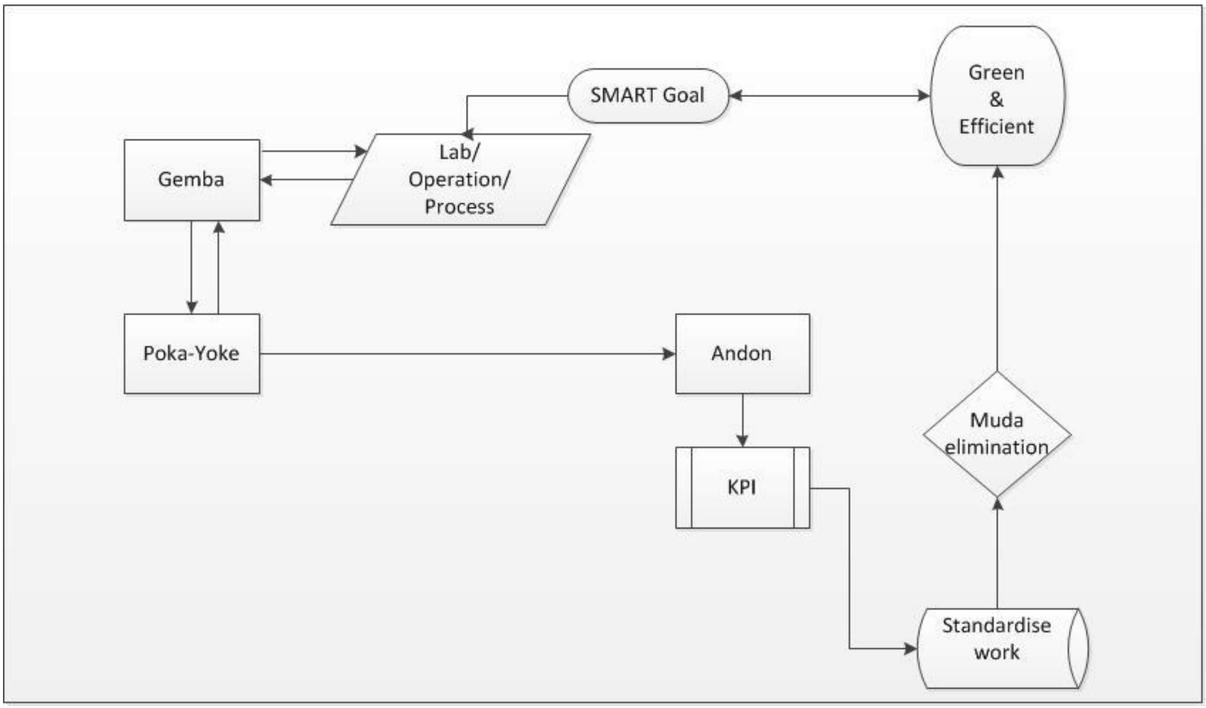

Figure 7. 9 Environment work model

1- Smart goal

The strategy begins with lean's strategy SMART goal being part of the planning process in setting a number of goals, with the following guidelines (Elbert ,2012):

- Specific: Be clearly set out in a specific manner (e.g. reduce waiting time by 5%).
- Measurable: the goal is to reduce processing time (5% is both readily measurable and specific).
- Achievable: the goal must be attainable or achievable, neither out of reach or too ambitious.
- Realistic: the goal must be realistic and challengeable (e.g. to reduce waiting time by 1% is too simple, and by 10% may be un-obtainable).
- Time based: the goal must have a due date, by when it should be achieved. It is possible to edit time support with a number of reasons (see SMART goal Table 7.2).

Table 7.2 SMART goal

<table>
<tr><td colspan="5">Operation:

Process:

Improvement description

Date</td></tr>
<tr><td>Target</td><td>Measurement</td><td>Before</td><td>After</td><td>% Different</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

2- Gemba

The second part of the strategy is Gemba = Workplace, which demonstrates increased commitment to the place of action and the collection of reputable data (Mann, 2010). This implies a direct contact with operations, and therefore the existence of a laboratory on the GC-floor is essential, enabling sampling from reservoirs and random stations in the GC. This data will be used to fill the recommended Kanban(s). Operators need to place action and collect ‘facts’ instead of engaging in a discussion of opinions in an office. This forms a mind-set that should be part of lean implementation, as it refers to the ability to manage and improve the shop-floor by being based there, so being aware of any waste. Gemba has four actuals:

- Go to the actual workplace;
- Watch the actual process;
- Observe what is actually happening;
- Collect actual data.

3- Poka yoke

‘Poka yoke’ is designed for the detection and prevention of error in the production process, with the goal of achieving zero defects or errors, and mistake proofing. The concept has been developed and classified by Shigeo Shingo, particularly in manufacturing, (Shingo, 1998). Lean strategy aims to build in quality at the source, rather than inspect the quality of a product at the end of the production line. In order to develop quality at the source, it is recommended that the sampling of the liquid oil from the reservoirs should be developed, in addition to the current sampling process in the GC-floor. Where Kaizen is developed in the future VSM, it appears that the desalter stage is critical, and therefore requires poka-yoke to ensure quality, allowing operators to create standard desalting procedures revealing the ideal time and resources without producing waste. Thus, the efficiency of the holistic production depends primarily on how clearly and quickly operators deal with the quality of the crude oil. Poka yoke is therefore essential to support Kanban.

The application of poka yoke is designed to detect and highlight errors, in order to prevent them from affecting the production processes, and with the goal of achieving zero defects. It might be not possible to find all defects through inspection, however identifying them in earlier stages costs significantly less, as correcting defects at later stages in the GC requires the repeating of operations, costing additional resources, expense and time. The availability of inspection systems represented by the laboratory on the GC-floor provides immediate feedback, monitoring and quality control. This leads to poka yoke mechanisms being widely employed techniques. Shingo also views quality control as a hierarchy of effectiveness from:

- 'Judgement inspection' (i.e. where inspectors inspect); to
- 'Informative inspection' (i.e. where information is used to control the process, as in Statistical Process Control (SPC)); and
- 'Source inspection' which aims at checking operational conditions.

Data are required to apply poka yoke, thus 'Gemba' will assist in the provision of data capable of identifying the defect. Operators observe what is actually taking place, and collect actual data, with the team working to acquire the ability to see and understand the error, in order to improve it.

4- Andon

A novel visual solution is recommended within GC operations, based on approach of Airbus UK (Filton), to manage their complex processes (Parry & Turner, 2006). This involves taking their settling process and injection system output (which gives schedules for desalter processing) and communicating them to shop floor cell activity using a method supporting lean practices. The values stream map has been developed for the GC in accordance with a belief in the effectiveness of lean philosophy, and includes engineering, material consumption, and processes and manufacturing engineering. Thus, it should introduce the benefits to the GC's shop-floor. This needs to be led by a team of operatives based at the GC, including visual management, to facilitate the development in the shop-floor, with divisions representing the vague settling process, vague injection dosage of chemicals, and the knowledge-based process of operators.

Use of the 'Andon' tool can be learnt in order to create a Crude Oil Quality Manual (COQM). Andon is a visual feedback system for the plant floor that indicates production status, puts out alerts when assistance is needed, and empowers operators to halt the production process. Thus, COQM will contain data concerning the complete history of the crude oil settling time, in parallel with all chemical dosages, dated to identify the season of the year, along with the ability to be updated to reveal any changes made (as Kanban earlier recommended that all information needs to be provided). Changes may occur while changing supplier (i.e. reservoirs) or when using a different brand of the chemical demulsifier. Any changes to the materials (or the system) need to be made by KOC's management, or the operators or suppliers of the chemicals. All should be correctly documented. Ensuring the correct data is captured to be included in the COQM involves desalting and dehydration processes, resulting in data available for the operators, and to be transferred to other interested departments (e.g. KOC's laboratories). For this specific stage of crude oil recovery, the recommended map to examining the schematic of crude oil is demonstrated in Figure 7.10 Crude Oil Quality Manual (COQM) board in p. 222). The left hand column illustrates the new task interred (i.e. the new batch transferred to the wet tank), which is represented by the Kanban 'T-cards'. The T-cards are comprised of different colours, with each colour representing the specific manifold from which the crude oil originates (each manifold represents a specific number of reservoirs). The boards read from left to right, as values are added to the batch in the wet oil container, and the degree of value added is identified by the result of the bottleneck settlement.

The T-cards migrate across the board, each with a specific coloured marker representing each shift, thus identifying which shift achieved a higher level of added value by consuming fewer treatment resources. Issues that emerge (along with notes and challenges) will be noted on a separate sheet, and must be assigned by shift. The value of the board is in the way it simulates the current state of the process, taking less time to achieve visibility concerning the process of each cycle, identifying the resources and activities being undertaken, along with the status of the work and the crude oil.

Depending on the progress of the board, meetings should be held to discuss the central aspects of daily activity, along with weekly progress reviews of the specific processes of dehydration and desalting. The effectiveness of the board consists of driving, controlling and ensuring the smooth active running of the COQMs process, while also awarding access to a chemist to review the current state of the process and the GC's view of their performance. The recommendation is to create 'dashboard' information displays to report the current state of GC production and processes. This information can also be displayed on a computer, using appropriate software, as a set of graphical outputs of metrics and lean tool key performance indicators (KPIs) for a particular process (Scheduleit.co.uk, 2014).

5- Standardised work

Standardised work is a documented manufacturing procedure that identifies best practice (including the time to complete each task). It utilises documentation that is easy to change and eliminates waste by consistently applying best practices, thus forming a baseline for future improvement activities.

6- Final Perfection (Green and Efficient)

This is not simply concerned with quality, but also the needs of the customer, and ensuring business sustainability and protection of the ecosystem, at the right time, and at the right price, with a minimum of waste.

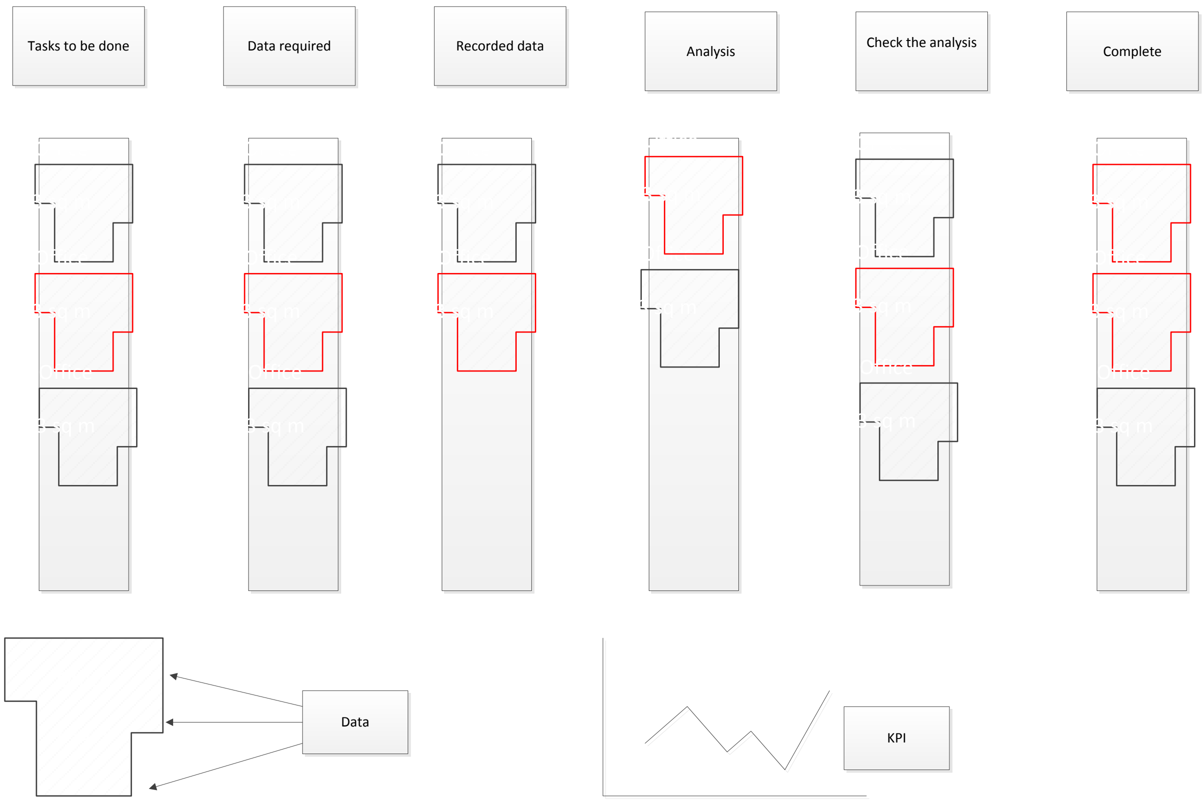

Figure 7.10 Crude Oil Quality Manual (COQM) board

7.4 The recommendation is to apply Total Productive Maintenance (TPM) for the GCs

TPM is recommended to maximise machine effectiveness, and increase the engagement of the workforce. This is particularly so when working under TQM, the key supporting tools model (see Figure 7.11 TPM tools model (adopted from Raouf, 1994), p. 223). In order to successfully apply the TPM approach, and support the current preventive maintenance schedule of GCs, the stake holders at the three different levels (i.e. senior managers, team leaders and workers) need to understand the significance of increasing engagement and focus with these operations, particularly when it comes to senior management. The maintenance group has already set up a current preventive maintenance plan, which will form the core of the recommended TPM.

