UTILIZATION OF LIQUEFIED PETROLEUM GAS AS INDUSTRIAL FUEL: BARRIERS AND OPPORTUNITIES

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Declaration

I hereby declare that this submission is my own work towards the MPhil and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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Abstract

Most people know Liquefied Petroleum Gas as the fuel in small-sized portable cylinders used in homes for cooking. The prospects for increased consumption in the other sectors, especially the industrial sector, remain unknown and very limited in some situations. This study addresses a series of fundamental issues related to the task of exploring the underlying factors for its under utilization in the industrial sector and the potential benefits to be derived from its consumption in this sector. It particularly seeks to identify and discuss the critical factors for the low patronage of LPG use by industries, the challenges and constraints of LPG use to the industrial user, the characteristics of LPG that makes it a preferred option for some manufacturers and make recommendations for policy.

The study was exploratory, using qualitative and quantitative, case study technique. It was carried out in Tema. A total of 60 manufacturing establishments, 26 oil marketing companies, 2 regulatory bodies and a refinery were selected for the study. Manufacturing industries were stratified into homogenous subsets using the Standard Industrial Classification and appropriate number of elements drawn from the homogenous subsets of the populations. Oil Marketing companies were selected by simple random sample. The refinery and the regulatory bodies were purposefully selected. Data was collected through in-depth interviews, questionnaire administration, document analysis and direct observation. Data collected was categorized, cross-tabulated and tabulated according to concepts in order to address the purpose of the study. In some cases, chi-square analysis was used to test relationships between some variables. Specific techniques such as pie charts, pictures and bar charts were also used.

The study suggests that problems of Liquefied Petroleum Gas utilization are not confined to just one factor. Unavailability of the gas, unsuitable design of furnaces and boilers,

comparatively high cost (or price volatility) of the gas and safety concerns were some of the reasons for the under utilization of the gas. There was the absence of policy on LPG utilization in the industrial sector and general lack of awareness of its applications in this sector. Thus, the non utilization of LP Gas as industrial fuel is due to financial, institutional and regulatory barriers other than technical feasibility of the technology. Meanwhile, the utilization of LP Gas would enhance energy security, reduce greenhouse emissions, reduce air pollution and enhance economic growth.

The study recommends a revision of policy that would recognize the significant role that LP Gas can and should play in meeting the country's energy need. Also, information on LPG industry applications and benefits communicated to all stakeholders.

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ABBREVIATIONS, ACRONYMS AND ENERGY UNITS CONVERSION FACTORS

AGI	Association of Ghana Industries
BSPD	Barrel Stream per Day
CEPA	Centre for Policy Analysis
EIA	Energy Information Administration
ESMAP	Energy Sector Management Assistance Programme
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse Gases
GNPC	Ghana National Petroleum Corporation
HSE	Health and Safety Executive
IEA	International Energy Agency
ILPGA	Irish Liquefied Petroleum Gas Association
ISSER	Institute of Statistical, Social and Economic Research
ITP	Industrial Technologies Programme
KAM	Kenya Association of Manufacturers
KITE	Kumasi Institute of Technology and Environment
KOE	Kilogrammes of Oil Equivalent
KWh	Kilowatt Hour
LPG	Liquefied Petroleum Gas
MoE	Ministry of Energy
MoFEP	Ministry of Finance and Economic Planning
MOTI PSI	Ministry of Trade & Industry and President's Special Initiative
NPA	National Petroleum Authority
OMC's	Oil Marketing Companies
RCEER	Research Centre for Energy Economics and Regulation
SSA	Sub Saharan Africa
TMC	Tema Municipal Council
TOE	Tonnes of Oil Equivalent
TOR	Tema Oil Refinery
UNEP	United Nations Environment Programme
UNDP	United Nations Development Programme

WAGP	West Africa Gas Pipeline
WEC	World Energy Council
WLPGA	World Liquefied Petroleum Gas Association

ENERGY UNITS CONVERSION FACTORS

1 Kilowatt-hour of Electricity = 3413 BTU

1 Gallon of Residual Fuel Oil = 149,690 BTU

1 Gallon of Diesel = 138,690 BTU

1 Gallon of LPG = 95,475 BTU

1 Gallon = 4.55 Liters

$10^{-4}m^3$ = 1Liter

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CHAPTER ONE

1.1 INTRODUCTION

Energy is central to sustainable development and poverty reduction efforts (UNDP, 2005). It affects all aspects of development- social, economic and environmental (UNDP, 2004). It fuels industry, commerce, transportation, agriculture and other economic activities. Wider access to energy services is a necessary condition for meeting most of the targets outlined in the Millennium Declaration which include eradicating poverty, ensuring environmental sustainability and for developing global partnership for development among others (UNDP, 2004).

The Industrial Sector is diverse, ranging from mining to construction to manufacturing. The industrial sector also produces a wide range of basic materials, such as cement and steel, which are used to produce goods for final consumption. Energy is an especially important input to the production processes of industries that produce basic materials such as food, beverages, cars and computers. Such industries use about 50 per cent of the total energy available in Ghana (Asante, 2004). Industries within the manufacturing sector compete among themselves and with foreign producers for market share. Consequently, variations in input prices can have significant competitive impacts.

Interruptions in energy supplies often force many industries to operate far below capacity utilization or incur huge additional costs in procuring off-grid energy supply equipment such as electric generators. For small domestic firms, such equipment costs are huge addition to costs and many are often forced out of business as a result of the huge capital investments. For large firms, the cost implication is such that they become internationally uncompetitive with regards to price and non-price competitions. VALCO closed down in 2007 because of worsening energy crisis the country experienced due to chronic power shortages caused by diminished rainfall. CEPA (2007) reports that Wahome Steel in the metal sub-sector cut down production by 50 per cent and sent 200 of its workers home due to this same energy crisis which spanned over a year. It further stated that the country's largest manufacturer, Unilever spent about US$ 45,000 every month on energy generation during this same period.

Price wise, and because of the uncompetitive cost structure, domestically produced goods become relatively more expensive than imported goods and services. Other non-price impacts exist in that it becomes difficult to guarantee delivery dates, plan outputs and investment levels, which adversely affect the growth and levels of economic activities.

Additionally, huge repair costs are incurred due to power 'outages' and power 'overloads'. The effects of electricity supply interruptions are particularly severe, especially given that traditionally; electricity provided the means by which energy was reliably delivered over large distances and together with its diversified end uses in industry and households makes it an essential component of economic growth. Thus, unless there is access to alternative and non-grid energy sources, interruptions in electricity supply cause the economy to operate below its full capacity with adverse consequences for income and employment.

Ghana's energy consumption is estimated at 6.6 million tonnes of oil equivalents (TOE) and per capita energy consumption is estimated at 360 kilograms of oil equivalent (KOE) (MOE). The majority of Ghana's energy use is from biomass in the form of firewood and charcoal. These two account for about 59 per cent of the total energy consumption. Petroleum products and electricity constitute 32 per cent and 9 per cent respectively (Amissah-Arthur and Amonoo, 2004). Most (95 per cent) of the electricity produced in Ghana is generated from hydropower schemes, with the combustion of fossil fuels supplying the balance. (UNDP, 2004; Asante, 2004).

Increasing power demands by industry and domestic consumption and a need to reduce the reliance on hydroelectric power is not only fuelling the search for oil and gas but has set in motion projects relating to the importation of gas via pipeline from Nigeria. The pipeline known as the West African Gas Pipeline (WAGP) is 688.6km/428miles gas pipeline transmission system, onshore and offshore from Nigeria to Ghana (Ababio et al, 2003). WAGP will deliver natural gas from Nigeria to markets in Benin, Ghana and Togo. The purpose of the project is to transport Nigerian-produced natural gas to commercially viable markets in Benin, Ghana and Togo thereby providing available source of energy for electrical power generation and industrial use in the three countries, providing commercially viable market for Nigerian natural gas produced oil wells, reducing the need to flare this gas and facilitate regional economic integration and development. It is envisaged that the transport of natural gas to these three countries will help to alleviate the energy needs of these countries, promote investment in thermal energy facilities and encourage economic growth. Ghana is expected to consume approximately 84 percent of the natural gas delivered via the WAGP project (Ababio et al, 2003).

Before this intervention, Liquefied Petroleum Gas simply known in the country as 'gas' was promoted in Ghana in 1990 as alternative source of energy for households, public institutions requiring mass catering and the informal commercial sector including small-scaled food sellers (UNDP, 2004). Belguedj and Beaussant (2001) in their study on African Gas Initiative stated that Natural Gas operation would increase the production of LPG by separation in the gas stream. Since LPG can be produced from natural gas, it is anticipated that the construction of the WAGP will boost the availability of LPG for consumption on the Ghanaian market (Ghana Poverty Reduction Draft Report, undated).

According to Emmanuel Chantelot, Managing Director of World Liquefied Petroleum Gas Association, "LPG can play an important role in steering countries onto more sustainable energy development paths. It contributes to strengthening the three pillars of sustainable development: the economy, by boosting productivity; Social welfare, by improving living standards and enhancing safety; and the environment by reducing indoor and outdoor air pollution". Indeed, gas is often touted as the transitional fuel that will lead the world towards the solar economy, where genuinely renewable sources such as wind and solar provide most of the energy required by the world's people (UNDP, undated).

1.2.1 Problem Statement

Humanity faces a unique and far-reaching challenge. Our energy needs are growing as a result of continued population increases, economic growth and individual energy consumption. At the same time, emissions from fuelwood and fossil fuels are contributing to climate change and affecting local air quality (WEC, 2005).

Business, industry and other consumers in Ghana are suffering from serious shortfall of electricity supply and highly volatile oil prices. This situation, usually referred to in crisis terms, has its roots in the mix of energy policy miscues, the country's overdependence on hydro power and the high oil prices that have increased the cost of generating electricity. In recent times, much emphasis has been placed on wider utilization of gas to contribute to fuel diversification and reduce the environmental impact of energy consumption. With the advent of gas as an energy source it is likely to continue increasing its significance as it is propelled into the spotlight as the fuel for the millennium.

There are many opportunities for LPG to contribute to improved living standards. LPG is a valuable resource that generates multiple productive services, applicable in several economic sectors. The introduction of LPG into this critical domestic market can then be leveraged to extend modern energy services to the wider community and for cultivating commercial and industrial growth in the local economy. Most of the LPG available in the Ghanaian market is utilized in the residential sector. The prospects for increased consumption in the other sectors, especially the industrial sector, remain very limited. There are almost no limitations for LPG use in the industrial sector (WLPGA, 2001) but limited number of Ghanaian industries uses this fuel. Almost no data were available on LP Gas use in the industrial sector. No conclusions are possible on industrial applications of LPG and policy; this is a research gap.

It is against this background that this study is carried out to explore the potential of LPG as a viable energy resource for our industries. This study aims to examine the factors that are particularly catalytic in the deployment of LPG as industrial fuel with the aim of providing some insights for industries that have plans to promote the use of gas as fuel in the country.

1.2.2 Research Questions

- Why is the patronage of LPG as industrial fuel low in the manufacturing industries?
- What are the challenges and constraints to the use of LPG as heat or power generation source for industries?

- What are the characteristics of LPG that influence the use or non-use of this source of energy by industries?

1.2.3 Main Goal and Objectives

The main objective of the study is to explore the potential of LPG as industrial fuel and to examine the factors that are particularly catalytic in the deployment of LPG as industrial fuel.

Specific objectives are:

- Examine the critical factors for the current low patronage of LPG use by industries
- Assess the characteristics of LPG that makes it a preferred option for some manufacturers
- Outline the challenges and constraints of LPG use to the industrial user
- Make recommendations for policy considerations

1.2.4 Justification of the Study

The research topic has received minimum attention by researchers and policy makers. It is hoped that the outcome of this study will be the foundation for other studies to be built on. With the construction of the WAGP, the country in the near future will add the consumption of gas to its energy mix. Many applications of LPG are similar to that of natural Gas and have acted as complementary fuels in most cases. In the industrial, commercial and agricultural sectors, LP Gas is particularly used in areas away from a Natural Gas supply (ILPGA, 2001). It is hoped that the outcome of this research will contribute to the smooth utilization of the WAGP; especially in achieving its first objective of providing energy source for industrial use.

It will also assist potential users to make informed decisions about their energy choices.