Tsang & Chan (2000) state that TPM can result in significant improvements in production performance. It allows stakeholders to predict a solution for increasing the performance of the machines, and is a method toward achieving desired goals (Eti *et al*., 2004). Chan *et al*., (2005) conducted a case study in semiconductor industry, establishing that the application of TPM has revealed results exceeding the goals, with an 83% improvement in equipment productivity, and the equipment stoppage rate reduced from 517 to 89. TPM assists in increasing overall equipment effectiveness (OEE), through the achievement of a reduction in downtime and other random production losses (Chan *et al*., 2005). Volvo Gent claims that the OEE in the company was 66-69% before TPM implementation, and 86-90% after implementation, over a five year period (Ljungberg, 1998).

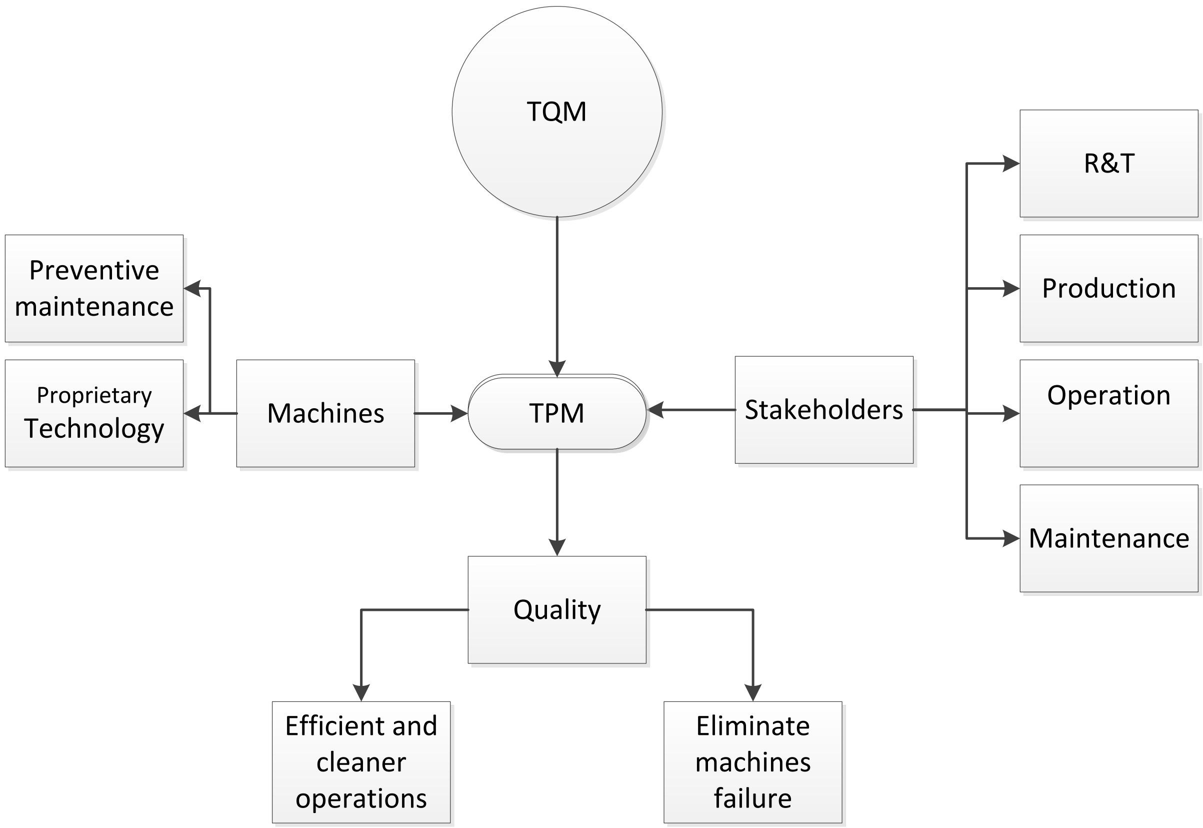

Figure 7.11 TPM tools model (adopted from Raouf, 1994)

Senior management set policies that identify the goals of the TPM programme. Middle management is represented by three groups (i.e. production, maintenance and operations), each of which are required to contribute to the plan. Co-corporation must take place between the production group, maintenance group, R&T group and operations group, in order to set polices and identify targets. The stakeholders taking part in the validation workshop did not agree that R&T should have a role to play in this area, claiming that the business of R&T is to investigate new technology, rather than maintenance issues. However, others claimed that GC is in need of research to establish ways to reduce machine downtime, and R&T and R&D are the only groups capable of conducting research in KOC.

Operators and maintenance personnel represent the vital elements for the development of a TPM programme in GC. Maintenance workers are most aware of the technical aspects of the machines, as they understand the design of the machines and are involved in maintenance and engineering activities. On the other hand, operators are so familiar with operating these machines that they can forecast the repeatable causes of failures. The main task for both groups will be to point out current gaps within the preventive maintenance programme and nominating a TPM group. The responsibility of the TPM group is to advocate TPM concepts to the workforce, through means of an educational programme, followed by checking that the concepts are being implemented (particularly when operators estimate failures due to a lack of response or knowledge among the maintenance workers, and vice versa).

Therefore, once the TPM group has been created, all personnel will be involved in the TPM programme. The action team will consist of representatives from those with a direct impact on the issues being addressed. TPM group will provide harmony between different groups of stakeholders. The workforce of KOC currently struggles to establish harmony between different groups (i.e. strained relations exist between groups A and B of the interviewees), and TPM will bring them together, so developing harmony and a professional culture. By the time the different groups become familiar with TPM methodology, they will be able to overcome different types of problems, and therefore any causes of complex problems can be identified in advance. The levels for the TPM group will be linked with the current preventive maintenance programme taking place for each single GC.

GC's preventive maintenance is planned for a specific period of the year and in such a way that failure is expected to occur anytime during the operation. The proposed TPM procedure is to divide the current preventive scheduled maintenance time into smaller increments, i.e. separating the maintenance processes into smaller sections that are performed more frequently and according to downtime events. Thus, maintenance is planned in such a way that it takes place during the process of disturbing the flow (or defect) created by a work stoppage for maintenance, resulting in a minimal disruption of flow.

The best example can be seen in Figure 7.12 Gas flaring 2012 (source KOC), where the issue consists of a high level of gas flaring. This results primarily in the part loading, or unscheduled shutdown, of the Condensate Recovery Unit (CRU). This can be as a result of a number of factors, as detailed below:

- Failure in CRU also can be due to processes or problems within the equipment (unplanned). The Tank Vapour Flare Header collects the vapours from the wet, dry, dual and test tanks. Generally, the vapours are taken to the CRU and compressed for further processing. According to the manual, should the CRU be operating on part load, or shut down, the vapours are routed it to the LP Flare system (see Figure 4 3 GC Overview, a capture screen from the control room, Chapter 4. p.127).
- A further reason can consist of a low section in CRU being down. This is a problem of process rather than maintenance (i.e. it must be done to avoid too much pressure), however it can be avoided by a more focussed study of this particular problem.

At least two of flaring events are planned due to a mini check (planned) in Figure 7.12, p. 226.

See APPENDICES I for CRU as planned in GC's preventive maintenance schedule. It takes place almost nine consecutive weeks during the calendar year. Such a plan gives the possibility of unexpected failures occurring at any time during the rest of the year, so generating high gas pressure in the GC pipelines until the issue with CRU is fixed. Conventional preventive maintenance revealed its weaknesses in Figure 7.12 Gas flaring 2012 (source KOC), with the result regarded as a waste of product gases, or a potential hazard of explosion in the GC if operators do not open high flaring to release gases that are naturally under high pressure. Gas flaring generates environmental pollution through an increase of GHG emissions.

Stakeholders claimed during the validation workshop that they lack data. However, there are methods of improvement, including implementation of the recommended model (see Figure 7.11 TPM tools model (adopted from Raouf, 1994), p. 223), apart from the recommendation of involving R&T. The ideal implementation of TPM requires available data of the machines' downtime, but no record of data was available concerning the downtimes of the machines in order to calculate OEE. It was concluded (and agreed from all those taking part in the validation workshop, in addition to the recommendations of the team leader) that KOC management should develop a data management strategy. The maintenance personnel claimed in the validation workshop that they are eager to reduce the downtime of the machines.

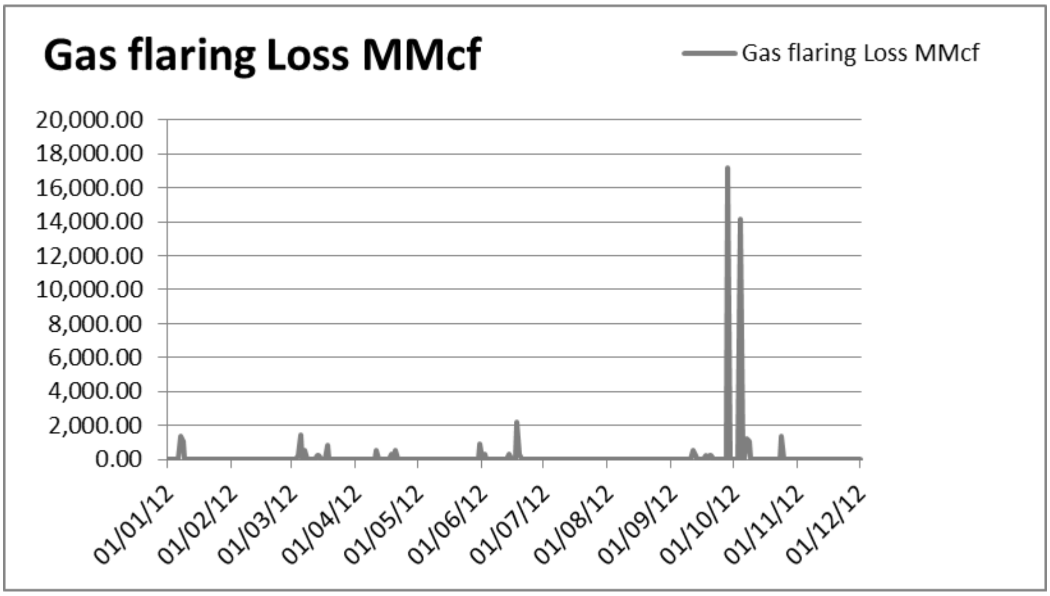

Figure 7.12 Gas flaring 2012 (source KOC)

7.5 Mixing Sources of Energy

The researcher would like to express his appreciation for the Kuwait Institute for Scientific Research KISR for offering their help and facilities in developing this section.

One of the greatest problems in KOC's reservoirs and production concerns the water cut in the oil, which (according to the production group) affects almost two thirds of the production. Water cut costs the company additional production time, and requires the use of additional hazardous raw materials for its treatment, in addition to the following:

- A higher dosage of electricity shocks in the desalter;
- Additional pumps consuming additional energy;
- Although there are currently two water treatment stations in the company, more will be needed in the future.

On the other hand (as concluded in Chapter 6), TOWS Matrix reveals that:

- KOC can be under threat of a lack of electric supply from MEW.
- There are currently high GHG emissions in the State.
- The developed world is turning towards renewables.
- The Middle East region could be an optimal place for the generation of solar energy.

It will therefore be of interest to develop a PV solar system model in order to feed GC's operations. The monthly electricity consumption data for a single GC for 2012 was officially handed to the researcher, which was then calculated and stored in an Excel file, in order to calculate the annual consumption. It should be noted that this is not the same GC that provided the production data for this study, as KOC does not generally record the electricity consumption of its facilities. However, KOC does have the load reading of electricity for this particular GC in 2012. However, since all GCs in the OC are 90% identical in design, this will not affect the quality of the research.

Figure 7.13 demonstrates the electricity consumption in the GC in 2012, from mid-October to December (i.e. when daily consumption of electricity is almost one third higher than daily consumption during rest of the year). It cannot be assumed that this occurred due to it being the winter season, as this can last until early March, clearly revealing a waste of electricity consumption.

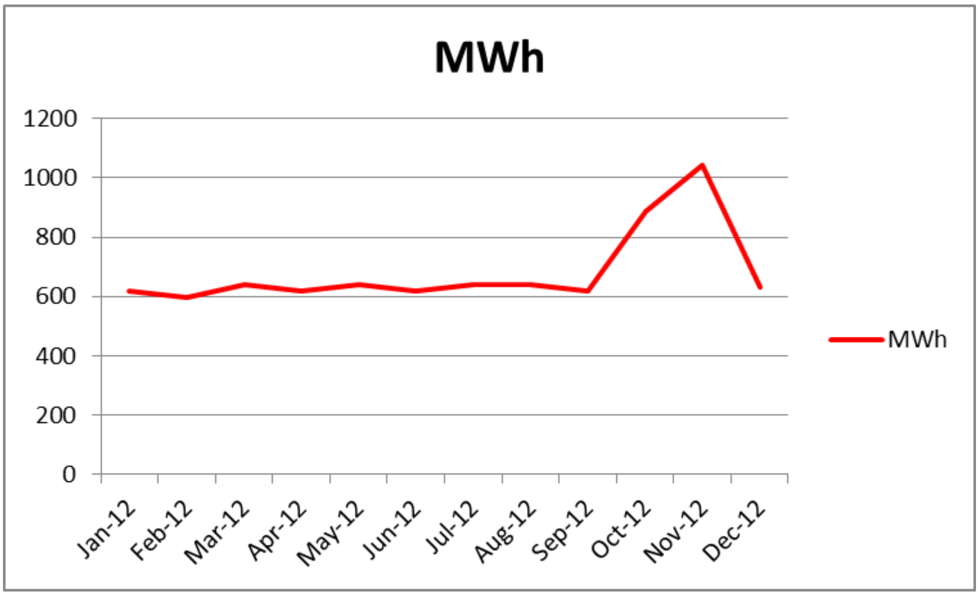

Figure 7.13 GC electricity consumption in 2012

The data available from KOC reveals that after mid-October the numerical values of consumption varied over a wide range. Table 7.3 demonstrates the monthly variation in electricity consumption. The highest standard deviation was found in October, November and December. The GC was on shutdown during the final week of December, and there is an assumption that there was a problem in the GC beginning on 14th October.

Table 7.3 Electricity consumption for GC in 2012

Date	Max MWh	Min MWh	AVG MWh	STD
Jan-12	24.24	12.24	19.9045161	3.185127
Feb-12	20.64	20.64	20.64	1.08E-14
Mar-12	20.64	20.64	20.64	1.08E-14
Apr-12	20.64	20.64	20.64	1.08E-14
May-12	20.64	20.64	20.64	1.08E-14
Jun-12	20.64	20.64	20.64	1.08E-14
Jul-12	20.64	20.64	20.64	1.08E-14
Aug-12	20.64	20.64	20.64	1.08E-14
Sep-12	20.64	20.64	20.64	1.08E-14
Oct-12	36.96	20.64	28.5832258	7.166416
Nov-12	36.96	31.68	34.784	1.897035
Dec-12	36.96	24.72	20.3922581	4.124047

November recorded the maximum average electricity consumption at GC (i.e. 33.66 MW/h), while February recorded the lowest average consumption (i.e. 19.31 MWh). The average electricity consumption in 2012 was 22.03 MWh, while the lowest consumption took place over a number of days in June (i.e. 12.24 MWh).

Table 7.4 demonstrates the total energy consumption profile for 2012, with 24 hour operating of the load per day.

Table 7.4 Estimated total energy consumption profile over 24 hours in 2012

Total (MWh)	Cons (MAX-MWh/d)	Cons (MIN-MWh/d)	Cons (AVG-MWh/d)	STD
8194.32	25.02	9.62	22.03	4.07

The most effective source of renewable energy for the Arabian Gulf region identified both in the literature (i.e. Ramadhan & Naseeb 2011; Doukas *et al*. 2006) and by KISR's interviewees, is PV solar systems. This is due to the most effective renewable resource in Kuwait being the sun, with (as noted previously) Kuwait's climate having a naturally high temperature (around 50C^{o}) and the sun shining almost every day of the year. Before designing a PV system model, it is first important to identify the average length of each day during the calendar year; in order to identify the proportion of energy the PV system can cover during the year (see Figure 7.14 Day length in Kuwait during the calendar year).

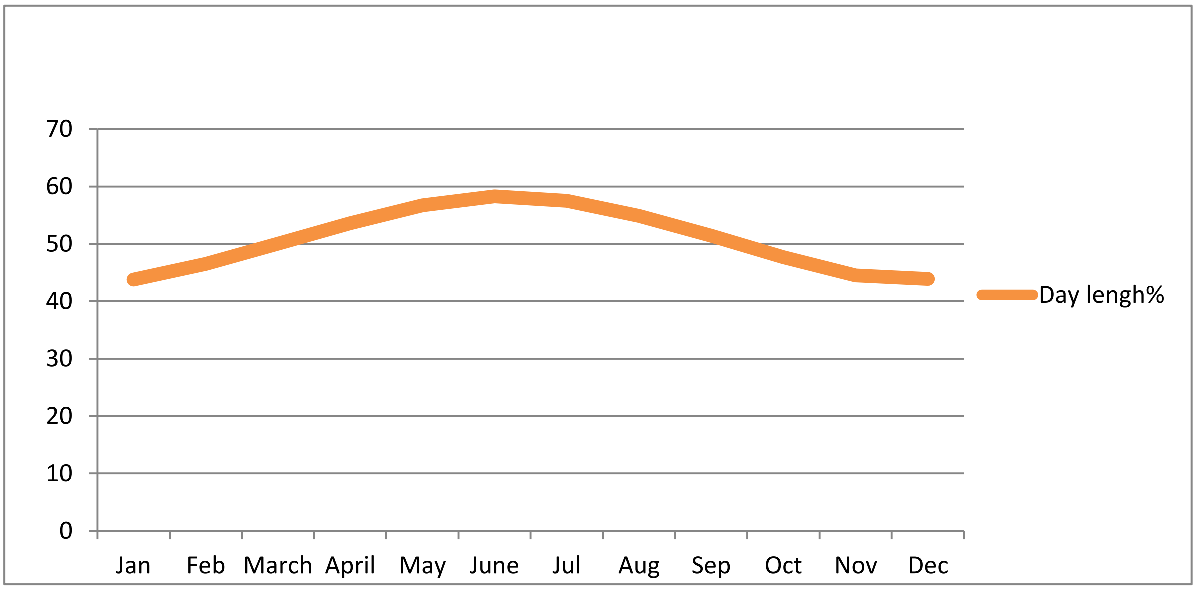

Figure 7.14 Day length in Kuwait during the calendar year

Day length (or the length of a day) refers to the time each day from when the upper rim of the sun's disk appears above the horizon during sunrise, to when the upper rim disappears below the horizon during sunset. It varies during the calendar year. In winter, daylight hours during the shortest day cover 43.8% of the day, and the longest daylight hours during summer forms 58.3% of the day. The average length of a day during the calendar year in Kuwait has been calculated as 50.7%, thus, average daylight is assumed to be approximately 40% of the day.

The calculations concerning the PV system model assume that the system will provide approximately 40% of the day's energy, and therefore total power coverage will be 40% of total energy consumption, and the power generated from the PV system should equal 3277.728 MWh (see Figure 7.15, total power coverage of PV system).

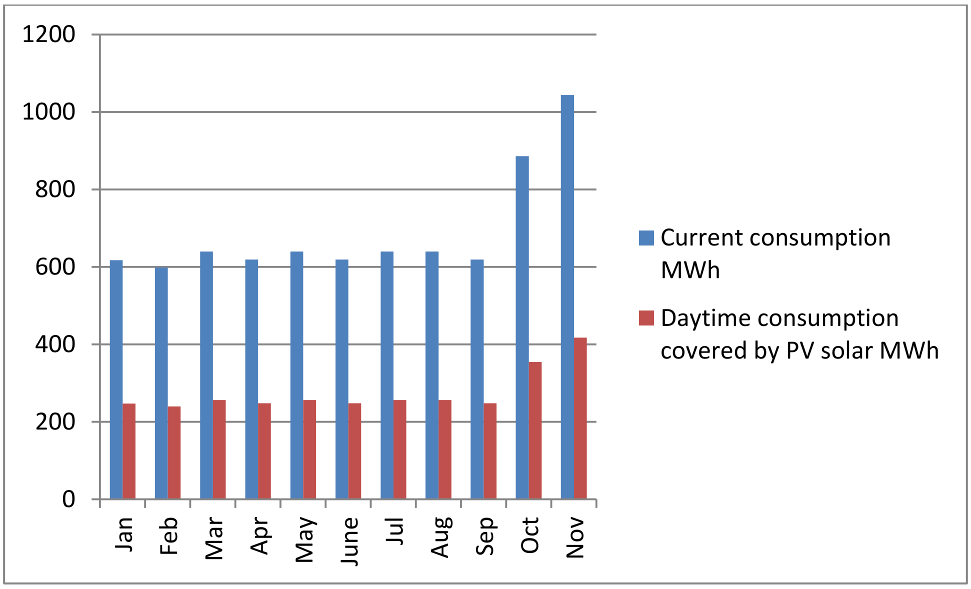

Figure 7.15 Total power coverage of PV system

A computer programme was employed to estimate the type, and size, of a renewable energy system capable of feeding the GC with electricity. This comprised software known as 'PV*Sol' (version 7) developed by Valentine Software, and provided by KISR. The programme is designed to calculate the cost of a PV solar system, along with its potential future profitability.

The PV system is developed to establish GC's need of energy, before the recommendation of waste reduction, as previously discussed. If lean improvements take place in the GC, the system could feed more than a single GC with electricity. Figure 7.16 reveals the design of the potential 2.79 PV system, which consists of 13500 solar panels with a surface area of 22,052.25/22,011.00 m^2: blue rectangles on the left represent solar panels and the light orange squares represent GCs.