This study focuses on the manufacturing sector, the usually the hardest hit by interruptions in energy supply and higher energy prices. This is the result of the fact that energy is ubiquitous in nearly every facet of their enterprise, including all parts of the manufacturing process-from powering machines to transporting products. The manufacturing industry consumes about 30 per cent of the total energy in the country (Asante, 2004) and is heavily dependent on affordable access to this resource in their product and delivery of goods. It is also the sector most under pressure to be internationally competitive (MOTI PSI, 2004).

1.2.5 Research Scope

The study intends to illustrate if gas could be a suitable energy alternative to hydroelectricity and other petroleum for our industries or not. This paper will use LPG as an example of gas that has the potential for utilization in the industrial sector in Ghana, with the expectation that the lessons drawn from this study will be applicable to the utilization of natural gas in industries.

Perspectives of all major stakeholders in the LPG industry are taken on the utilization of the LP Gas as industrial fuel. Though the industrial sector consists of manufacturing, construction and mining and quarrying, the study limits itself to manufacturing with particular emphasis on food and beverage industries, textiles, petroleum refinery, chemicals and metals sub-sectors. For the purposes of this study, the main industries are the food and beverage, chemicals and the metals. All other sectors are categorized as "others".

The research was conducted in Tema. Collection of data covered c arbon emissions of LP Gas in comparison with other fuels, risk analysis of the LP Gas (hazards and precautionary measures), cost of LP Gas in comparison with other alternative fuels and the availability of the gas. Ultimately, the researcher aims at outlining the advantage and disadvantages of using the LP Gas as industrial fuel with the overall aim of determining if it is advisable for industries using electricity and oil to switch to LPG in particular and gas as a whole.

1.2 Organization of Thesis

Chapter 1 gives background information to the problem of study. It then outlines the objectives and the justification for this study.

Chapter 2 gives background information on the Ghanaian industrial sector with focus on the manufacturing sub-sector. It then discusses the perception of manufacturers' towards energy and sets out what the literature has to say, or what can be inferred from the literature, about pricing, availability, and environment and safety issues of energy. The chapter then defines LP Gas as an alternative source of energy, describes the nature, origin and composition of LP Gas, then briefly describes the institutional and policy environment of LPG industry in Ghana and provides a summary of literature reviewed.

Chapter 3 provides a detailed account of the methodology used, including research design, definition of the population researched, justification of industries selected, describes sampling procedure adopted, discusses techniques for data collection and analysis.

Chapter 4 presents the findings of the study, including a detailed discussion of the findings from the in-depth interviews, the field notes analysis and the document analysis. The results of the quantitative (questionnaire) analysis are also presented. Here, findings of empirical research are related to research problems and objectives. **Chapter 5** gives the conclusions and recommendations of the study. The implications of the findings are presented, as are recommended areas for further research.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Energy in the African Context

Energy sources can broadly be grouped into two, namely, conventional and the non-conventional energy sources. Conventional energy sources are of two types. These are renewable energy (hydroelectric and wood fuels) and non-renewable sources (coal, lignite, crude oil, natural gas and nuclear fuels). Non-conventional sources of energy include solar energy, geothermal energy, biomass, oil shale and tar sands, wind energy and tidal energy from the sea (World Bank, 2001).

The African continent is well endowed with a variety of energy resources which are unevenly distributed. Among these are crude oil, natural gas, coal, nuclear, tar sand, hydro-electricity, geothermal, biomass, solar, wind and other renewable energy resources. Oil and gas are concentrated in Northern and Western Africa – mainly in a few countries: Algeria, Libya and Nigeria. In 2002, total world gas consumption was about 2600 bcm of which 2.7 per cent was in African countries, mainly in the gas producing countries such as Algeria, Egypt and Nigeria (UNECA; WEC, 2005). The region has over 10 per cent of the world hydro resources and significant other renewable energy resources. Two large areas particularly rich in hydro resources are the axis of the great African lakes from Kenya to Zambia, and the Atlantic coastline from Guinea to Angola. Forest area cover is estimated at about 22.2 per cent of the total land area. Biomass resources are estimated at about 82 billion tons, with an annual average growth of 1.7 billion tons – more than sufficient to cover current use. Africa being mainly within the tropics, most of it has long hours of sunshine, with significant radiation that can be exploited. Wind resources are available in selected sites, mostly on the coastlines in the North, West and South (Davidson and Sokona, 2002; WEC, 2005).

This aggregation does, however, conceal major differences in distribution and production between and within sub-regions. Because of this skewed distribution, over 70 per cent of African countries import oil and gas – much of their scarce foreign exchange earnings going on oil imports being a major drain on their economies (Davidson and Sokona, 2002; WEC, 2005).

2.1.1 Ghana's Energy Sector: an overview

The energy picture for Ghana is similar to that of the other African nations, with an increasing demand for energy. This section focuses on the country's current energy sources and uses of energy, with focus on the industrial sector.

The energy supply sector of Ghana comprises biomass, petroleum and electricity. The integrated energy supply feeds the economy comprising residential, commercial, agricultural, transport and industries (RCEER, 2006; Energy Commission, 2006).

The Energy Commission (2006) reports that the primary indigenous energy comprised of 90-95 per cent biomass, 5-10 per cent hydroelectricity and less than 1 per cent solar (mainly for drying of crops). Net import comprised 80-83 per cent crude oil and about 15-19 per cent petroleum products. The indigenous primary energy production grew at an average rate of 2.4 per cent between 2000 and 2004. It raised from 6.1 million tones of oil equivalent in 2000 to 6.8 million tones of oil equivalent by 2004. Net energy import was about 1.9 million tones of oil equivalent in 2000 increasing to 2.6 million tones of oil equivalent by 2004. Ghana imports all of its crude oil requirements (which amount to 60,000 bpsd) and even though there are indications of oil and gas resources, their potential is yet to be fully exploited (AfDB/OECD 2003; Yakubu et al, 2005).

Ahiataku-Togobo (2005) of Ministry of Energy established that energy consumption in 2002 was as follows: Electricity-11 per cent; Petroleum-29 per cent and Biomass-60 per cent. As at 2004, Biomass in the form of firewood and charcoal still dominated the final energy reaching the consumer, averaging 64 percent over the period. Petroleum products and electricity followed with 27 per cent and 9 per cent respectively (Energy Commission, 2006). Electricity access exceeds 50 per cent, though its use by households and small- and medium-sized enterprises remains limited.

The country's energy environment is changing dramatically. Integration through the West African Gas Pipeline (WAGP) and transmission links under the West African Power Pool (WAPP) is enabling access to other regional energy resources.

The residential sector accounts for almost 50 per cent of the country's energy consumption. This is attributed to the high usage of woodfuels comprising mainly of firewood and charcoal. The industrial sector's share of the total energy share is about 23 per cent per annum. The commercial sector's share of total national energy use has been less than 3 per cent per annum since 2000. The agriculture sector also accounts for less than 2 per cent of the total energy use with the transport sector constituting the rest (Energy Commission, 2006).

The industrial sector encompasses establishments engaged in mining and quarrying, manufacturing, construction and electricity and water (ISSER, 2004). The manufacturing sector is a very broad sector comprising of sub-sectors such as Food

Processing, Beverages, Wood Processing, Paper and Print, Chemicals and Gas, Metal, Steel and Glass, Plastics and Rubber.

According to the Energy Commission (2006) the industrial sector without VALCO had 21-22 per cent of total national energy share every year since 2000. Manufacturing has been the dominant sub-sector accounting for about 74 per cent of industrial energy share since 2000, followed by mining and quarrying (9-10 per cent). Utilities had been taking about one and half per cent, whilst construction has accounted for less than one per cent of energy share per annum.

The main fuels for industrial purposes are woodfuels, electricity and petroleum products. As at 2004, industrial energy shares consisted of 80 per cent woodfuels, 12 per cent electricity and 8 per cent petroleum (Energy Commission, 2006). Woodfuel is used predominantly in the informal manufacturing sub-sector and as fuel for baking and heating in the ceramics, commercial food processing and local textile industries. On the other hand, if only in the formal manufacturing sub-sector is considered, the major industrial energy was electricity (55-56 per cent) followed by petroleum products (averaging 39-42 per cent) and woodfuel (about 5.1 per cent). For the manufacturing (both formal and informal) sub-sector, woodfuel is the predominant fuel (88-89 per cent), followed by petroleum products (5-7 per cent), then electricity (4-5 per cent). However, if only the formal sub-sector of manufacturing is considered, then petroleum products' share is the largest. The Energy Commission estimates it around 48 per cent of manufacturing formal sub-sector fuel shares in 2004.

2.1.2 Critical Issues Affecting Energy in Africa

The challenge society faces is increasing demand for energy and the provision of adequate access to affordable energy whilst reducing environmental impacts, such as climate change, air pollution and other atmospheric emissions.

Despite Africa's enormous potential in fossil and renewable energy resources, it suffers from major energy deficits. The continent's resources are under-exploited or exported in raw form or wasted in the course of extraction (AfDB/OECD, 2004). Importantly, the diversity of energy resources is not being optimally utilized. This results in wasted energy such as the vast hydro resources on the Congo River and the flaring of gas in Angola and Nigeria. As a result, supplies available for local consumption are largely insufficient (AfDB/OECD, 2004).

A key challenge for sustainable energy development concerns the optimal utilization of the region's energy resources to facilitate both individual country and regional energy and economic development. There is a low level of modern energy consumption in the region and the heavy reliance on biomass. Figures from IEA indicate the distribution as 59 per cent biomass, 25 per cent petroleum, 8 per cent electricity, 4 per cent coal and 4 per cent gas (OECD/AfDB, 2004). Continued reliance on traditional fuels and technologies brings hardships and health problems to people and ecological strains to countries (Economic Commission for Africa, 2007). Some argue the key challenge facing the continent is not to increase energy consumption per se, but to ensure access to cleaner energy services (UN-DESA, 2004).

High biomass use raises serious problems because of its low conversion rate, high wastage and poor quality method of production. Associated health and other environmental problems are also significant. Supply of woodfuel is constrained by a rapidly deteriorating environment and ecological damage in the form of deforestation, and worsening effects of atmospheric pollutants from the inefficient use of woodfuels. The cost of environmental degradation due to the cutting of trees for fuel has however, not been estimated to allow fair comparison with other causes of deforestation. Nevertheless, fuelwood, compared with timber is a consumable item and consequently, the need for it exceeds by far the volume of commercial timber removed from the forests. In Ghana, the Forestry Services Division statistics suggests that as much as ten times more fuelwood is removed from the forest and Savannah zones together than timber (Akuffo et al, 2003).

For those relying on hydropower for bulk of their grid supply, the generation capacity even with good rainfall is becoming inadequate because of increase in demand. Hence with water levels in dams running at historic lows for the past years, generating stations are forced to curtail the hydroelectric supply being dispatched. At the same time, economic growth and increasing urban or peri-urban electricity use continue to push demand levels higher. In Ghana, local manufacturing costs, as would be expected, rose significantly as a result of the load-shedding exercise leading to significant increases in cost build-up of most industries (CEPA, 2007).

Oil remains the single most important fuel, amounting to 35 per cent of total primary energy supply (UN, 2006). The impact of the current volatile oil prices is a serious concern for the fragile oil-importing countries. Higher energy prices are promoting energy efficiency but also causing concerns. International oil prices have risen in late 2005 and early 2006 to the highest levels in history. According to UN (2006), these high prices are promoting energy conservation and efficiency efforts and making alternative energy sources, more competitive. However, it was quick to add that the possibility of continuing price increases raises genuine concerns over adverse global economic impacts. Energy price volatility poses problems for sustainable development in both exporting and importing countries.

Traditional gas markets (residential and commercial sectors; conventional industry) in sub-Saharan Africa are small. The potential demand of residential and commercial markets is limited to domestic uses (cooking and water heating), which makes the profitability of dedicated gas networks unlikely (Economic Commission for Africa (UNECA) Report on energy for sustainable development). The major problem with gas production in Africa is that most of the associated gas is flared or vented, especially in West Africa. Only 18 per cent of such gas in West Africa is marketed or used, and 11 per cent re-injected to enhance oil recovery. Most of the 71 per cent flared in Sub-Saharan Africa are from West Africa (OGJ, 2000 in Davidson, 2007). This amount of flared gas is significant because of not only a waste and its contribution to global warming but it could be used to produce power for most of the West African region. Northern Africa and other developing regions flare substantially lower than West Africa. Poorly developed gas markets, attitude of operators and weak legislation are the main factors for the high gas flaring in West Africa (Davidson, 2007).