Project Name:	Ali-Al-Saygh-project-1	04/01/2014
Variant Reference:	System Variant	

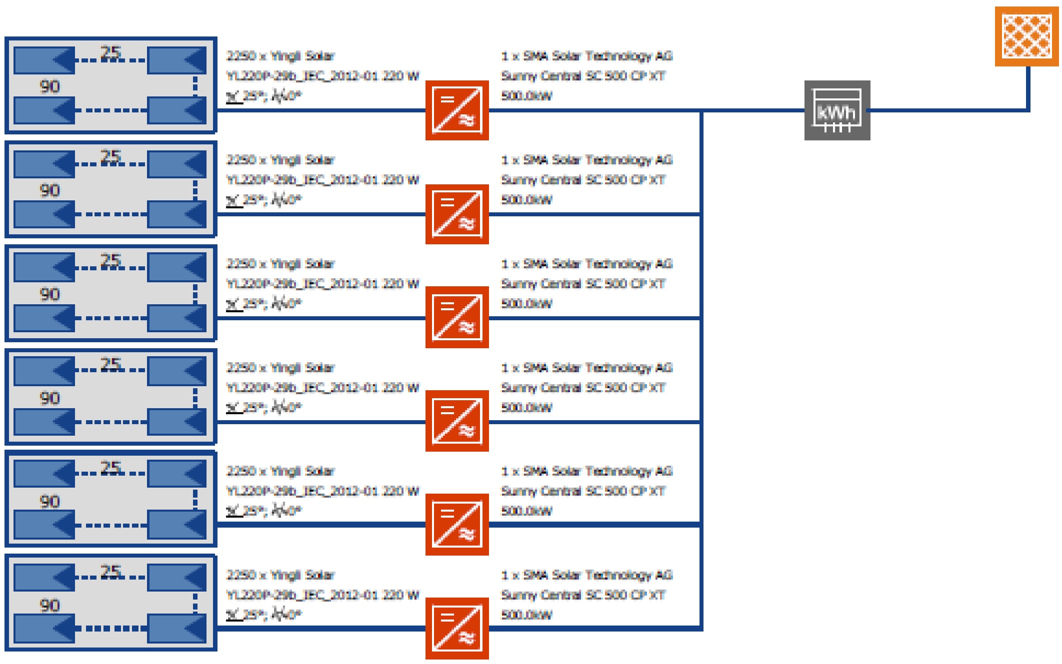

Figure 7.16 2.79 PV solar system design

In order to cover 40% of the energy required for GCs, the PV system must generate 3277.28 MWh in a year. The new 2.79 MWh PV system model is designed to produce an energy PV array (AC) 5199176 KWh = 5199.176 MWh for a year. Thus, the PV system model will provide more than the required amount of energy for the GC to operate safely. Furthermore, OC will avoid 4,604,077 kg annually of CO_2 emissions for a single GC (see Figure 7.17 The 2.79 PV system specifications).

Location:	Kuwait2	
Climate Data Record:	Kuwait2	
PV Output:	2,970.00	kWp
Gross/Active PV Surface Area:	22,052.25 / 22,011.00	m²

PV Array Irradiation:	50,042,432	kWh
Energy Produced by PV Array (AC):	5,199,176	kWh
Grid Feed-in:	5,199,176	kWh

System Efficiency:	10.4	%
Performance Ratio:	77.0	%
Specific Annual Yield:	1,750	kWh/kWp
CO2 Emissions Avoided:	4,604,077	kg/a

The results are determined by a mathematical model calculation. The actual yields of the photovoltaic system can deviate from these values due to fluctuations in the weather, the efficiency of modules and inverters, and other factors. The System Diagram above does not represent and cannot replace a full technical drawing of the solar system.

PV*SOL Expert 6.0 (R6) 1

Figure 7.17 The 2.79 PV system specifications

System variants (see Figure 7.18 System variant/kWh/m^2, and Figure 7.19 System variant/ kWh) demonstrate the monthly sun irradiation and the amount of energy produced to different parameters.

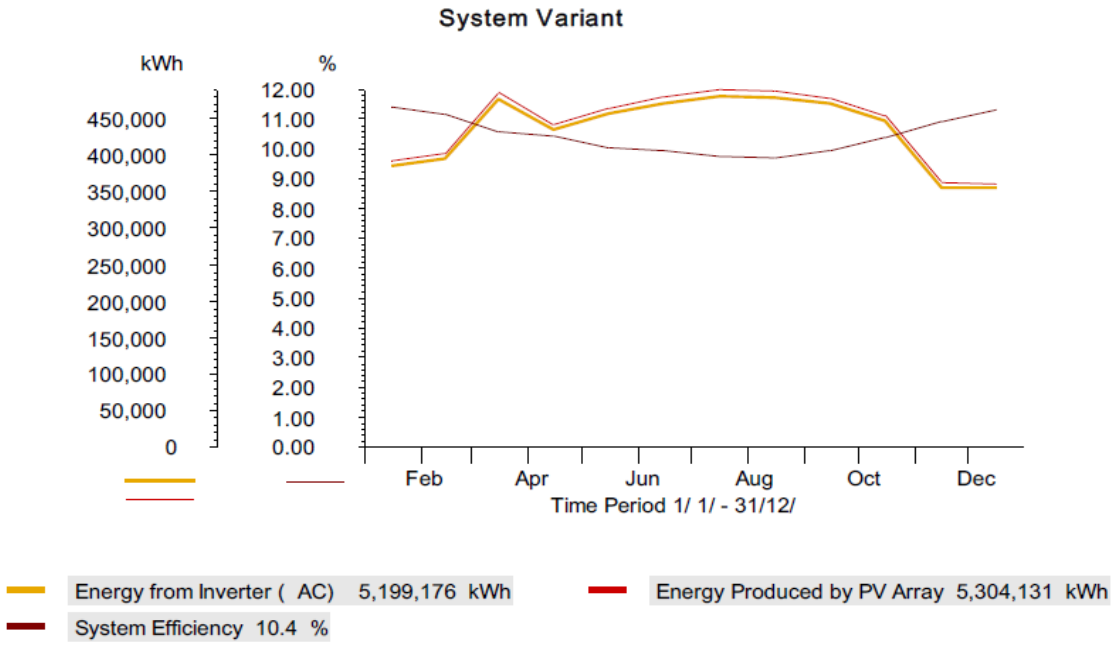

Figure 7.18 System variant/kWh/m^2

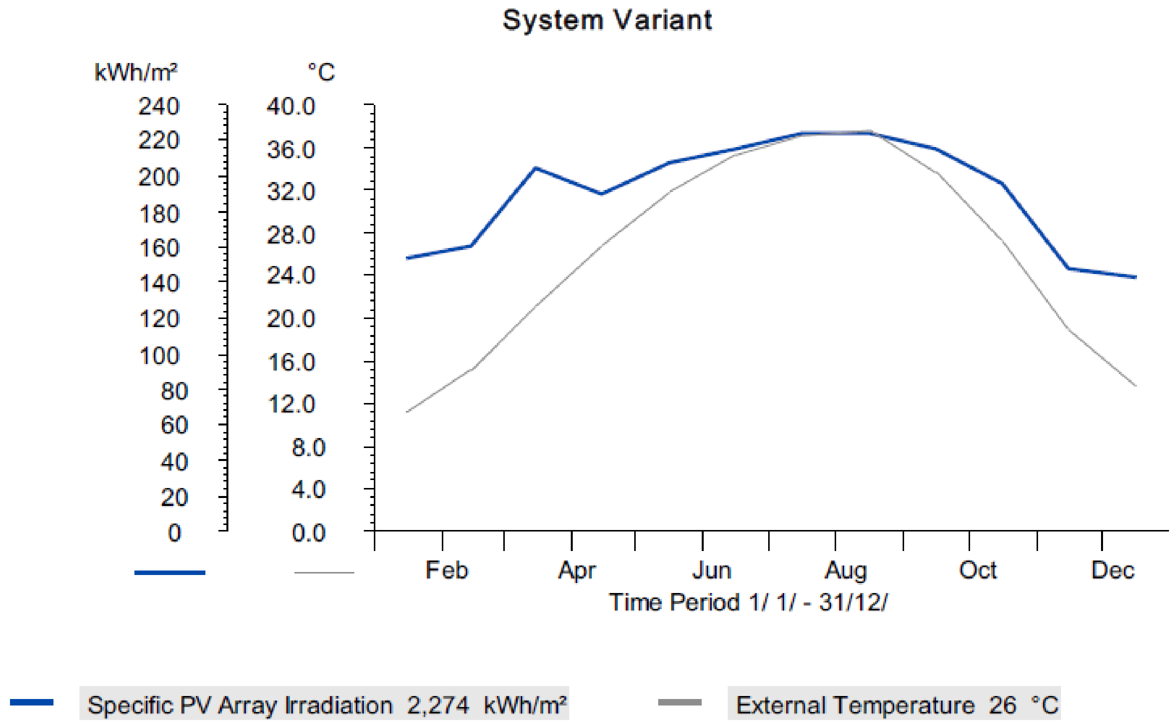

Figure 7.19 System variant/ kWh

The PV system itself also requires energy to operate, although it is self-sufficient in energy generation. The advantages of the system consist of the fact that during the peak consumption the system consumes a lower amount of energy for self-operating, due to high availability of array irradiation (see Figure 7.20 The system's own use of energy).

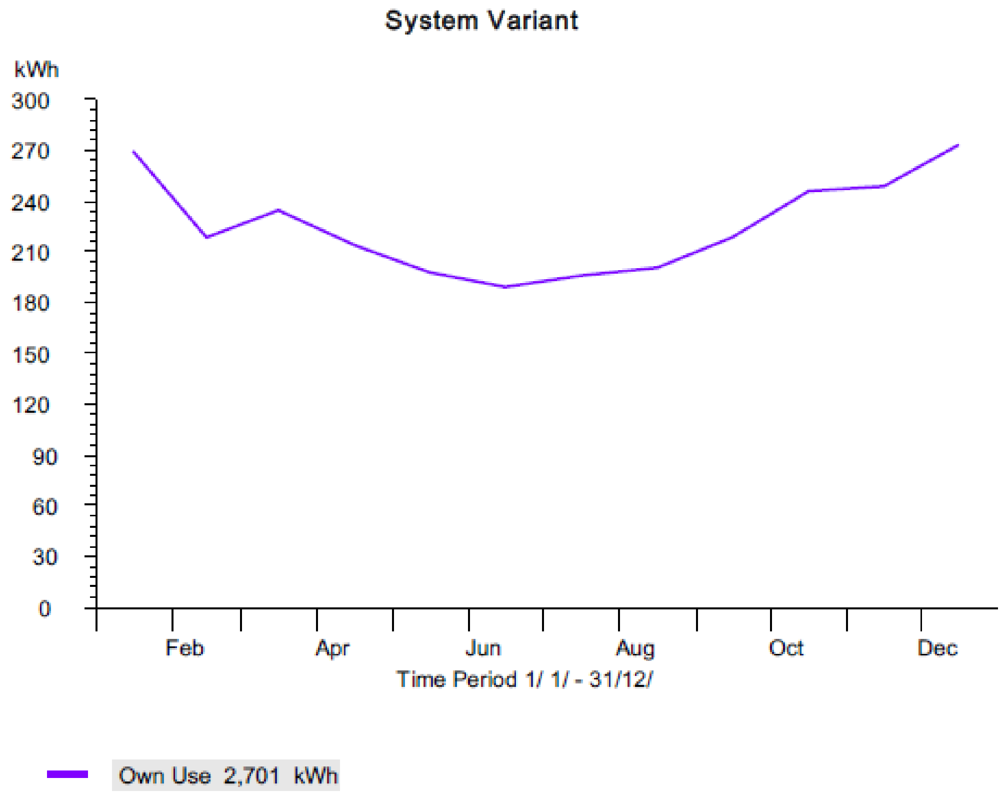

Figure 7.20 The system's own use of energy

Economic feasibility of a PV system:

A long-term supply model was designed, with supply drivers demonstrating estimated annual profit. Consequently, the PV system is designed to operate for twenty years. The inputs focus on the relationship between subsidy and electricity consumption.

The model inputs in this study reveal that cost of this PV system can be covered in 8.4 years. The driver variables of building this PV system model were selected based on the influence of historical electricity demand and consumption in the GC, including its geographical location, time frame and electricity tariff in the State. The size of the PV station is 2.97 MWp, installed under assumptions of price/W. The PV solar systems are compared on the basis of their standardised electricity costs (LCOE), which depend on: (1) the capital cost of the station; (2) the efficiency of module cells; (3) region solar radiation; (4) system output; (5) annual operation and maintenance costs using these parameters; (6) an average of PV systems prices offered to KISR for tenders (as demonstrated in Figure 7.21 Financial analysis, and Figure7. 22 Cash balance, below).

Project Name:	System Variant	04/01/2014
Variant Reference:	System Variant	

Financial Anlalysis Calculation

System Data	
PV Output: 2,970.00 kWp	
System Operating Start: 01/02/2014	Total Degradation: 10.00 %

Electricity Feed-in	
Grid Concept:	Full Feed-in
For the First 20 Years:	0.0340 KWD/kWh
Thereafter:	0.0340 KWD/kWh

Basic Financial Anlalysis Parameters	
Assessment Period:	20 Years
Interest on Capital:	0.00 %
All entries without sales tax	

Income and expenditure	
One-off Payments:	1,630,000.00 KWD
Feed-in Payment Received in First Year:	176,771.99 KWD/a

Results According to Net Present Value Method	
Net Present Value:	**1,881,587.69 KWD**
Payback Period:	**9.4 Years**
Yield:	**8.4 %**
Electricity Production Costs:	**0.01 KWD/kWh**

Figure 7.21 Financial analysis

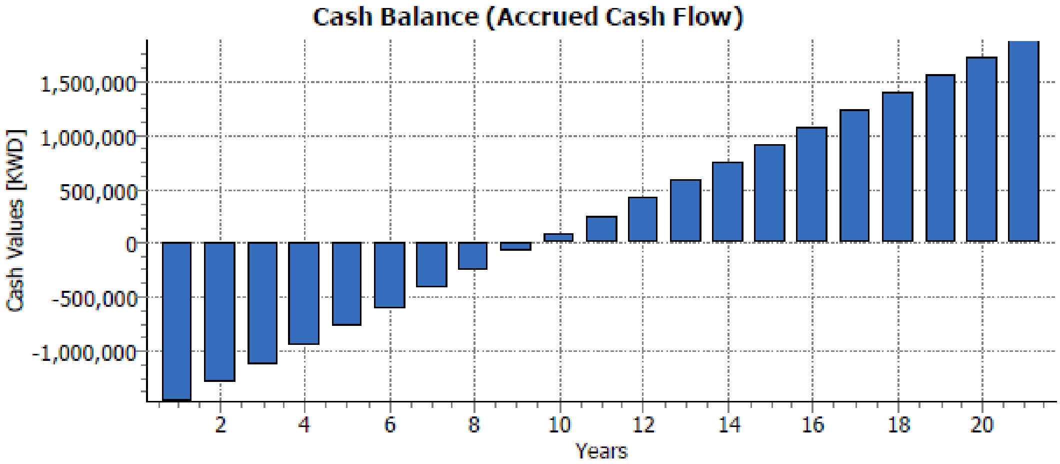

Figure7. 22 Cash balance

The primary reason for this study is to develop L&G GCs, and thus establish the concept of “renewable energy resources are fundamental to oil and gas production” and the creation of profit. This model is to be utilised in KOC’s facilities, which demand that development needs to be steady (i.e. no unexpected or abrupt changes). GC operations requiring the following were all considered in the building of this system: (1) an air conditioning system; (2) a boiler system for operations; (3) high energy usage.

Electricity in Kuwait is (as noted previously in the literature review) highly subsided leading, to tariff being considered an important influence in the cost of the system. The cost of the primary fuels (i.e. oil and gas), directly influence the cost of the electricity. The results in Figure 7.23, emphasise the notion that the PV 0.037 KWD/W (0.08 GBP/W), along with the efficiency of the cells and the discount rates, are major factors in determining the cost of electricity generated. The results clearly indicate a sharp decline in annual average electricity costs (LCOE).

Please enter under Options-> Settings

Project Name:	System Variant	04/01/2014
Variant Reference:	System Variant	

Detailed List of all Payments Received and Made

One-off Payments

Position		Amount[KWD]
One-off Payments		1,630,000.00

Operating Costs

Position	Inflation [%]	Amount[KWD]/a
Running Costs	0.00	0.00

Income from Export to utility grid

Position	Inflation [%]	Amount[KWD]/a
Income from Export to utility grid	0.00	176,771.99

Figure 7.23 detailed list of all payments received and made

Current annual average electricity costs (LCOE) for the GC = 0.37 KWD * 8194320 KWh = 303189.84 KDW/ 663775.08 GBP per annum.

If it is assumed 40% is covered by the PV solar station = 3277728 KWh * 0.037 KWD =121275.936 KWD / 265510.03 GBP:

Annual saving = 181913.904.

The system assumes maintenance expenses =5171.914 KWD / 11322.90 GBP:

Total saving = 176,771.99 KWD/a / 387,007.83 GBP/a.

(Google currency converter has been used to convert currency on 15/11/2104.)

The environmental benefit of lowering CO2 emissions

The most important environmental benefit resulting from the installation and operation of solar energy systems concerns the reduction in pollutant emissions, as current conventional energy used from the grid contributes to the cycle of pollution. A general conservative estimate of this value is 4606.08 ton/a of CO_2. By considering the average of KOC to include 24 GC (4606.08 ton/a * 24 GC), the implementation of the PV and Carbon Price Support (CPS) in Kuwait will contribute to the lowering of emissions of CO_2 and other pollutants into the atmosphere. The price of one tonne of CO_2 emission in monetary value is £15.3 (Ramadhan & Naseeb, 2011), HM Revenue & Customs (2014) state that the carbon price floor in the UK will be £18.

Thus, it can be calculated that, assuming the price of tonne of CO_2 is £16, and then KOC will add £7,369.82 profit to its annual budget from a single GC. If KOC applies this strategy for twenty-four GCs, it will gain £1,768,734.27 per annum, due to being green, in addition to saving additional barrels of oil for from being burned for the generation of electricity.

The economic benefit of PV system

Economically speaking, profit is the difference between total revenue and total cost, including both its explicit and implicit components. From an economic point of view, money does not need to change hands before a cost is incurred. Cost cannot comprise of sacrifices, and economies can be made, and alternatives can be forfeited, without money changing hands. It is within this context that the economic profit (benefit) of producing electricity using PV solar system can be analysed.

Each watt of electricity produced using PV system will replace a watt of electricity produced using fossil fuel. The savings benefit the current energy resources (i.e. oil and gas), which can be sold on the oil and gas market, or preserved for future generations. The cost of burning fossil fuel in producing electricity (apart from the price at which it is sold) can be accounted for in order to determine the economic profit of PV solar systems. Furthermore, this cost can be accounted for as an implicit cost of environmental pollution.

7.6 The Future State Revisited

The future VSM for oil and gas production operations in GC is shown in Figure 7.24, (p. 243). The results of the foregoing analysis are documented on the future state map, and the proposed lean tools are shown as kaizen bursts to highlight the improvement areas, in addition to one supermarket after the wet tank and before the desalter trains. As seen on the map, GC receives on daily basis a single schedule only for one product with different characteristics (wet/dry), i.e. dry at the continuous production flow line for the hybrid system (pull before dry tank and push after dry tank) with no changes, and wet at the desalter trains for the pull system at the finish end (desalter) where the improvement is recommended.

The new improvements at GC for the wet crude oil production line result in a value added time (660 minutes) being up from approximately 45.8% of the holistic production lead-time in the old system during twenty-four hours' of production.

The non-value added time in the waiting time drops from 0.146 to 0.0625 per day for each batch of the wet crude. The VSM provides dynamics that allow work to be JIT (one of the main recommendations that drew approval from operators during the validation workshop). Operators claim they are facing difficulties in reaching the level of producing JIT.

If the laboratory is situated in the GC-floor, the testing of the sampling process will not consume more than 60 minutes. This will result in an elimination of at least 60 minutes from the delivery of samples, and waiting the waiting time for each delivery to be value added, in addition to reducing the impact upon the environment. Sampling takes place on average three times a day (i.e. 60 minutes * 3 = 180 minutes value added from sampling per 24 hours). The sampling process takes place to test the percentage of salt in the crude. In the validation workshop, operators were comfortable about this recommendation. Operators claim that the device for testing the crude is small, available, cheap and simple to use, and does not require training courses. Operators claim they would be happy to avoid interaction with laboratory technicians, due to such technicians being busy or unavailable. In addition to saving time, this approach would save the effort of travelling to the laboratory.

Subsequently, for each batch allocated in the wet crude, 60 minutes value would be added from the processing time, through reducing the waiting time and WIP for settling the crude. The visual lean tools described to integrate future VSM enables the measurement of GC's operations to fulfil the guiding principles through achieving salience in the shop-floor (Cash *et al.*, 2003). Therefore only 30 minutes (90 minutes – 60 minutes) settling time is more than enough for each batch of wet crude in the wet tank, before it is pushed to the supermarket. The GC's manual notes that there is evidence for 30 minutes being sufficient for settling:

> *''Settling & gravity separation, this is done in wet tanks. Free Water carried in the crude separates easily when given enough space and sufficient residence time (20-30 minutes). Separation is effected by the gravitational method''*. (GC Manual)

The availability of supermarkets will allow the desalter to pull already settled wet oil (i.e. zero waiting time from the perspective of the desalter) to create a continuous flow. In the current VSM, the desalter trains take approximately 300 minutes to process settled wet crude, with 60 minutes normally added, due to waiting for the delivery of the samples. It can be assumed that an additional 40 minutes of over processing of the desalter can be eliminated. The operators state this could be achieved by increased precision and clarity and certainty concerning the status of the crude. Therefore, the actual time taken by desalter processing in the future state map is 200 minutes for each batch As previously discussed, operators assume the current processing time of desalter for each batch to be 180 to 360 minutes (see Proposed time reduction Table 7.5, p. 240).

However, stakeholders are more likely to object to this recommendation, due to its cost. The recommendation is to use the dual tank as a supermarket, due to availability of the tank without usage. However, the dual tank must be on standby mode, in case of any failure or damage within the wet tank. This means that if the supermarket is applied it would require construction work. The building of a new tank may involve additional cost, and it would also require the installation of a new pump. For this reason, stakeholders did not show enthusiasm for the idea of supermarket, however, they did show enthusiasm for establishing third-stage settling (i.e. a supermarket) in terms of the process of improvement, having verified that this would save time, along with the amount of demulsifier chemicals used, and also provide consistency. Providing a supermarket would eliminate both vagueness and waste at this stage. The researcher argues that this would save additional expense in the future, and that stakeholders require a feasibility study to verify that would not incur any additional expense.

The 2.97 PV solar applications linked to the GC can produce energy to meet 40% of demand. Moreover, this will contribute substantially to CO_2 reduction efforts from the GC, and can reduce pressure on current power stations to generate electricity.

In the validation workshop, the recommendations of lean tools and method were unanimously agreed, along with the fact that the availability of the laboratory and supermarket would all lead to the delivery of efficiency and accuracy in processing and precision (apart from the question over the cost of building the supermarket). Stakeholders added that, theoretically, the work is correct, particularly from an operational perspective. However, the researcher also needs to consult the operatives working with the chemicals involved.

Table 7.5 Proposed time reduction

Process	Current time (minutes)	Proposed time (minutes)	Nature of time
SETTLING & GRAVITY SEPARATION	90	30	Waiting
Sample delivery and testing	120	60	Waiting
Desalter processing	300	200	Processing

Calculation of future VSM:

The batches style has been developed in order to produce a small increment of 10 batches of wet crude from the wet tank to the desalter trains.

Sample delivery time eliminated = 60 minutes.

Total settling WIP inventory avoided in wet tank = 60 minutes settling time for each batch.

Waiting time avoided = 60 + 60 = 120 minutes = 0.083 day.

Waiting time in future VSM = 0.063 day.