In the face of these challenges, key industrial sectors such as chemicals, plastics, materials, agriculture, tourism and construction are at risk of being undermined. The time has come for us to confront future energy options. A mix of energy sources is required to provide sufficient power for the future. Plentiful, accessible, inexpensive energy is the underpinning of modern society. It is the basis for meeting numerous national and global needs such as increased demands for electricity and transportation, affordable food and water, and adequate resources for manufacturing. Thus, investment in increasing energy options is paramount. Finding solutions to meet advancing world needs for sustainable energy is one of the biggest challenges mankind will ever face. Recognizing that ongoing technological innovation may provide solutions to current challenges, all energy sources should be considered as options to meet increasing energy demand. They should be evaluated based on their merits and relative attributes recognising that each presents issues, barriers and opportunities including cost, performance, safety, primary resource depletion, energy security, reliability, land use, waste disposal, availability of required infrastructure and capacity, and emissions affecting local and regional air pollution and climate change.

Meeting society's needs, aspirations and expectations for a better life will require growing supplies of reliable, affordable energy. Indeed, business and industry itself relies on energy in all phases of operations. Without access to sufficient, quality and reliable energy, every social and development activity is critically constrained. The optimum choice of energy technology depends on a number of factors including resource availability, affordability, ease of access and local capacity to absorb, use and maintain the technology. It will also depend on the services and end uses desired in each locality, as not all technologies are adaptable and cost effective for particular end uses (Postnote, 2002).

Lack of reliable and secure energy supplies limits economic development. Adequate and affordable energy services have been critical to economic development and transition from subsistence agricultural economies to modern industrial and service oriented societies. Industries and productive activities (agriculture, commerce) require energy in various forms to fuel machines, power transformation processes, conserve perishable goods, ensure transport, etc.

In order to meet the above mentioned challenges, it is essential to keep all energy options open and to assess them according to their ability to deliver sustainable and reliable energy, at a cost effective and competitive price. To reduce the volatility of energy prices, a more diverse energy portfolio is required. This should be developed by avoiding excessive dominance in the market by certain energies and by promoting the development of clean alternative energies in parallel with renewable to complement conventional sources. African countries (be it producers or consumers) need to be very much interested in the gas sector. This is because it is clean and recent technological developments in liquefaction of gases make it much easier for transportation to wherever it is needed.

2.2.1 LP Gas as an alternative Source of Energy

LP Gas is a clean, versatile fuel with a wide range of other uses in household, commercial, transport and industrial energy applications as is the case in Nigeria (ESMAP, 2004). There are so many different applications for this fuel that it is hard to provide an exhaustive list of everything it is used for.

Commercially, applications include commercial food refrigeration, preparation and processing (restaurants and small and large-scale catering), and water and space heating in offices and other commercial premises.

In the industrial sector, LP Gas provides a wide range of industrial processes and services, notably a high degree of precision and flexibility in process temperatures - as well as a strong flame – when required. Common applications include heat treatment furnaces, direct firing of ceramic kilns, glass working, textile and paper processing, paint drying, cotton singeing, metal works, and the brick, glass and pottery making. LP Gas can also provide back-up reliability for industrial electricity generators. These industrial applications catalyze the development of a variety of micro enterprises and generate income at the community level (ESMAP 2001).

LP Gas is increasingly used as a low-emission alternative to traditional road-transport fuels such as gasoline and diesel consumption in taxis, buses and private cars. A compact gas system supplied from a portable bottle of gas gives low-income families access to modern cooking, space and water heating, drying and lighting services (UNDP and WLPGA, 2003).

Although normally used in gaseous form, LP Gas is readily transformed to liquid for storage and transport. Liquid LP Gas weighs about half as much as water and is much more energy intensive than in gaseous form. ESMAP (2001) outlines some of the positive attributes of LPG as easy to transport, easy to handle, its implementation requiring less capital intensive infrastructure facilities and generally safer than liquids—provided that it is correctly stored and handled. However, these useful attributes come at a cost in that the LP Gas container must be robust, and the gas must be drawn from it in a controlled manner. Hence, LP Gas storage and transportation tends to be more expensive than other fuels (ESMAP, 2004).

2.2.2 The LP Gas: status of technology and utilization in Ghana

In Ghana, just like in most African countries, Liquefied Petroleum Gas is minor component of energy supply. It is used principally as a cooking fuel in households and in catering. LP Gas use in Ghana accounts for 4-6 per cent of the residential sector. This is concentrated in the urban areas among the middle and higher income groups. Total LP Gas consumption by the residential sector was about twenty-seven tones (about 1.7 million filled regular-size domestic cylinders) in 2000 and forty-nine thousand tones (about 2 million and 160 thousand filled regular-size domestic cylinders) in 2004. The estimated long-term sectoral growth rate in the LPG demand is between 8.5-10 per cent per annum. Consumers in this sector have exhibited high income and price sensitivity to changes in LPG prices. In effect they are more likely to switch from LPG to other alternatives in the event of price hikes (Energy Commission, 2006).

LPG is the main (99 per cent) petroleum product consumed by the commercial and services sector. Restaurants are responsible for over 75 per cent of LPG consumed by the sector and chop bars take on the average about 13 per cent shares every year. LPG demand is dominated by the restaurants and the chop bars, apparently for cooking (Energy Commission, 2006).

As Rod Crompton noted at LPG challenge workshop in South Africa(Integrated Energy Solutions (Pty) Ltd and AGAMA Energy (Pty) Ltd, 2004), despite the suitability of LP Gas, penetration had not reached high levels in many developing nations. The question now is why not? With the exception of LP Gas being used as domestic fuel, very little is known of its applications in the other sectors.

2.2.3 Global LPG Production and Consumption

LP Gas is a small, but increasingly important constituent of the global gas market. Combined with Natural Gas, LP Gas can provide significant project or market development opportunities. Promotion of LP Gas can be considered to support sustainable development and climate change prevention (WLPGA, 2005 report on UNECE Working Party on Gas).

LPG trade is supply-driven. Production is a by-product of oil and gas and is thus generally unaffected by LPG demand trends. LP Gas supply is increasing at approximately 3 per cent per year with greater contribution coming from natural gas production (WLPGA Statistical Review of Global LPG, 2002). It is anticipated that the LPG production which will materialize on the export market will rise from 50 million tons in 2004 to 75 million tons by 2010 and close to 85 million tons by 2015 (POTEN & PARTNERS, undated).

The LPG will go to whichever market will pay the best netbacks. There will be three countries which will take the major share of increased LPG trade volumes over this period. Two are in the East, China and India, one is in the West, the United States (POTEN & PARTNERS, undated). Asia has become largest LPG market in world since 1990, mainly in residential or commercial sector. China's LPG demand and import is strongly approaching Japan's market size. Imports curbed by increased domestic refinery production. Middle East instability will continue to play havoc with world markets (NPGA, 2004).

More than 207 million tonnes of LP Gas were consumed in 2003 (245 million toe, equivalent to 10 per cent of global natural gas consumption). Consumption was 212 million tonnes/yr in 2004 – global increase of 2.4 per cent on 2003. In context, annual consumption (on energy content basis) is equivalent to 7 per cent of annual oil consumption or 11 per cent of annual natural gas consumption or, 42 per cent of annual hydroelectric consumption (UNDP/WLPGA, 2007).

Sectoral consumption of LP Gas was domestic- 48.9 per cent; chemical-22.2 per cent; autogas-7.7 per cent; industry-12.9 per cent and agric-2 per cent (WLPGA Statistical Review of Global LPG, 2002). Sectoral consumption of LP Gas is as follows: Domestic-49.7 per cent; Agriculture-2.0 per cent; Industry-11.8 per cent;

Transport-7.9 per cent; Refinery-5.6 per cent; Chemical-23.0 per cent (WLPGA Statistical Review of Global LP Gas, 2004). Global use of LP Gas as a domestic fuel will double between 1990 and 2010 (WLPGA).

Drivers of LP Gas demand include economic growth, in particular personal income growth, access to LP Gas - investment in infrastructure, environmental and health initiatives and Government policy to encourage investment in distribution (NPGA, 2004).

2.2.4 LP Gas and Natural Gas- Complementary fuels

Liquefied petroleum gas can be used for the same domestic, commercial and industrial applications as natural gas (United States Environmental Protection Agency, 1993). LP Gas and natural gas share many similar attributes: To the end user, they can be indistinguishable. They can share end-use appliances interchangeably. Synthetic Natural Gas (SNG) is propane or LPG: air mixture, effectively interchangeable with natural gas. Many case studies of complementary SNG or Natural Gas projects exist: In China more than 30 cities developing natural gas with SNG as a precursor fuel (WLPGA/ UNECE working paper on gas, 2005). Both are clean and efficient sources of energy. They contribute to regional socio-economic development. LP Gas can be used as a precursor fuel in new areas, allowing market development at lower cost and risk (WLPGA/ UNECE working paper on gas, 2005).

LP Gas provides an alternative in off-grid areas e.g. remote regions. It is an option in regions of declining natural gas supply or in areas no longer served by grid e.g. areas of natural or man-made disasters. L.P. Gas is widely used in Ireland in the Industrial, Commercial and Agricultural sectors in areas located away from a Natural Gas supply. Where new industries set up in similar locations for specific economic, logistic or social reasons, they can depend on having access to a gas supply from the L.P. Gas Industry (Irish Liquefied Petroleum Gas Association 2001).

The main advantage of LPG relative to natural gas is that, under pressure, it is a liquid which reduces transportation costs and makes long term storage practical. The main disadvantages are higher fuel costs and potential safety hazards in the event of leaks arising from the fact that LPG is heavier than air and may settle in explosive pockets in the absence of local air movement. Liquefied petroleum gas is also used in commercial and industrial applications as a standby fuel to replace natural gas during emergencies, or curtailments of baseline fuels (United States Environmental Protection Agency, 1993).

According to Ramón de Luis Serrano, Vice President of the WLPGA, the availability of natural gas affects the LP Gas market. However, even in those markets in which natural gas is becoming available, there are opportunities for LP Gas operators. They can, for example, take advantage of natural gas communication campaigns which educate the public on the benefits of using gas. It is also important to note that because of the cost involved, a natural gas pipeline will only be installed to areas of high population density. This means there are many areas which will never be on the natural gas network. LP Gas is the most suitable energy in such areas. There is therefore no need for the Natural Gas pipeline to be uneconomically extended to new geographical regions at an additional cost to the tax payer (Irish Liquefied Petroleum Gas Association 2001).

2.2.5 Varying Views on the Use of LP Gas as alternative fuels

It is argued that LP Gas cannot be utilized as alternative fuels on the basis of availability, safety and frequent price spikes. They emphasis that LP Gas is a non-renewable fossil fuel which when used faster than the rate of its generation will deplete. According to this school of thought, LP Gas or Propane is a by-product of two processes: natural gas production and petroleum. Thus, there is no readily available source of incremental production that can increase supply when needed. While storing excess LP Gas can provide a cushion against unexpected demand increases, nationwide storage at the refinery is always limited. In addition, LP Gas is primarily transported on trucks that have limited capacity. This lack of local LP Gas storage and the constrained capacity of distribution system they say, create bottlenecks in moving LP Gas to consumers in periods of high demand. This makes LP Gas market more susceptible to significant price fluctuations. Relatively, small shifts in supply or demand could result in significant price changes.

LPG supply is relatively fixed in the short term because it is limited to available storage within the market and cannot be quickly increased to meet increased demand. Thus increase in demand will result in a greater increase in price than if supply were more elastic. Also, because demand is inelastic, decreases in supply will result in a greater increase in price. Storing excess LPG could provide a cushion against unexpected demand increases (United States General Accounting Office, 2003).

According to the United States General Accounting Office (2003), LP Gas (Propane) price spikes are generally caused by the inability of LPG supplies to adjust quickly to unusual demand increases such as those caused by cold winters. Additionally, LPG prices are influenced by crude oil and natural gas prices and competition with other commodities used as fuel or feedstock (Energy Information Administration/Petroleum Marketing Monthly, 1997). LPG prices can be as volatile and as unpredictable as the weather. While prices can move sharply up and down, it is the drastic price spikes upward that grabs the attention of consumers.

This group of people also argues that high concentrations of LPG can displace oxygen in air, causing the potential for asphyxiation. While LPG itself does not irritate the skin, the LPG becomes very cold upon escaping from a high-pressure tank, and may therefore cause frostbite, should it contact unprotected skin. LPG can form explosive mixtures with air. Since the gas is slightly heavier than air, it may form a continuous stream that stretches a considerable distance from a leak or open container, which may lead to a flashback explosion upon contacting a source of ignition (United States Department of Energy's Office of Energy Efficiency and Renewable Energy, 2003; Chan, 2005).

Most optimists argue that there are huge reserves due to its dual origin (60 per cent from natural gas field extraction and 40 per cent from crude oil refining) and as such there is no reason to expect a decrease in LPG's availability in the foreseeable future; They claim the amount of readily available LPG is plenty in the market and its supply is estimated to last for at least another 75 years (World LP Gas Association, 2004). According to them, the price of LPG is cheaper than other conventional fuels and it has a comparable performance if compared to other conventional fuels with lower pollutant emission.

However, there is no disagreement that LPG is friendly to the environment. It produces fewer pollutants to the atmosphere with virtually no particulate matters (PM), low level of carbon monoxide (CO), hydrocarbons (HC), and oxides of nitrogen (NOx). LPG emits less greenhouse gases (GHG) compared to any other fossil fuel when measured through the total fuel cycle (World LP Gas Association, 2004).

2.3.1 Energy Issues and Perceptions in the Manufacturing Sector

For the majority of industries, energy is one of the many inputs that enable the creation of products. These industries require energy to light, heat, cool, and ventilate facilities. They also use energy to drill and extract minerals, power various manufacturing processes, move equipment and materials, raise steam, and generate electricity. Some industries require additional energy fuels for use as raw materials (feedstock) in their production processes. Many industries use by-product fuels to satisfy part or most of their energy requirements (EIA, 1999). Industrial energy use can be broken down into that of the energy-intensive industries (e.g. primary metals, pulp and paper, primary chemicals, oil refining, building materials) and the non-energy intensive industries (e.g. services, electronics and food) (Worrell et al, undated). Energy use in the industrial sector is dominated by the production of a few major energy-intensive commodities such as steel, paper, cement, and chemicals.

The manufacturing sector is highly diverse and energy patterns vary dramatically from industry to industry (ITP, 2004). The major types of energy consumed in the formal manufacturing sector are electricity, diesel and residual fluid oil (MOTI, 2004). Electricity is used for, inter alia cooling, hot air, hot water steam, direct heat chemicals production and mechanical purposes, while fuel oil and diesel are also widely used in production for furnaces, boilers, hot air, hot water and steam (MOTI, 2004). In general, this sector is characterized by the intensive use of fuels and electricity for process heating and cooling. In the basic manufacturing industries, raw materials are often transformed into usable products through various physical, chemical, and mechanical conversion processes requiring very high temperatures and pressures or otherwise severe conditions (ITP, 2004).

There are many different uses and a variety of different energy sources in the manufacturing sector. One main use is as boiler fuel, which means producing heat that is transferred to the boiler vessel to generate steam or hot water. Another use is as process heating, which is when energy is used directly to raise the temperature of products in the manufacturing process; examples are separating components of crude oil in petroleum refining, drying paint in automobile manufacturing, and cooking packaged foods (EIA).

In other parts of the world, the heavy reliance on electricity makes this sector vulnerable to fluctuation in crude oil prices and imports. Furthermore, since an increasing share of electricity is generated from thermal sources, the manufacturing sector's dependence on electricity is influenced by factors that influence the supply of crude oil. Currently, the hydro plants generates about 65 per cent of total power in the country while the thermal plants account for 35 per cent of energy supply (Ministry of Trade and Industry, 2004). With the demand for energy growing at an average rate of between 10-14 per cent, the decline in power production has a negative effect on the productivity of other vital sectors such as manufacturing.

Energy expenses generally represent less than five per cent of total operating costs, although energy tends to be a much higher percentage of total controllable costs. Regardless of percentage expenditure, a breaching fuel or power supplies can nonetheless stop production, which greatly impacts on business performance through wasted raw materials, idle resources and lost revenue (Bennett and Wells, 2002).

Historically, sectors such as food manufacturing have viewed energy as a fixed cost, which means that there is little incentive to pursue energy-savings opportunities (IFC, 2007). In some cases, energy costs may be paid by headquarters, while equipment purchasing decision-making happens at the facility level. If energy costs are outside the plant manager's incentive structure, he or she may have little reason to pursue investments in energy-efficient equipment. Conversely, facility managers may be reluctant to invest the time and effort in making the case for energy efficiency-related capital upgrades to corporate management, as such investments may not be perceived as integral to the business's profitability.

By their very nature, energy investments can be very risky; as such investors prefer places where the uncertainties are minimized. Additionally, other considerations are required for optimum energy choices. These include affordability of energy, ease of access and local capacity to absorb, use and maintain technology, since not all technology is adaptable and cost effective (RCEER, 2006). While a company's ability to control the availability and cost of energy may be limited, its ability to plan for and manage potential effects is much greater (Bennett and Wells, 2002).

2.3.2 Energy pricing and its effects on the output of the manufacturer

Rising oil and gas prices are depressing growth in manufacturing and are leaving much of the global economy vulnerable to intense energy shocks. Factories burn huge amounts of energy making products and shipping them around the world. In today's business climate, manufacturers are three times more sensitive than the general economy to oil prices (Norman, 2006). Oil prices these days have reached new highs causing inflation-adjusted oil prices. These have more than tripled since the last recession ended in late 2001. It was the first oil shock in the modern era of globalization. Along with that, the world GDP growth may have been at least half a percentage point higher in the last two or three years had prices remained at mid-2001 levels now (Norman, 2006). Not only has high oil prices had an effect on the economy but since countries are hit not only by the direct effects of rising energy costs they are also hit by the indirect effects of energy-related pressures on their trading partners.

What we do not need is high variability in prices, because that creates uncertainty and uncertainty is the enemy of planned, rational and forward looking investment in any industry. Volatility matters for all consumers and producers in the economy. Business firms, both energy and non-energy, make investment decisions based on expectations about prices. If decisions are made on the expectation of low (or high) energy prices, and the energy market varies sharply from these expectations, firms may make inappropriate investment and business decisions. Even those firms that expect volatility may be adversely affected by simply putting off a decision until the market is more stable. The economy would most likely perform better with stable or predictable energy prices, than when the price of energy fluctuates greatly.

Rising energy costs and greater volatility in energy prices can have a negative effect on both individual firms and the broader financial environment, generally producing lower assets prices and higher interest rates. For businesses, higher energy prices and disruptions in energy supply may increase inflation and reduce profits, production, investment and employment. The impact of higher energy prices takes two forms: the higher costs of paying for the energy to run the business and the higher costs when raw fuel sources are used in manufacturing. When energy prices increase, profit margins are not as high and, in general, companies will not be hiring additional workers to the extent they would if energy costs were cheaper. High energy costs directly affect manufacturing costs, and they indirectly reduce the demand for manufactured goods by consumers and businesses as discretionary funds are redirected towards paying for energy.

In their study on 'Energy Price Increases in Developing Countries', Hope and Singh (1995) state that the effect of energy prices on industries is modest, since cost share of energy typically range from 0.5to 3 per cent. In addition, many industries are flexible enough to substitute when energy prices increases. According to the study, industrial output increases even with higher energy prices. Energy prices tended to increase in adjustment and liberalization programmes and industrial output usually increased even with the higher energy prices. This suggests that the effect of the price increase is modest compared with the effects of other changes in the environment. There are exceptions, of course, such as energy intensive industries with limited possibilities for substitution. Impact of energy price on the industrial customer includes effects on costs, output and consumption (Hope and Singh, 1995). They go on to state that the impact of an increase in the price of energy on industrial output depends on three parameters which are: the importance of energy inputs in production as represented by energy cost shares; the ease with which energy can be substituted by other inputs; the ability of the producers to pass on the increase in energy costs to the consumers, as measured by the elasticity of demand for output.

In some energy-intensive industries, rising energy prices have had significant effect on product prices and operations. In some instances, industries have to experience higher energy costs but have been unable to pass these increases on to customers due to intense foreign and domestic competition and slowing demand. This absorption of much of the higher costs of energy has reduced the profit margins of many businesses.

Energy-intensive manufacturing industries are very sensitive to changes in energy prices and adjust their production accordingly. For other industries energy is not an important component of total cost. However, many such industries require a high-quality, reliable source of power. Even a brief loss of power can impose significant costs on high-technology firms (National Energy Policy Development Group Report, 2001).

2.3.3 Energy Availability and its effect on the output of the manufacturer

According to Ramani and Heijndermans (2003), situations exist in which more than one type of alternative energy technology is feasible but availability restrict the choices available to the people.

Availability involves ensuring the immediate uninterrupted daily operation of the fuel supply systems. Energy is an indispensable tool for industrial and commercial wealth generation and, like any other raw material, the quality of supply is very important. A key difference between energy and other inputs to delivery of services is that availability (adequacy and reliability) of energy are critical issues: without electricity a television set does not work unless it has some local energy storage or back-up electricity source. Disruptions in the provision of energy services carry a heavy price. The viability of delivery of many services is dependent on reliable energy supply, so that any disruption of input electricity or gas supply is experienced as a severe and widespread problem (Greene and Pear, 2003).

Interruptible energy supply may result in loss of output, waste of raw materials and manpower and inability of manufacturer to supply to the customer or to meet deadlines. Lack of reliability of energy supply is identified as a major constraint to many industries. Expanded energy access based on adequate and reliable supply of energy plays a major role in the large gains in productivity and higher economic growth (ADB, 2006). Availability of energy affects productivity, employment and development. Better energy supply opens the way to longer working hours and to reduction in periods of forced inactivity resulting from power cuts.

The frequent supply interruptions consumers suffer add a significant cost burden and severely hamper economic development. At the other end of the development spectrum, the dependence of high-tech, largely urbanized societies on uninterrupted energy supplies grows even greater. Sustainable energy systems must offer security and reliability, the WEC's goal of energy availability (WEC, 2005).

2.3.4 Energy, environmental and safety issues

2.3.4.1 Environmental Issues

During the past two decades, people have become concerned with how human activity may be affecting the world's climate. The concern is that human activity may be increasing the concentration of atmospheric GHGs enough to alter the climate worldwide.

Increase emissions from the combustion of fossil fuel are a major health problem. Greenhouse Gas emissions and local air pollution are the two environmental impacts of greatest concern from gas-fired, combined-cycle plants (David Sazuki Foundation, 2001).

Ghana generally enjoys ‘clean’ atmospheric conditions (Tamakloe/EPA). Her contribution to global greenhouse gas emissions is relatively small. However, the distances that pollutant gases travel means that pollution is an international problem. In 1998, for example, the UK received one quarter of its sulphur deposition from other countries whereas, for example, Sweden and Norway both received more than

90 per cent of their sulphur pollution from abroad (Hare et al, 2002). Pollutants are not necessarily deposited in the same country where they were produced.

Gas turbines burn fossil fuels, converting hydrocarbons into carbon dioxide, the primary greenhouse gas and steam. In addition to carbon dioxide, nitrous oxide (NO_2) and methane (CH_4) are powerful greenhouse gases produced. These emissions pollute the environment and contribute to global warming, acid rain and smog. Each of these has different potential to bring about global warming, so for comparison purposes, each has been given a carbon dioxide-equivalence rating by the IPCC. In their effect on the global climate over 100-year period, CH_4 is 21 times as potent as CO_2, while N_2O is 310 times more potent than CO_2 (David Sazuki Foundation, 2001).

A major form of environmental abuse are the CO_2 emissions from fossil fuel combustion which increased from 3,811 mmt of carbon equivalent in 1970 to 5,821 mmt in 1990 (Average Annual Growth Rate -2.1 per cent). Such emissions are projected to reach 9,762 mmt of carbon equivalent in 2020. Approximately 67 per cent of the growth in emissions between 1999 and 2020 is projected to come from the developing countries where population growth, rising personal incomes, rising standards of living, and further industrialization are expected to have a much greater influence on levels of energy consumption than in the industrialized countries (Ernst & Young India, 2004).

Emissions such as Nitrogen oxides (NOx), Carbon monoxide (CO), Sulphur oxides (SO_2) and so on have adverse impacts on the human body. The extent and magnitude of these climate change effects on natural ecosystems are uncertain. But ecologically sensitive zones in Africa including Ghana are among the world's most vulnerable areas. The population of Africa is relatively vulnerable to damages wrought by climate change due to its high dependence on natural systems for daily survival. Therefore, alternative fuels are being considered to replace the role of conventional fuels in order to reduce these harmful emissions to a safer level (Chan, 2005).