As seen from Table 7.6, (p. 241) in the future VSM there will be an improvement of lead time by 42.81%, so eliminating the non-value added waiting time from 0.146 day to 0.063 day of waiting-reduced work in WIP process, and reveals the bottleneck in the main workstation (i.e. the desalter trains).

Actual processing time for the desalter is reduced 100 minutes (i.e. savings of energy and raw materials).

Table 7.6 proposed improvements

Key measurement	Proposed reduction	Scenario
Desalter processing	33 %	Overcrossing elimination
WIP inventory wet tank	66%	time reduction
Sapling and testing	50 %	time reduction
Electricity consumption	40%	Green energy covers
Gas flaring	Reduction	TPM
Chemical demolsifier	less consumption	Peacemaker apply, salience in desalted process, quicker samples result, batches style; 10 batches
Waiting time future VSM	42.81%	Improvement by apply lean tools

7.7 Summary

This chapter discussed and presented the format of the fieldwork results from the site observations process and KOC's official documents. Firstly, at the operational level this chapter discussed the application of L&G to develop the L&G oil and gas operations concept. Oil and gas production operations have attributes that differ from conventional production systems, such as in mining or the automotive sector. These attributes are identified along with elements that require optimization prior to the processes being applied at GC's operations. A description of the application of L&G oil and gas production and the operations needed to re-engineer the current GC's operations were also discussed, in detail, in this chapter.

Section 7.5 in this chapter presented a PV solar model that could supply the GC's with renewable energy. The obtained qualitative data was used to understand the manner of electricity consumption of the GC and consider the PV model. Issues were identified during the development of the PV model, advantages and disadvantages were discussed and the model cost was assessed against its ability to achieve environmental benefits. This was to ensure the sustainability of KOC's business.

Chapter 8 provides the conclusion for this research project. It identifies the limitations of the research and suggests recommendations for future work.

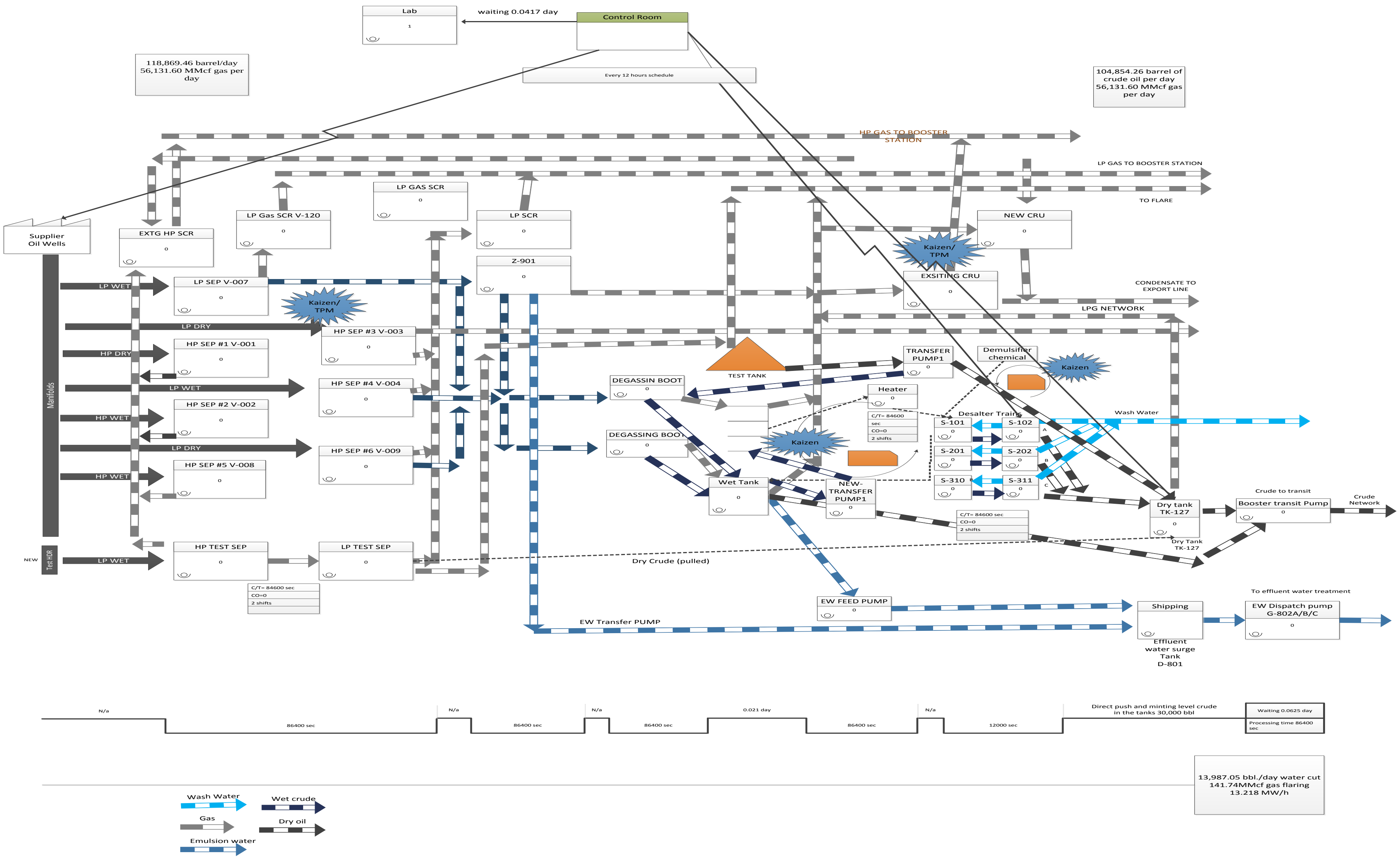

Figure 7.24 Future VSM

Chapter 8 Conclusion

This chapter summarises the overall approach taken when conducting the research, and describes its contribution to knowledge. In addition, it includes recommendations for further research, which are discussed alongside proposed improvements for further research.

8.1 Introduction

This study aimed to consider green upstream oil and gas operations, to assess future economic growth and to determine Kuwait's future energy demand, by analysing the strategy of a single case study (Kuwait Oil Company (KOC) as a pioneer in hydrocarbon industry)). This was done using the TOWS Matrix and then applying lean and green (L&G) principles to the company's oil and gas production operations. This was achieved by fulfilling four objectives.

Objective (1), review the academic literature:

The literature review in chapter two involved a desk-study that identified six different subjects. Part 1 in Chapter 2 identified the experts and organisations involved in energy demand, consumption and energy developments. This helped to understand the economic fundamentals and the primary sources of Kuwait's income. It also included discussions of the hydrocarbon industry, in addition to energy consumption and generations are playing a significant role in the country's economy.

Part 2 of Chapter 2 covered the work content of the lean production system, the understanding of how work is performed and the consequences faced by the worker in a lean environment. The review is in four parts and gives an account of the lean production system and how it has emerged within different industries/branches. It also discussed L&G operations and it gave a discussion of how the classic Toyota Production System (TPS) evolved until it reached a level of green. Finally it provided an argument as to whether lean is green and identified the lean gaps (part 2 of the literature).

Part 2 of Chapter 2 explored the value of the SWOT analysis as a tool to understand the nature and implications for the organisation. A SWOT refers to the Strengths, Weaknesses, Opportunities and Threats of an organisation. The TOWS Matrix is also discussed, as a tool to enhance the SWOT analysis, through the development of other matrices which link the findings and validate the SWOT analysis. The TOWS Matrix creates solutions for each negative scenario that emerged in the SWOT analysis.

Finally part 3 of Chapter 2 presented the interaction between objective (1) and the other objectives. It demonstrated how it would not be possible to conduct any other objectives in this research, without refereeing to objective (1). It discussed the links and interactions between the different subjects that had been identified in the literature. It helped to identify the gap in the literature review. It highlighted research related to the study and provided an overview of the methodologies used in past studies, which concerned the similar topics.

Objectives (2): Conduct a SWOT Analysis to develop a TOWS Matrix in order to analyse the current and expected future environment, and to determine the direction of the case study (KOC) with respect to the ecosystem:

Objective (2) aimed to investigate a single case study, the KOC and assess its strategy and plans in order to evaluate the strategy of a hydrocarbon firm in the Middle East (Non-OECD country). The TOWS Matrix was used as an analytical tool to identify KOC's strengths and weaknesses and its relationship to external opportunities and threats. It was used to develop four distinct strategies, the SO, ST, WO and WT strategies. These choices should be made in congruence with the vision of the top managers and in light of risks.

As KOC moves towards the third decade in the twenty first century, it will have to make some new strategic choices. KOC's mission is still to exclusively focus on the production of hydrocarbons, within the State of Kuwait (ARAMCO 2015; Statoil 2014). KOC now faces fierce competition from its competitors in the hydrocarbon market and is currently experiencing unfavourable circumstances. This includes a drop in oil prices in 2014/2015 (BBC 2015), tighter international environment laws and inefficient local oil consumption, which will be deducted directly from its sales on a daily bases.

Objective (3): Investigate the existing oil and gas production operations in a single Gathering Centre (GC) of KOC and seek to re-engineer these operations. L&G operations were adapted to enhance the efficiency of the plant and value stream mapping was used as a main tool to identify the opportunities for various lean techniques.

Objectives (3) aimed to investigate KOC's oil and gas production operations at the operational level. The choice of a single case study approach was a further attempt to understand the nature of the upstream oil and gas operations, at a micro level. It was essential to explore the upstream oil and gas operations in detail. In order to understand how best to deliver green oil and gas production operations, a number of lean and green tools were outlined, mainly through the use of value stream mapping. This method provided evidence for developing efficient L&G operations in the oil and gas industry.

L&G was harnessed to eliminate different types of wastes and to achieve Just in Time (JIT) delivery, by avoiding unnecessary energy consumption and thus making the oil and gas operations more green and sustainable. As a result from an L&G process, a Kaizen event was run to identify the waste in resources and time. The recommendation from this event was to check the quality from the source (oil wells), instead of solving quality issues within production line.

Objective (4) Design/develop a photovoltaic model to supply oil and gas operations with a cheap and clean renewable energy for the Gathering Centre used in the case study:

At this time, the Ministry of Electricity and Water (MEW) in Kuwait struggles with unsure stable power supply, especially during peak time in summer. For this reason, the KOC provides mobile electricity generators fuelled by diesel. Therefore, objective (4) investigated electricity consumption on a single GC and developed a suitable PV model to insure clean and cost effective electricity supply for GC's operations. It showed that the implementation of PV solar power will contribute substantially to CO_2 reduction efforts in the country and can reduce the pressure upon the MEW's shoulders. The cost effective 2.79 KWp PV model was used to feed GC's operations, this could be open to new avenue in the future, with the idea of working towards fully operating renewables.

Objective (5) evaluated the proposed solutions and validated the theory (L&G operations in oil and gas) upon which the strategy is based:

Objective (5) aimed to deliver validation which was essential to prove the validity of the data analysis, findings and also to recommend improvements. It was conducted and achieved in accordance with predefined protocols, as shown in Table 3.10 steps undertaken to ensure research validity and reliability p.111). In addition a workshop was conducted with the stakeholders (see section 3.8.1 in Chapter 3, p. 108) Objective (5)) to establish that the work was well developed, well maintained, and reliable.

The research methods employed were direct site observations and 22 interviews. Since the nature of the study was exploratory and descriptive. The level of the data was very detailed and a single case study was used for this research.

8.2 Major Elements of Work

This thesis addressed the need for hydrocarbon firms to employ a new L&G operational strategy, in The State of Kuwait. It developed a new design for upstream oil and gas operations to eliminate waste and the hazards resulting from these operations. Whilst KOC's strategy and operations follow a conventional approach, the new strategic and operational approaches, introduced in this thesis, sought to show the hydrocarbon industry the benefit of developing a green approach.