2.3.4.2 Safety issues

LP Gas is potentially hazardous from production until it has been used and the combustion products have been safely disposed off (UNEP, 1998). Hazards commonly associated with LP utilization include fire, explosion and carbon monoxide poisoning caused by faulty appliances. LPG forms a flammable mixture with air in concentrations of between approximately 2 per cent and 10 per cent (HSE, 2006). It can be a serious fire or explosion hazard or be fatal in concentration. LPG and dispensing gases are heavier than air and will sink into drains and cellars.

The main operational areas found to be most likely to represent a risk include the main storage tanks, cylinder filling areas and the roads during transport of the fuel. Accidents that could happen include gas leaks in hoses, cylinders, storage vessels etc; ignition sources brought onto site or lit on site, deliberate release of the gas and failure of safety systems put in place or employee training.

Safety comes from understanding the behaviour of LP Gas and keeping it under control. Attempts are constantly being made to eliminate or manage risks and practices at the workplace that could cause accidents or illness to people, damage to property or unacceptable impacts on the environment and people.

2.3.5 Factors to consider in Energy Technology Deployment

According to Sagar and Gallagher (undated) technical feasibility of a new technology is not enough reason for its adoption by any group of people. They argue this new technology must be able to compete in the market with already established technologies. They identified cost, information, infrastructure and regulations as some factors that may impede the adoption of a technology.

The Economic Community of Africa (2006) identifies barriers to widespread use of renewable energy technologies in the sub-region to include lack of legal and regulatory framework, inadequate renewable energy technology policies, pricing distortions which has placed renewable at disadvantage, high initial costs and weak dissemination strategies.

ICF (2004) groups factors that impede the adoption of energy technologies into non-regulatory factors and regulatory factors. Non-regulatory factors include financial barriers, technical barriers and institutional barriers. Most of the energy consumed in the industrial sector is consumed in a few basic industries that produce commodity products—such as steel, basic chemicals, petroleum products, and paper—that are subject to stiff domestic and international competition. These industries have little appetite for new capital investment, unless it is likely to bolster their future success. Discretionary investments for energy efficiency or clean energy projects must often compete with these higher-priority investments. Some clean energy opportunities are not well suited to a given industry's manufacturing process. In other cases, process-related technical constraints affect the extent to which a given opportunity can be utilized. Regulations also may limit broader application of energy efficiency and clean energy technologies and impede the achievement of environmentally preferable energy outcomes in manufacturing industries. Regulations or policies may contribute to unfavorable market conditions for clean energy opportunities (ICF, 2007).

Each potential approach to energy supply or use has advantages and disadvantages relative to alternatives. There are many salient features analysts must strive to evaluate. Among them are:

I. Resource availability (whether the fuel source is domestic or foreign and their intermittent nature of supply)
II. Cost of the fuel
III. Environmental emissions (Reduction in Greenhouse Gas emissions)
IV. Consumer safety
V. Infrastructure systems capital
VI. Resultant low efficiencies in performance leading to substantially less useful energies than implied by rated systems capacities.
VII. Local capacity to absorb, use and maintain the technology

2.4 Conceptual Framework

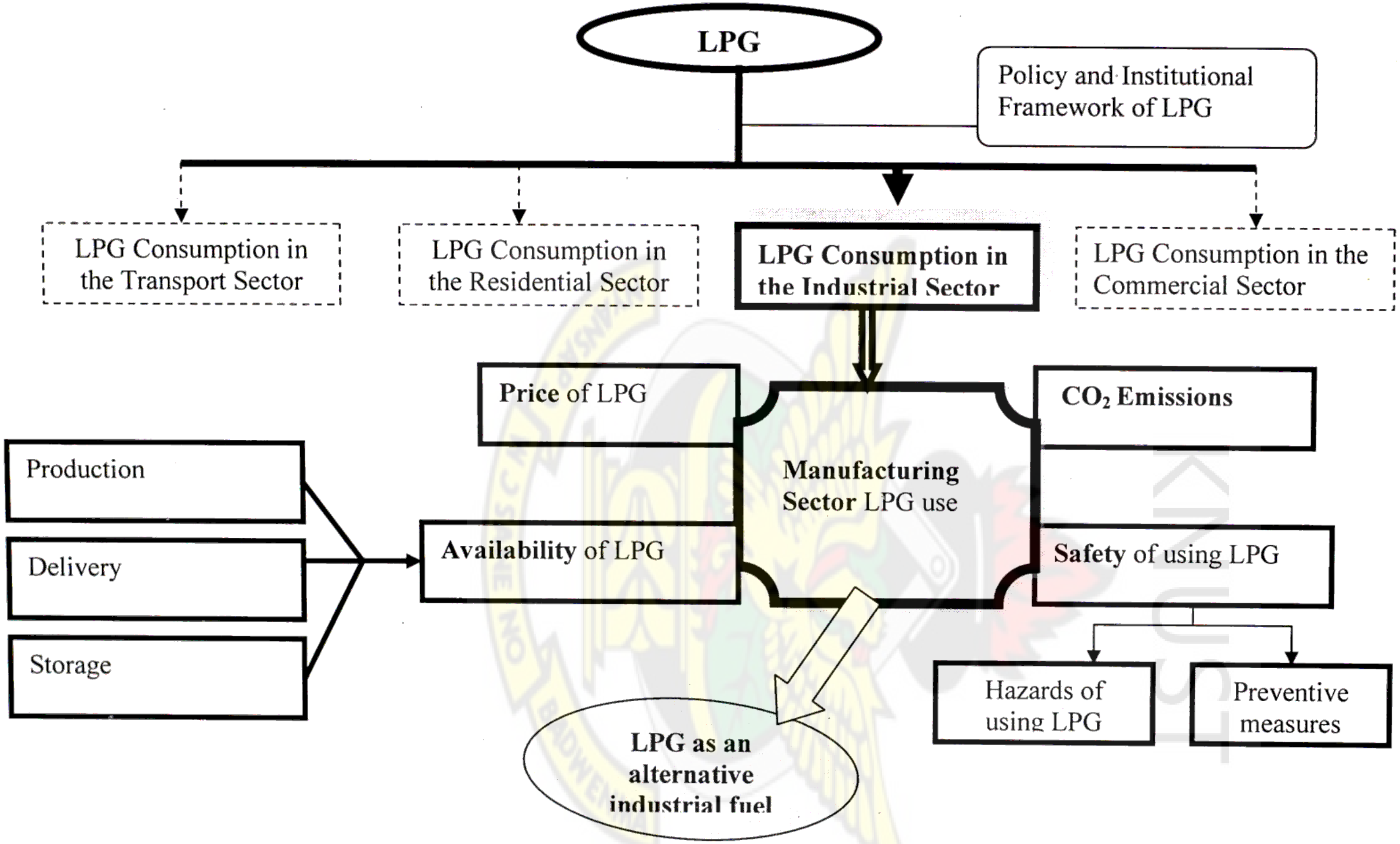
2.4.1 Key Concepts and Terminology

This section defines the conceptual and analytical framework within which the study was conducted. This is done against the theoretical background of the subject and the existing body of knowledge in the field. The theoretical and empirical bases of each of the concepts have been presented as a way of helping to present the case study material in context and to enlighten the study on the various elements of the concepts. Thus providing the basis for building data blocks for the collection of field data, and preventing the researcher from collecting a wide range data that will be very difficult to analyze.

This study will not attempt to address comprehensively all of the issues which should be considered in evaluating alternative energies. Instead, it has a more modest goal in assessing the potential of LP Gas as industrial fuel. The researcher focuses on availability of the gas, cost of fuel, environmental emissions and safety. The themes discussed here are those that could be managed within the competence of the author. It is therefore possible that other researchers will differ in emphasis on the main concepts.

Figure 2.1 below is diagrammatic representation of the conceptual framework.

Figure 2.1 Diagrammatic Representation of concepts and their interrelationships



Source: Author's construct, 2006

2.4.2. Energy or Fuel

Energy or fuel is used interchangeably in this study to mean any substance that supplies heat or power, e.g. liquefied petroleum gas, residual fluid oil, electricity, diesel among others.

2.4.2.1 What is Liquefied Petroleum Gas?

Propane, liquefied petroleum gas, and LPG are inter-changeable names for the same commodity. (Technically, however, propane is just one, predominant component in LPG, which often contains smaller amounts of butane, propylene, and butylenes.) By whatever name, it is a fuel increasingly recognized worldwide as a clean, safe, and practical alternative energy source.

2.4.2.2 Composition of the liquefied petroleum gas

LPG is light paraffinic hydrocarbons derived from the refinery processes, crude oil stabilisation and natural gas proce ssing plants. They consist mainly of propane (C_3H_3) and butane (C_4H_{10}) or a combination of the two. They could also include propylene, isobutene and isobutylene (IEA, 2005). It is a by-product of natural gas processing and crude oil refining. Worldwide, about 60 per cent of LPG comes from natural gas processing, while crude refining produces 40 per cent, according to the WLPGA (WLPGA, 2004).

2.4.2.2a Natural gas processing

When gas is drawn from the earth, it is a mixture of several gases and liquids. Commercial natural gas is mainly composed of methane, but it also includes ethane, propane and butane in such proportions that its quality is in conformity with the market where it is distributed. In order to stabilize the crude oil for pipeline or tanker distribution, these "associated" or "natural gases" are further processed into LP Gas. Worldwide, gas processing is the source of approximately 60 per cent of LP Gas (BAE, 2007).

2.4.2.2b Crude oil refining

In an oil refinery, LP gases are produced at various stages of the operations: atmospheric distillation, reforming, cracking and others. LP Gas represents between 1 per cent and 4 per cent of the ton of crude oil processed. Refining is the source of approximately 40 per cent of LP Gas produced worldwide (BAE, 2007).

2.4.3 Availability:

Availability covers both the adequacy and reliability of delivered energy to the end user (in this case the manufacturer). For the purpose of this study, adequacy is the sufficiency of LPG supply to meet the needs of industry while reliability means LPG are supplied to customers with no or little interruptions in supply and quality. Thus availability is defined as the absence of uncertainties associated with LPG supply and use. In assessing the availability of the fuel, this paper looks at three important themes that underpin availability. These are production, delivery and storage. Production will look at the production at the refinery. Delivery will focus on existing infrastructure that moves LPG from its point of production to an end-use device and the rate of delivery. Storage refers to the confinement of the gas at the refinery and at the industries. This is done in an attempt to answer the question under consideration "Do we have enough supply of LP Gas that will be able to meet demand resulting from industrial utilization?"

2.4.4 Cost

Cost refers to the price value of the LPG on the domestic market. Here, the study intends to compare the price of LP Gas with other alternatives and assess if the price of the gas has also played a role in its underutilization.

2.4.5 Safety

Safety is one of the key requirements for successful industrial environmental management. Because many energy resources pose a threat to people, it is important to minimize risks and seek safer energy sources. LP Gas is potentially hazardous from production until it has been used and combustion products have finally been disposed off safely (UNEP, 1998). The study focuses on hazards associated with the utilization of LP Gas and measures put in place to prevent these hazards. The question at hand is whether the perceived hazardous nature of the gas has played any role in its underutilization by the manufacturer.

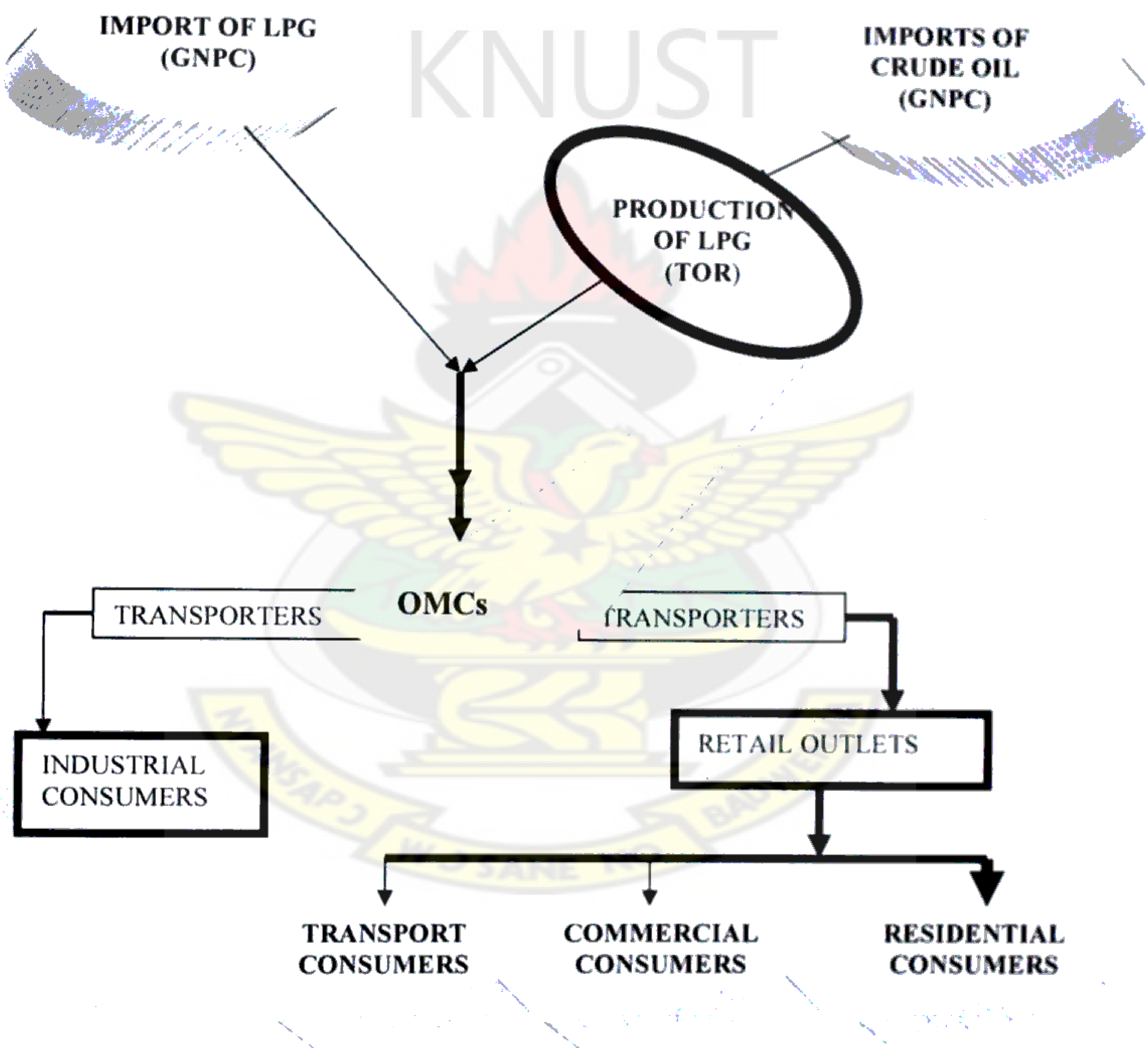
2.4.6 Carbon dioxide emissions

Greenhouse gas emissions and local air pollution are the two environmental impacts of greatest concern from gas-fired, combined cycle plants. Other localized impacts include noise pollution (Sazuki Foundation, 2001). This paper focuses on greenhouse gas emissions particularly carbon dioxide emissions during the combustion of the various fuels by the manufacturer. Carbon dioxide is good indicator of how much fossil fuel is burnt and how much of other pollutants we cause to be emitted (EIA).

2.5 Stakeholders and their functions in the LPG industry

The key actors in the LPG distribution chain are Tema Oil Refinery (TOR), Oil Marketing Companies (OMC's), Retailers and Transporters, LPG Cylinders and Accessories Manufacturing Facilities and end-users. Figure 2.2 shows the various stakeholders and the distribution of the fuel in the country.

Figure 2.2 Diagrammatic Representation of LPG distribution in Ghana



SOURCE: Author's construct, 2006

2.5.1 Ghana National Petroleum Corporation (GNPC)

In the upstream segment of the Petroleum Sector, the Ghana National Petroleum Corporation (GNPC) is the key institution that is working to deliver on our national mandate. The Ghana National Petroleum Corporation was established to undertake the "exploration, development, production and disposal of petroleum". It among other things oversees the importation of all crude oil including LP Gas.

2.5.2 The Tema Oil Refinery (TOR)

The Tema Oil Refinery, TOR, is the only refinery in Ghana and is wholly owned by the government of Ghana. TOR specializes in the downstream oil industry and is primarily responsible for refining imported crude oil, which is purchased from the international oil market. TOR provides Ghana with a wide range of finished petroleum products such as LPG, Petrol, Kerosene, Aviation Turbine, Kerosene, Diesel, Industrial Diesel Oil, Premix Fuel, Inland Fuel Oil and Residue Fuel Oil (KITE, 2003).

2.5.3 Oil Marketing Companies (OMCs)

The OMCs comprise both foreign and locally owned, are registered with TOR as distributors and sellers of petroleum products, including LPG, throughout the country. OMCs operating in Ghana are mainly multinationals; however the last decade has seen an increase in the establishment of a number of small to medium scale OMCs. Retailer outlets (stations) operate under franchise arrangements with these companies. Most of the LPG retailer outlets are fully owned by private individuals who register with the Oil Marketing Companies for supplies.

2.5.4 Retailers and Transporters

The Transporters taken as a separate entity from the OMCs serve as middle men between the OMCs and the Retailers. The transporters load the LPG from the OMCs and transport them to the Retail points. LPG is stored in overhead bulk storage tanks and cylinders at these stations. These companies are the final link to the end consumers and industrial clients. All LPG retail outlets have to be registered with an OMC to be able to obtain a license to operate.

2.5.5 LPG Cylinders and accessories manufacturing facilities

There are two LPG cylinder manufacturing companies in Ghana. These are Ghana Cylinder Manufacturing Company and Sigma Gas Ghana Ltd, both located in Accra. The products from these companies compete favorably with imported used cylinders and other LPG accessories. There is an abundance of LPG cylinders of various sizes together with their accessories such as regulators, hoses, valves, locally made and imported stoves and burners on the Ghanaian market. The main issues worth considering are that of safety. The cylinders are sold through agencies and dealers to the general public.

The pricing of LPG is highly controlled by the Government in Ghana. The study also intends to find out how the price of LPG compares with other competitive energy sources and how the price of LPG affects prices of manufactured goods and profitability.

2.6. State action and policy issues on Liquefied Petroleum Gas industry in Ghana

Government policies and measures can strongly influence LPG market development and active government support can catalyze LPG market take-off and establish virtuous circle of growing market potential, increased investment and expanded availability (UNEP, 2006).

The Government of Ghana launched the National LPG Program in 1990 under which the Tema Oil Refinery was to be modernized and a massive LPG campaign was to be implemented. It is worth noting that at the inception of the 1990 LPG program TOR was flaring LPG. As part of the modernization, a secondary conversion unit was to be added to the Tema Oil Refinery (TOR) resulting in an increase in production level of LPG from an annual figure of 11,000 MT to 130,000 MT by November 2002. The increase in availability of LPG offered an opportunity to promote this energy source as an alternative to charcoal and firewood, which presently constitute the bulk of energy consumed by the domestic sector (KITE, 2003).

As part of the promotion, extensive promotional and educational campaigns were carried out to ensure that environmental, health and safety regulations were observed and the benefits of switching to LPG were communicated to the public. The government also played a lead role in delivering LPG to remote parts of the country by establishing retail outlets in Takoradi, Tamale and Bolgatanga in 1995. The developments led to significant improvement in the supply of gas in the areas though it was skewed towards urban areas (KITE, 2003).

Plate 1: Spherical Tank at Refinery

Source: Author, December 2006

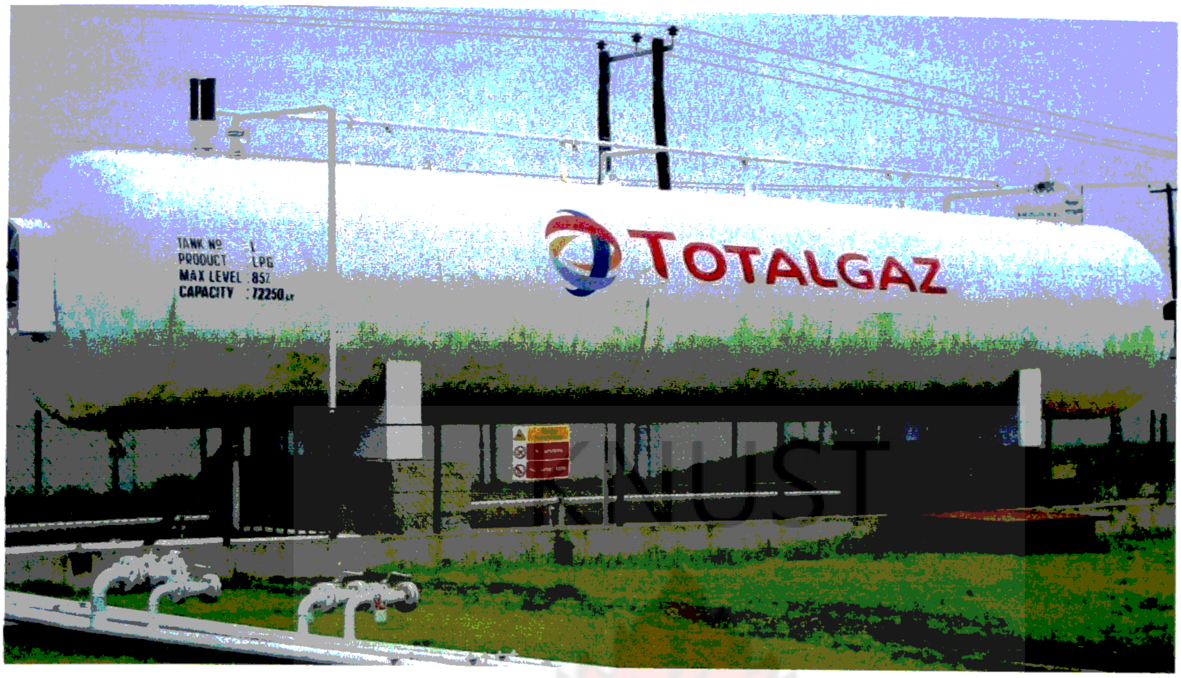
Plate 1 is LPG storage facility installed at the refinery

Plate 2: Tanker for transport of LP Gas

Source: Author, December 2006

Plate 2 is an infrastructure that moves LPG from point of production or the refinery to an end-use device.

Plate 3: Installed bulk tank at an industrial site



Source: Author, December 2006

Plate 3 is storage facility at one of the industrial sites visited.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

According to Yin (2003), the research design is the logical sequence that connects the empirical data to a study's initial research questions and ultimately to its conclusions. The research design is the overall plan for relating the conceptual research problem to relevant and practicable empirical research (Ghauri and Grønhaug, 2002). It can therefore be conceived as the overall strategy to get the information needed to answer the question under scrutiny. The choice of a research design influences what data to collect and how they should be collected.

In this section the type of research design chosen will be discussed and a justification provided for the use of the chosen methodology. Also, this section describes the various methods and procedures that guided the researcher in the process of collecting and analyzing data. Each stage of the methodology consists of a discussion of the procedures recommended in literature, followed by a discussion of the application of those procedures in this research.

The section contains strategies utilized in the study, sampling plan, data collection techniques, statistical considerations and data analysis techniques.

3.2.1 Rationale for Using the Exploratory Case Study Approach

Research involves choices. There are different research strategies. Each is a different way of collecting and analyzing empirical evidence, following its own logic. (Yin, 2003) states that the distinction between the different strategies depends on:

a) the type of research questions posed

b) the extent of control an investigator has over actual behaviour events

c) the degree of focus on contemporary as opposed to historical events

Table 3.1 below presents the relevant situations for different research strategies as identified by Yin in 2003.

Table 3.1 Relevant Situations for Different Research Strategies

Strategy	Form of Research question	Requires Control of Behavioral Events	Focuses on Contemporary events?
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival analysis	Who, what, where, how many, how much?	No	Yes/No
History	How, why?	No	No
Case study	How, why?	No	Yes

Cosmos Corporation, in Yin (2003, p.5)

"Why" questions are appropriate for the case study research whereas "what" questions according to Yin (2003) should be mapped through survey and archival analysis. As such, various research designs can be applied although a case study and survey designs are considered pertinent for this thesis.