The design and implementation of future oil and gas operations is intended to evade the future risk from a lack of resources and to reduce the causes of environmental damage, when viewed from a global context. The author proposes that it is possible to create a sustainable and green hydrocarbon industry based on an optimised use of L&G operations within the company's operations. The author proposes that there is a need to link these operations with renewable resources. The findings from the TOWS Matrix indicate that a big risk threatens the company's future if it fails to develop greener business processes.

Chapter 6 discussed and summarised the general research findings. It discussed answers to the research question. It also looked at the findings from Chapter 6, future Value Stream Mapping (VSM) which included ways to develop L&G operations at the micro level. The results can help the KOC to maintain a leading position in the future, in addition to the other solutions illustrated in in chapter 6.

The literature review provided a detailed understanding of the global energy needs, the necessity of reducing GHGs emissions and explained how L&G operations can help to achieve a cleaner industry. The primary task when developing a green oil and gas production, within the context of L&G, are to create a strategy that creates a green and sustainable hydrocarbon company. A study of lean thinking is also carried out, highlighting the fundamental principles of L&G and a sustainable strategy that can be applied in practice.

The thesis began with a thorough literature review, tracing existing background literature and covering the work energy demand and consumption at different levels. This included country level and industry and renewables systems. It was important to understand the future plans linked to energy consumption and production in developed countries and within leading hydrocarbon companies. A review of renewable energy applications identified potential solutions that will meet the demand for energy, without harming the ecosystem.

The review was focussed on Kuwait's major energy and pollution problems. In this section of the literature it was identified that the State's economy relied on a single industry, within a single corporation (the backbone of the country). Kuwait Petrochemical Corporation (KPC) is the only corporation producing hydrocarbons inside Kuwait. The researcher addressed a single case study: KOC, one of KPC's subsidiaries. From the review the country is found to be facing a critical situation. If steps are not taken then the entire country's economy could fall into a catastrophic deficit. The review of the literature found that the energy consumption of Kuwait is directly deducted from oil exports, which directly affects the country's economy. Furthermore, the opinions of most authors have been that Kuwait lacks essential resources including water and gas. The only source of fresh water in the country is desalinated seawater. All desalinating stations in the country are oil and gas powered. Thus, conserving oil consumption and diversifying the country's resources is a high priority (Ramadhan & Naseeb 2011; Al-Rashed & Sherif 2000). In the future, Kuwait is still expected to be heavily dependent on oil, as it is still ranked as one of the highest gas emitting countries per capita in the world (Wood & Alsayegh 2014).

The TOWS matrix was successfully tested by developing strategic solutions for German industries, this had a significant impact on the country's economy and its position regarding intrinsic national forces in social, economic, political, and technological areas (Weihrich 1982). Thus, the TOWS matrix was also used in this study, as a method to highlight the need for KOC to make decisions. It was also used to assess an unpredictable future in which global preferences might shift to favour alternative sources of energy. The TOWS helped to provide strategic choices and to ensure a good position in terms of market competition for the company in the future.

In addition, according to the literature L&G presents a number of tools and strategies that could result in a high potential for waste elimination and better efficiency for oil and gas operations. Information regarding the nature of lean thinking, L&G and the associated benefits was given. The three part review of lean provided an account of lean production, lean gaps and lean and green operations. Lean thinking and L&G, involves a complex set of practices including improved productivity and new measures that involve delivering green and efficient oil and gas production operations (Martinez 2004; UNFCCC 2011; Simons & Mason 2003). In summary, the literature described lead oil and gas production operations in the work content using L&G, to reduce resources consumption, eliminate waste and reduce the hazards to the industry. It also investigated energy consumption and energy demand in the world and created a tailored sustainable strategy for the case study.

The thesis developed a lean map model with a strategy matrix, which aided the identification of elements required to sustain a good position in the hydrocarbon industry. KOC fundamentally sought to enhance business performance through L&G operations. The attributes for potential oil and gas production operations were specified and a mapped model of the system developed. Potential opportunities in the current KOC practices were demonstrated, with the assistance of technical implementation on the shop-floor. A comparative study between oil and gas production operations and lean thinking is described. Investigations were carried out in a single case study; a method for identifying the gaps was described. The analytical results are discussed and findings highlighted below:

- The TOWS Matrix was used to develop four distinct strategies, the SO, ST, WO and WT strategies. These choices were made in the light of possible risks and in congruence with the vision of MOC's top managers.

- KOC must prepare for harsh competitive global energy markets.

- According to Figure 7.3 Liquid oil production historical data 2012 (source KOC)), p.195, and Figure 7.4 Five years' production (2007-2012), (source OC).196 the water cut in liquid oil is fixed and constant, in contrast to crude oil production, which oscillates.

- As shown recently, oil prices fell especially in 2014 and KOC had to fulfil the local demand for oil, as it would be expected to make a strategic choice.

- KOC is sticking with its classic hydrocarbon mission. Whereas National Oil Companies (NOC) and International Oil Companies (IOC) have started to implement changes to their businesses, in order to support their strength in the market.

- Peer competitors of KOC represent the biggest challenge for the company, when seeking to attract customers, especially from the Middle East market.

- The availability of the information provided by site observation can facilitate and validate the decision to implement L&G and can also motivate KOC during the actual implementation phase. This will help to obtain the company's desired results.

- With upstream oil and gas operations a number of L&G techniques can be suitability adopted, fundamentally by utilising lean value stream mapping and engaging with a number of lean tools.

8.3 Contribution to Knowledge

The literature review in this research combined three distinct fields, oil and gas, renewables and L&G. The TOWS Matrix emerged a number of strategies (S-O, S-T, W-O, and W-T) to define a comprehensive company strategy. The L&G model combined a number of definitions to explain the company’s oil and gas production operations comprehensively, which has not been done previously in the literature. The researcher contributed to an initiative by attempting to develop a greener hydrocarbon industry, through model and strategy. This provided a series of valuable, context specific findings to assist KOC in delivering a better company strategy and in designing better oil and gas operations.

Lean manufacturing has the power to improve shop-floor productivity, but these studies have presented shop-floor accounts based on the interviews, that have challenged prior assumptions and existing theories. This research formed an understanding of how to enhance a country’s economy through its main industries, as well as enhancing the environment.

The TOWS matrix and the L&G model combined different measures and explored different levels of meaning associated with the hydrocarbon organisation, strategic decision-making and operational decisions. A similar model that encompasses all these aspects together has not been found in the literature to date. This view contrasts with much of the existing literature, as this research focussed on KOC’s situation and their capacity to change their approach. This gave an opportunity to manage the development of national and international hydrocarbon companies, by applying strategic theories of organisational leadership and operational change, rather than following proven organisational or market driven models.

According to the literature review, the application of L&G has been uncommon in the hydrocarbon sector. This is because in industry, lean was always linked to automotive production and mining, rather than hazard and complex hydrocarbon production. Applications of lean manufacturing have been less common in the multi-stage process industry. This is partially because of a perception that this sector is less amenable to many lean techniques, and partially because of the lack of documented applications. This caused managers to be reluctant to commit to an improvement program.

Previous research for L&G was mainly applied to automotive production and mining, and lean manufacturing was mainly seen as a single stage or as part of a sequential process.

- This research applies both lean and green to complex multi stage hydrocarbon processes.

The current model relied in approximately 73,000 barrel of oil per day being processed, operators recognised they has issues specifying the time of the release and the quantity of chemical treatment. Operators also had difficulties identifying the status of the oil in the desalter trains (demulsifier to desalter trains). The operators identified issues with communication and transportation with the testing laboratory that was located five miles away. Lead times were also vague.

- This research was not looking for ‘one-off’ improvements, it was looking for Kaizen (continuous improvement). In the VSM it applied Kanban and peacemaker processes to identify 10 batches of 7560 barrel per batch. This facilitated the immediate identification of the nature and source of waste, so that it could be reduced, as well as providing an opportunity to reduce CO_2 emissions (Rother & Shook 2003; Poppendieck 2011; Honeycutt 2013).
- The batching is intended to increase the process of intervention and for that process to be efficient, this research recommends the siting of a testing laboratory on the GC floor. This could result in significant time saving, the elimination of transportation issues, improved environmental performance and cost savings.
- In addition, the use of a supermarket could enhance the pull of the desalter’s feed pump. This would significantly reduce the waiting time in the wet tank, provide clarity to the process and avoid the unnecessary use of energy and raw materials.

- VSM is likely to achieve increased lead times with a value of 42.81%.

- This research also created the Crude Oil Quality Manual (COQM) which can help to regulate chemicals dosage, make the supply activity greener and more sustainable.

- The use of a qualitative analysis showed that the installation of PV solar system could supply about 40% of daily electricity consumption, leading to profits after 8.4 years, before considering the application of L&G.

- The research has generated a new theory (L&G operations in the oil and gas) that is relevant and appropriate to the hydrocarbon industry in general.

8.4 Limitations of the Study

- The findings do not represent a complete theory that can be applied to the entire hydrocarbon industry, but they do highlights aspects that are relevant to this huge industry.

- The research findings cannot be viewed as facts or objective truths; they result from interactions between the researcher and the researched.

- The research findings cannot be assessed in terms of reliability, rather their value results from their degree of credibility to those with an interest in the area.

- The views of the chemicals experts' could provide deeper clues about the proposed solution; however no chemicals experts were involved in this research.

It is clear that there is some lack of clarity and uncertainty in the results because of the reliance on what is known and familiar to managers, how operators influence managers and vice versa. Work therefore needs to be conducted to define cultural and behavioural factors, which could clearly reflect and reinforce what a green plan means to those working for KOC. This would lead to an improvement level within their work processes that would better suit their strategy and means of operation. Top managers should be the first to visibly support and provide new strategies for team leaders. This support should be carried down and applied by team leaders, who finally pass this message onto the operators, who then carry out the processes to align operations accordingly. This step-by-step process should reflect a new emphasis on maintaining a green environment.

8.5 Recommendations for future research

The proposed L&G GC model can only identify 'what changes' or what key relationships are needed between processes within a given context. This is why a number of lean tools and strategies have been proposed. The model does not provide any guidance regarding how to overcome current problems, because there is a lack of access to data to assist improvement. Future research is recommended to identify and focus on machine downtime, and to implement context specific changes in places where GC is already linked to the PV system.

The L&G GC is limited in terms of its ability to offer precision guidance to the operations that are needed to identify changes that are context specific to a number of machines and processes. There are various perspectives that can be under taken to test the model. The researcher recommends that a longitudinal study of interaction between oil and gas production operations in L&G industries and non-lean industries should be conducted to understand waste management in oil and gas. This study should look at improvements in efficiency and should introduce mixed sources of energy, to cover those areas that provide a broader contextual understanding of what potential situations can be characterised when merging different domains. Other recommendations were recommended by stakeholders in a validation workshop:

- Prepare a feasibility study to install a new extra tank in the GC's floor to create a new 3rd stage separation.
- Undertake a study to calculate the downtime of machines, in order to reduce and deliver world class OEE
- Investigate and improve KOC's culture and employees' behaviour.
- Apply the required VSM model, so that it can be tested on the GC-floor.
- Expand the studies of value stream mapping to include SPC.
- Conduct further studies to find more efficient solutions to KOC's data management concerns.
- Although theoretically the work is valid, it would be necessary also to include chemicals experts in any further research.

The research findings reported improvement at both the operational and strategic levels of KOC, highlighting the fact that carrying out changes in the industry can be complex. Understanding of a SWOT analysis enables managers to understand the key associations between strategic and operational situations. This means that risks are less likely to occur and provides a versatile framework to address issues of strategic change and operation together.

- In relation to the strengths and threats, KOC could take advantage of its significant position in the country and large budget to investigate in a serious solution for local irrational consumption. This could be done by providing energy from renewable resources.

- To overcome the bureaucratic requirements and high cost structure, the structure of green jobs, mainly represented by carbon management, should be established as a means to harness opportunities to cover weaknesses.