The integration of different methods is to allow the researcher answer different research questions with different methods and sources and to corroborate one source and method with another, and to enhance the quality of the data. Though each strategy has its distinctive characteristics, there are large overlaps among them. Each of these strategies has its advantages and disadvantages. It is the combination of these assets that justify the rationale for integrating them, thereby obtaining the best possible output or results.

The objective of this thesis is to describe and analyze a contemporary process and to answer the research questions formulated. According to Yin (2003) if research questions focus mainly on "what" questions, either exploratory research or survey can be adopted. Some types of "what" questions are exploratory such as, "What are the challenges and constraints to LPG as industrial fuel?" According to Yin (2003), this type of question is a justifiable rationale for conducting an exploratory study, the goal being to develop pertinent hypotheses and propositions for further enquiries.

Also, almost no research has been done on this topic-based on this difficulty it became apparent that the research should be an exploratory study, attempting to obtain a deeper understanding of why LPG is not being used by industries, the challenges and constraints to LPG use and the characteristics of LPG. It is in this regard that, the exploratory case study was adopted since it fits into the research settings and best addresses the research concerns to a greater depth.

A case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident (Yin 2003, p. 13). This is consistent with the objectives of this study, as the intention is to understand why only few industries use LPG as industrial fuel.

The case study as a research strategy comprises an all-encompassing method covering the logic of design, data collection techniques and specific approaches to data analysis (Yin, 2003). The essential methodological feature of a case study is that it provides in-depth and detailed analysis (Casley and Lury, 1987; Sidhu, 2003). It relies on multiple sources of evidence and often makes use of propositions to guide data collection and analysis.

3.2.2 Internal Validity

Internal validity refers to the extent to which inferences can be made that a causal relationship exists between two or more variables (Ghauri and Grønhaug, 2002). According to Yin (2003) internal validity is only concerned for causal or explanatory case studies, in which an investigator is trying to determine whether event *x* led to event *y*. To improve the internal validity of the information gathered, the study used multiple sources of evidence including document analysis, self-completion questionnaire and face-face interview to triangulate data.

3.2.3 External Validity

External Validity relates to what extent the research findings can be generalized to particular population (Ghauri and Grønhaug, 2002; Yin, 2003). The external validity problem has been a major barrier in doing case studies. Critics argue that a single case offers a poor basis for generalizing, paying little or no attention to the fact that case studies rely on analytical generalization and not statistical generalization. To ensure that evidence collected can be generalized to a large extent, manufacturing industries were sub grouped into homogenous entities and samples randomly selected within the sub-sectors.

3.2.4 Reliability

Reliability means demonstrating that the operations of a study such as data collection procedures can be repeated with the same results. The goal of reliability is to minimize the errors and biases in the study. To ensure this, all procedures (methodological, theoretical and practical steps) followed in carrying out this study have been documented.

3.3 Case Study Area and Justification

The Tema Municipality (pop. 141,000) is part of the Accra-Tema Metropolitan Area (2000 Population and Housing Census). It is located in the Coastal savanna zone. Tema city is located in Southeast Ghana, near Accra. It lies along the Gulf of Guinea (an embayment of the Atlantic Ocean), 18 miles (29 km) east of Accra (Encyclopedia Britannica). The City was built in 1960 as a manmade harbor. Its port, developed in the 1950s and opened in 1961, is the busiest in Ghana.

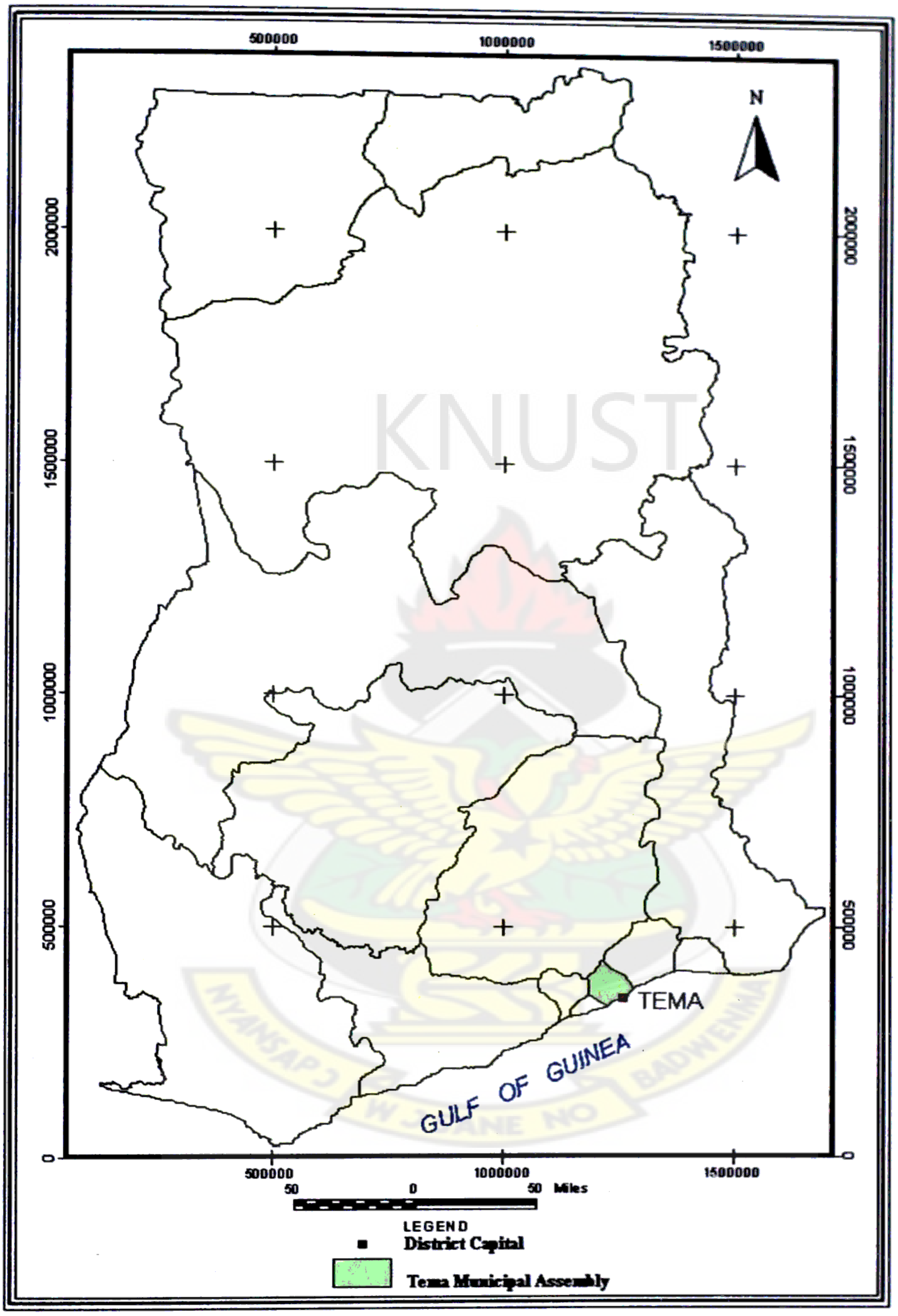
With the opening of an artificial harbor in 1961, Tema developed from a small fishing village to become Ghana's leading seaport and an industrial center. The city has industries producing aluminum, refined petroleum, chemicals, food products, and building materials.

Tema is the most industrialized city in Ghana and its industrial sector is the most important revenue generation for the Municipality (Ababio et al, 2003). There are three steel manufacturing companies, two large textile manufacturing companies in Tema. In addition to these heavy industries, there are also more than two hundred and fifty light industry companies in the chemicals, textiles, food processing, engineering, paint, fish cold stores, printing and wood working enterprises (ISSER, 2001; Ministry of Local Government and Rural Development, 2000). In all, there are over four hundred factories in Tema which have been categorized into eight major areas- Chemicals, Textiles, Food Processing, Engineering, Paints, Fish Cold Stores, Printing and Woodworks Industries (TMA, 2001). Hence by using Tema as the study area, there will be a high representation of all the manufacturing industries across the country.

Secondly, the only oil refinery in the country is sited in Tema and it is assumed that because of the nearness of the refinery to most industries, the utilization of LPG will be convenient to and hence highly utilized and represented in Tema than in any other part of the country.

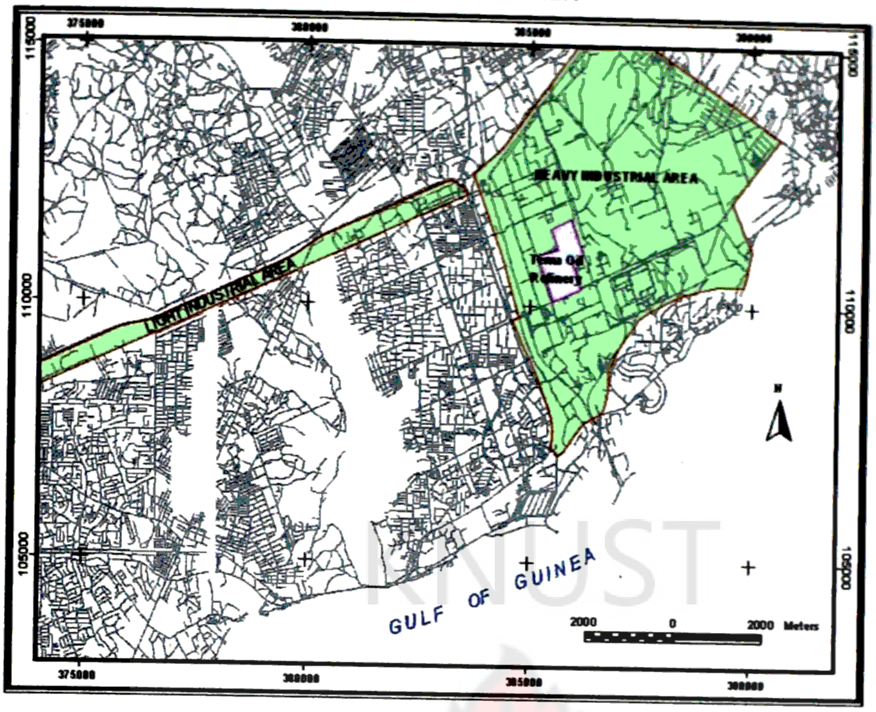
Again, with the construction of the WAGP which passes through Tema, most of the potential users are located in Tema and it is anticipated that the outcome of these study will inform stakeholders in the WAGP and contribute to its smooth operations.

MAP OF GHANA SHOWING TEMA



Source: TMA/GSS, June 2007

TEMA INDUSTRIAL AREA



Source: TMA/GSS, June 2007

3.4.1 Unit of analysis

Kumekpor (2002) defines the unit of analysis as the actual empirical units, objects, occurrences which must be observed or measured in order to study a particular phenomenon. In connection to the stated objectives, establishments (firms) were chosen as the unit of analysis even though the interviewees were individuals. Thus the perspective given in the cases reflect the views and opinions of stakeholders on LPG use by the industrial sector. To limit the scope, the emphasis is on manufacturing industries utilization of LPG since its use is very limited in this sector.

3.4.2 Definition of Population Researched

The population for this study was defined by the research question. The target population consists of all major stakeholders in the LPG industry in Ghana. They included NPA, TOR, OMCs and manufacturing industries (end-users) in Tema.

3.5.1 Sampling

A major issue with any scientific research is the extent to which the sample is representative of the population at large. Sampling is the process of selecting observations (Rubbin and Babbie, 2001). According to Ghauri and Gronhaug (2002), deciding on the relevant population to survey is not an easy task. The key question is to know whom or what one wants information about. A critical part of social science research is the decision about what will and will not be observed.

The case will be selected to represent some population of cases. Therefore, considerable effort was expended in the selection of the sample. In this section the type of sampling method chosen is discussed, and then the techniques used to select the industries and the interviewees is discussed, including a justification for the sample size.