- Highlighting a variety of threats that arise from local consumption practices, threats were found to be mainly related to external factors, such as satisfying internal and external costumer demand, the potential lack of crude oil and the current lack of gas. Thus, the company might need to turn to an unconventional reservoir, or persuade the government to raise prices/tariffs for electricity or petroleum.

- KOC's strengths are related to their opportunities which could inform productivity improvement and cost reduction, through innovations related to environmental performance. This could support the company's economy and enhance its ecosystem.

8.6 Summary

This research has been conducted with the aim of proposing a greener hydrocarbon industry, which enables both academics and industrialists to consider a new concept, which is to develop/design L&G operations in oil and gas. This concept linked with renewable energy use and the development of new L&G strategies, will improve the economic business and also improve aspects of the ecosystem.

The factors that influenced the development of KOC's strategy are L&G oil and gas operations and the PV model. These considerations have been used alongside the key energy market competition, the ecosystem and Kuwait's economy. The holistic outcome of this research has been the development of strategic solutions, a new management philosophy and new engineering processes, which will allow KOC to consider measures of improving its business and to prepare for an unexpected future.

The pilot interviews used were structured and semi-structured interviews that sampled various viewpoints, at different companies, in addition to KISR. The interviews primarily sought three perspectives:

Questions about mixing source of energy with industry in Kuwait and the reduced reliance on conventional electricity were posed, with particular emphasis on the environment. There were various macro and micro issues that related to the industry and their issues with MEW. Other questions were about electricity generation and the supply and production processes of the MEW. These questions were posed with particular emphasis of how to deal with industry demands in the country.

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APPENDICES I

OIL COMPANY

GC INSTRUMENTS PREVENTIVE MAINTENANCE SCHEDULE

AREA		LOOP ID	TAG No.	SERVICE / DESCRIPTION	2009	2010	2011	2012	2013	2014
	9	022PIC3510	022PIC 3510 022PCV -3510A 022PCV -3510B	TV FLARE CONTROL Tank Vapour to Flare KO Drum Tank Vapour to Flare KO Drum	10-Sep-14	31-Aug-10	20-Sep-11	14-Oct-12	17-Sep-13	21-Sep-14
VSM	1	022FIC5101	022FIT 5101B 022FCV 5101B	MOL PP G302 RECYCLE	14-Sep-09	02-Sep-10	22-Sep-11	16-Oct-12	19-Sep-13	23-Sep-14
	2	022PIC5117	022PIT 704 022PCV 5117	MOL PP DISC PRESSURE	16-Sep-09	05-Sep-10	25-Sep-11	18-Oct-12	22-Sep-13	25-Sep-14
COOPER BESSEMER	1	022LIC118	022LIT 118 022LCV 118	JACKET WATER	27-Sep-09	07-Sep-10	22-Sep-11	21-Oct-12	24-Sep-13	28-Sep-14
	2	022LIC135	022LIT 135 022LCV 135	C102 AUTO DUMP	29-Sep-09	09-Sep-10	25-Sep-11	23-Oct-12	26-Sep-13	30-Sep-14
	3	022LIC137	022LIT 137 022LCV 137A 022LCV 137B	C103 LEVEL CONTROL C103 EXTRA DUMP VALVE	04-Oct-09	13-Sep-10	27-Sep-11	25-Oct-12	29-Sep-13	1-Oct-14
	4	022LIC138	022LIT 138 022LCV 138	C103 AUTO DUMP	14-Jun-09	15-Sep-10	29-Sep-11	28-Oct-12	01-Oct-13	5-Oct-14
	5	022LIC140	022LIT 140 022LCV 140A 022LCV 140B	C104 LEVEL CONTROL C104 EXTRA DUMP VALVE	06-Oct-09	19-Sep-10	02-Oct-11	30-Oct-12	03-Oct-13	7-Oct-14

OIL COMPANY

GC INSTRUMENTS PREVENTIVE MAINTENANCE SCHEDULE

AREA		LOOP ID	TAG No.	SERVICE / DESCRIPTION	2009	2010	2011	2012	2013	2014
CRU - C	6	022LIC141	022LIT 141 022LCV 141	C104 AUTO DUMP	08-Oct-09	21-Sep-10	04-Oct-11	01-Nov-12	06-Oct-13	9-Oct-14
	7	022PIC114	022PIT 114 022PCV 114	TRIMMING VALVE	11-Oct-09	23-Sep-10	06-Oct-11	05-Nov-12	08-Oct-13	12-Oct-14
	8	022PIC111	022PIT 111 022PCV 111	LEAN GAS PRESSURE	13-Oct-09	26-Sep-10	09-Oct-11	07-Nov-12	10-Oct-13	14-Oct-14
	9	022PIC145	022PIT 145 022PCV 145	C104 VESSEL	18-Oct-09	29-Sep-10	11-Oct-11	12-Nov-12	13-Oct-13	16-Oct-14
	10	022TIC113	022TIT 113 022TCV 113	E103 TEMP CONTROL	20-Oct-09	03-Oct-10	13-Oct-11	14-Nov-12	15-Oct-13	19-Oct-14
	1	022FIC3408	022FIT 3400A 022FIT 3400C 022PIT 3404A 022PIT 3404B 022PIT 3407A 022PIT 3407B 022TIT 3402B 022TIT 3402C 022TIT 3403B 022TIT 3403C 022-FIC 3403 022FCV -3403	TV COMP DISCH FLOW TV COMP DISCH FLOW TV COMP SUCTION PR TV COMP SUCTION PR TV COMP DISCHARGE PR TV COMP DISCHARGE PR TV COMP SUCTION TEMP TV COMP SUCTION TEMP TV COMP DISCHARGE TEMP TV COMP DISCHARGE TEMP Anti Surge Conrtoller 22-K-111A to 22-C-111	S/D JOB	S/D JOB	S/D JOB	S/D JOB	S/D JOB	S/D JOB

OIL COMPANY

GC INSTRUMENTS PREVENTIVE MAINTENANCE SCHEDULE

AREA		LOOP ID	TAG No.	SERVICE / DESCRIPTION	2009	2010	2011	2012	2013	2014
CRU - MANTURBO	2	022FIC3408	022FIT -3408 022FCV -3408	22-G-112A Min.Flow RECYL	22-Oct-09	05-Oct-10	18-Oct-11	18-Nov-12	17-Oct-13	23-Oct-14
	3	022FIC3414	022FIT 3407A	HPCOMP DISCH FLOW	S/D JOB	S/D JOB	S/D JOB	S/D JOB	S/D JOB	S/D JOB
			022FIT 3407C	HPCOMP DISCH FLOW						
			022PIT 3414A	HP COMP SUCTION PR						
			022PIT 3414B	HP COMP SUCTION PR						
			022PIT 3416A	HP COMP DISCHARGE PR						
			022PIT 3416B	HP COMP DISCHARGE PR						
			022TIT 3413B	HP COMP SUCTION TEMP						
			022TIT 3413C	HP COMP SUCTION TEMP						
			022TIT 3414B	HP COMP DISCHARGE TEMP						
			022TIT 3414C	HP COMP DISCHARGE TEMP						
			022-FIC 3414	Anti Surge Conrtoller						
			022FCV -3414	RECYL Gas to 22-C-112						
	4	022FIC3410	022FIT -3415 022FCV -3415	22-G-112B Min.Flow RECYL	25-Oct-09	07-Oct-10	20-Oct-11	20-Nov-12	20-Oct-13	26-Oct-14
	5	022FIC3416	022FIT -3416 022FCV -3416	G-111A Min. Bypass Line						

OIL COMPANY

GC INSTRUMENTS PREVENTIVE MAINTENANCE SCHEDULE

AREA		LOOP ID	TAG No.	SERVICE / DESCRIPTION	2009	2010	2011	2012	2013	2014
CRU - MANTURBO	6	022FIC3416	022FIT -3410 022FCV -3410	G-111B Min. Bypass Line						
	7	022FIC3450	022-FIC 3450	Anti Surge Controller	S/D JOB	S/D JOB	S/D JOB	S/D JOB	S/D JOB	S/D JOB
			022-HIC 3450	HOT BYPASS CONTROL						
			022FCV -3450	HP Gas Comp. suction Scrub						
	8	022LIC3401	022LIT -3401	Scrubber Drain Seal Drum C-114	27-Oct-09	11-Oct-10	23-Oct-11	21-Nov-12	22-Oct-13	29-Oct-14
			022LCV -3401A	22-C-111 LIQto 22-C-114						
			022LCV -3401B	FG to 22-C-114						
			022LCV -3401C	22-C-114 to Wet Dual TK						
	9	022LIC3404	022LHIT -3404	HP Gas COMP SUCT Scrubber C-112	29-Oct-09	14-Oct-10	25-Oct-11	25-Nov-12	24-Oct-13	3-Nov-14
			022LCV -3404	CNDS to Ex. LP Wet HDR						
	10	022LIC3405	022LIT -3405	HP Gas COMP DISCH Scrubber C-113	01-Nov-09	18-Oct-10	27-Oct-11	26-Nov-12	27-Oct-13	5-Nov-14
			022LCV -3405	CNDS to Ex. LN						
	11	022LIC3407	022LHIT -3407	HP Gas COMP DISCH Scrubber C-113	03-Nov-09	20-Oct-10	30-Oct-11	28-Nov-12	29-Oct-13	9-Nov-14
			022LCV -3407	CNDS to Ex. HP CNDS						
	12	022LIC3408	022LIT -3408 022LCV -3408	HP Gas COMP SUCT Scrubber C-112	05-Nov-09	24-Oct-10	01-Nov-11	29-Nov-12	04-Nov-13	12-Nov-14
	13	022LDIC3402	022LDIT -3402 022LDCV -3402	HP COMP SUCT SCRBR	08-Nov-09	26-Oct-10	03-Nov-11	02-Dec-12	06-Nov-13	16-Nov-14

OIL COMPANY

GC INSTRUMENTS PREVENTIVE MAINTENANCE SCHEDULE

AREA		LOOP ID	TAG No.	SERVICE / DESCRIPTION	2009	2010	2011	2012	2013	2014
CRU - MANTURBO	14	022LDIC3406	022LDIT -3406 022LDCV -3406	HP Gas COMP DISCH Scrubber C-113	10-Nov-09	28-Oct-10	07-Nov-11	04-Dec-12	12-Nov-13	18-Nov-14
	15	022PIC3400	022PIT -3400 022PCV -3400	TV COMP SUCT Scrubber C-111	12-Nov-09	01-Nov-10	10-Nov-11	06-Dec-12	14-Nov-13	20-Nov-14
	16	022PIC3403	022PIT -3403 022PCV -3403	FG to 22-C-114	15-Nov-09	03-Nov-10	13-Nov-11	09-Dec-12	17-Nov-13	23-Nov-14
	17	022PIC3433A	022PIT -3433 022PCV -3433A	HP Gas From 22-C-113 HP Gas to HP FLR	22-Nov-09	08-Nov-10	15-Nov-11	11-Dec-12	19-Nov-13	25-Nov-14
	18	022PIC3433B	022PIT -3433 022PCV -3433B	HP Gas From 22-C-113 HP Gas to Ex. LN	22-Nov-09	10-Nov-10	17-Nov-11	13-Dec-12	21-Nov-13	30-Nov-14
	19	022PIC3440	022PIT -3440 022PCV -3440	Dry Gas Seal (LP Compressor)						
	20	022PDIC3440	022PIT -3440 022PCV -3440	TV COMP SEAL GAS PRESS. CNT.						
	21	022PDIC3450	022PIT -3450 022PCV -34350	HP COMP SEAL GAS PRESS. CNT.						
	22	022TIC3407	022TIT -3407 022TCV -3407A 022TCV -3407B	22-E-111 OUTLET	24-Nov-09	16-Nov-10	22-Nov-11	16-Dec-12	26-Nov-13	2-Dec-14
	23	022TIC3418	022TIT -3418 022TCV -3418A 022TCV -3418B	22-E-112 OUTLET	01-Dec-09	18-Nov-10	27-Nov-11	17-Dec-12	01-Dec-13	4-Dec-14