3.5.2 Sampling Frame

A sampling frame is a listing of units from which the actual sample is drawn (Rubin and Babbie, 2001; Ghauri and Grønhaug, 2002). This leads to the sample units of the analysis about which information is obtained. To give a comprehensive understanding of all issues, evidence from different perspectives were considered. As such the sampling frame is as shown below:

Table 3.2 Sampling Frame

Name of Population	Sample Frame	Sample Identification
Manufacturing Establishments	65	▪ Registered members of AGI ▪ Registered members of Chamber of Mines ▪ Industrial customers of OMCs in Tema
OMCs	27	Registered OMCs (source: TOR)
Regulatory Bodies	2	Personal Identification
LPG Producers	1	Personal Identification

Source: Author's Construct, May, 2006

The list from AGI and Ghana Chamber of Mines and Industries were adopted for this study, since they gave the location, products produced by each industry and their contacts. The researcher found this list adequate and reliable for the study and hence adopted it as part of its sampling frame. It must however be stated that not all manufacturing industries in Tema are members of these two associations. Also, most of the industries were members of both associations. It was also observed that most of the industries that use LPG were not members of these associations. Hence, a list of industries indicated by OMCs as being their Industrial customers in Tema was also included in the sampling frame. A new frame, consisting of registered members of AGI, Chamber of Mines and industries (Tema Branch) and OMCs was used. With respect to the OMCs, a list provided by TOR as registered members of OMCs was adopted as part of the sampling frame.

3.5.3 Sample Selection

Establishments like NPA, TOR and EPA were purposefully selected because of their unique roles they play in the LPG industry. However, respondents were identified through snowballing-interviewers were assisted by staff of the establishments to identify the right persons to be interviewed.

3.5.4.1 Determining Sample Size for Oil Marketing Companies

Total Number of OMCs 27

Confidence Level	Sample Size
96%	26
92%	23

Mathematical formula used: $$\text{Sample Size} = \frac{N}{1 + N(\alpha)^2}$$

Where **α** is the Confident Interval

At 92% confidence level, 23 establishments were to be interviewed. To make up for non-response, all the 27 OMCs were included in the survey. However, interviewees, which consisted of 27 marketing managers from the various OMCs, were purposefully selected to assess their views on the subject.

3.5.4.2 Determining Sample Size for Manufacturing Establishments

Total Number of manufacturing establishments 65

Confidence Level	Sample Size
95%	56
92%	46

Mathematical formula used: Sample Size = $\frac{N}{1 + N(\alpha)^2}$

Where α is the Confident Interval

At 95% confidence level, 56 establishments were to be interviewed. To make up for non-response, 60 establishments were included in the survey.

The stratified sampling method is used for the selection of manufacturing establishments. The manufacturing is divided into mutually exclusive and exhaustive subsets; sample of units is chosen independently from each subset. The idea of stratified sampling is to ensure that every part of the population that is every stratum gets better representation (Ghauri and Grønhaug, 2002). According to Keller and Warrack (1999), one advantage of stratification is that, besides acquiring information about entire population, one can also make inferences within each stratum or compare strata.

For the purposes of this study, the standard industrial classification was adopted for classifying manufacturing industries. This is in consonance with the classification used by the Ministry of Trade and industry in its book "Government of Ghana: Review of Industrial and Trade Performance." Only establishments primarily engaged in the following activities were considered manufacturing establishments for the purposes of this study: food products and beverages, textiles, paper and paper products, basic metals and petroleum products.

Then appropriate number of elements was drawn from homogenous subsets of that population. This was to ensure proper representation of all selected industrial groups and to enhance the representation of other variables related to them, thus reducing sampling error (Rubin and Babbie, 2001). The establishments were selected at random and to reflect the proportions of the various major industry groups in the sampling frame as shown in appendix 1.

3.6 Selection of Respondents

Selection of participants does favor those willing and able to dedicate at least thirty minutes to an unpaid activity. Each of the participants was contacted by means of phone or in person. Finally, with non-random sampling of interviewees, respondents may not typify practitioners in the manufacturing sectors they are chosen to represent. The respondent may experience greater-than-average impacts from the energy situation, may self-identify as an industry spokesperson, may be more articulate, or may simply have more free time. In each of these cases, selection bias is toward likely program participants—the subject of this research.

The purpose of this exploratory assessment was to highlight a range of perspectives, experiences, and actions related to industrial LP Gas utilization among manufacturing industries in Ghana-not to produce a representative sample of industrial energy users.

3.7 Data Collection Techniques

Several methods were used in the collection of information from respondents. Yin states that no single source of data has a complete advantage over the others and that the various sources of data collection are highly complementary (2003, p.85). Ghauri and Grønhaug (2003, p.181) refers to the combination of methodologies in the study of the same phenomenon as triangulation. Through triangulation a researcher (s) can improve the accuracy of results by collecting data through different methods or even collecting different kinds of data on the subject matter of the study. This not only increases the validity of the study, but increases the enriching and completing of knowledge and increases scope, depth and consistency of methodological proceedings."

A multiple approach of data gathering has been adopted for the purpose of this research which includes questionnaires, interviews and document analysis. The obvious reason for adopting the multiple approaches is the possible combination and integration of strengths and weaknesses concerned with each method. A detailed description of each method and procedures is addressed in the next few pages of this section. The techniques used to collect the empirical data were:

3.7.1 Documentary analysis

Where possible documents were obtained in their original format and filed for later analysis. Internet documents (corporate websites) were printed out and filed for analysis. These were summarized on site by reducing them to their key meanings and listing the types of issues discussed. These were also then filed for later analysis.

First, a literature review of liquefied petroleum gas (LPG) was performed to explain the background of LPG formation. The literature survey was undertaken from various sources such as journals, conference articles, online sources, and reference books. All relevant information were analyzed to construct a precise summary of background information which included the nature and origin of LPG, advantages and limitations of LPG, physical and chemical properties of LPG. At the same time, comparisons between diesel, electricity, gasoline and LPG were also noted.

Information on Production and pricing of LPG from 1999-2006 were collected for analysis. This data was gathered basically from documentary sources. This allows the researcher to analyze trends, variations and fluctuations in production and prices of LPG for the past eight years. Market share of the Oil Marketing Companies for May- 2006 was also compiled from documents. This is to enable the researcher estimate the demand for that month.

3.7.2 Questionnaires

A questionnaire is a form prepared and distributed to secure responses to certain questions (Sidhu, 2003). Two types of questionnaires were designed: one for manufacturing industries and the other for OMCs. Both closed and open ended questions formed part of the questionnaires administered to address the objectives stated in the study.

Although a total number of 30 questions were posed to the manufacturing industries, the actual number asked of a given respondent depended on the relevance of certain questions or sets of questions. Questions were grouped as follows:

- Profile of manufacturing establishments
- General information on main fuels used by specific industries
- Usage of LPG, opportunities and constraints to the use of LPG
- Reasons why LPG is not a fuel of choice by some industries

However, in the case of the OMCs, 15 questions were posed. Questions were grouped as:

- Profile of OMCs
- Market share of LPG in Ghana
- Opportunities and constraints to LPG use as industrial fuel in terms of availability, cost, safety and environmental emissions.

3.7.3 In-Depth Interview

Data from regulatory bodies were collected through an in-depth interview. Both structured and unstructured interviews were used. The structured interviews are more scientific in nature for they introduce controls that are required to permit the formulation of scientific generalization (Sidhu, 2003). However, to allow for respondents to express themselves fully, unstructured interviews were used in some cases. Thus a semi-structured interview was employed.

Interviews were conducted at the comfort of the interviewee at his or her office. As interviews were conducted, the answers provided by the participants were summarized and a brief summary of the interviewee's answer to a particular question was recorded on a sheet of paper and filed for analysis.

3.7.4 Direct Observation

The researcher took field trips to 4 manufacturing industries identified to be using LPG to observe the various applications of the LPG, problems encountered in its use and safety measures put in place to avoid the occurrence of accidents. Field personnel spent a day in each of the selected manufacturing industries to do the observations. Pictures were taken to aid in the analysis of the data.

3.8 Protocol

One of the major problems in preparation for field work is access, the selection of a research site and the negotiations necessary to gain entry to it. In recognition of these problems, the researcher personally contacted members of the samples. The purpose of this was to brief them on the purpose of the study, solicit for their co-operation and brief them on their roles. This helped in the reformation of research objectives, interview questions and identification of respondents.

3.9 Pilot Study

The piloting of self-completion survey allows a researcher to gather information on the appropriateness of the questions, the pre-defined response categories for each question, and how the overall structure actually function (David and Sutton, 2004). The pilot study is more formative, assisting the researcher to develop relevant lines of questions-possibly even providing some conceptual clarification for the research design as well (Yin, 2003).

It is in this regard that the researcher conducted a pilot study in September to obtain information on the following:

- appropriateness of the sample
- efficiency of the questionnaire
- field organization

The pilot covered a sample of 5 manufacturing establishments and 3 oil marketing companies. On completion of questionnaire which took an average of 35 minutes for each establishment visited and a total of 8 working days, a data processing specialist was consulted to assist in the final design of the questionnaire. The main revisions were in the categorization of the questions, the order in which questions were asked, the rephrasing and elimination of some questions. The pilot experience informed the finalization of field procedure.

3.10 Training of Interviewers

Interviewers went through training to equip themselves psychologically and materially. This was to educate the interviewers on the purposes and implications of the study. All the questions on the questionnaire were carefully explained to the interviewers. This was to ensure that at the end of the training, the interviewer has become acquainted with the nature of work the study entails, the type of data to be collected and the caliber of people to be contacted for the required information.

3.11 Pre-testing of Questionnaires

The questionnaire was then pre-tested. This was to enable the interviewer to have a first hand experience with the questionnaire. It was observed that the questionnaire for manufacturing industries had to go to about three different people (i.e. the account's office, production manager and in some cases Energy Manager) for the questionnaire to be filled. Hence, some of the questions especially with respect to the amount spent on energy were eliminated. Where possible, the investigator used document analysis.

3.12 Fieldwork

The field survey is involved with the collection of primary (empirical) data. Kumekpor (2002) states that a well-designed questionnaire containing all necessary checks and controls is useless if the fieldwork is slovenly carried out. Fieldwork is very difficult and requires shifts here and there and sometimes, temporary suspension of certain aspects of the work.

Questionnaires were given for self completion. It took two weeks to collect the questionnaires.

3.13 Data Analysis

Data analysis is the process of bringing order, structure and meaning to the mass of collected data (Ghauri and Gronhaug, 2002). In this section the treatment of the raw data in terms of storing and sorting it prior to analysis, as well as the analysis techniques and procedures used will be discussed.

Data was edited and coded for entry into the computer using Statistical Package for Social Scientists (SPSS). Editing involved the inspection and correction of questionnaires. Both qualitative and quantitative analysis was employed in this study.

Data has been categorized, cross-tabulated and tabulated according to concepts in order to address the purpose of the study. In some cases, chi-square analysis was adopted to test relationships between some variables. Specific techniques such as pie charts, pictures and bar charts have also been used.

3.14 Limitations of the study

1. The unavailability of observed data and secondary data on industrial emissions by fuel type in the country necessitated the need to rely on international data. Emission figures may not correspond to the actual emissions by fuel type in this country and hence constitute a major limitation to this study.
2. Due to the use of different energy units in the different energy industries, namely kilowatt-hour for electricity, liter for diesel and RFO and Kilogramme for LP Gas, it is difficult to compare costs of different energy sources. However, conversion factors were used in order to achieve the cost competitiveness of competing fuels. It must also be noted that different

electricity tariffs are available for industrial users. However, an average price was adopted for the purpose of this study.

3. The manufacturing sector is highly diverse and energy patterns vary dramatically from industry to industry. Extrapolation of research findings to other industries other than those considered in the study should be done with circumspection.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.0 Introduction

The study involved a number of organizations working in a variety of areas and with varying interests in the LPG industry. Depending on the category being considered, information determined to be useful is collected and analyzed. However, much emphasis is on the manufacturing industries since they are the target group of this study.

Information gathered included perspectives of the various institutions on the use of LPG as industrial fuel with reference to its availability, its environmental and safety characteristics and the pricing of the fuel. In order to investigate the stated objectives, the analysis phase of the research is presented as follows: First, the content analysis of the interview transcriptions, the analysis of the field notes taken during the interviews, and the analysis of the documentary evidence collected during the study is analyzed and presented together with the results of the quantitative analytic methods.

The analyses of results in this chapter are structured in this order: brief profile of manufacturing industries, environment and safety characteristics of LPG, pricing of LPG and the availability of LPG as industrial fuel. Finally, the conclusions from each analytic methodology are drawn together in order to provide an overall conclusion to the empirical component of the research. Issues arising from the literature are presented in, and will be compared and contrasted with the empirical findings. Conclusions regarding the sub-objectives will be presented in chapter 5.

4.1: Profile of Respondents from manufacturing industries

Table 4.1 Distribution of Manufacturing Sub sectors

	Frequency	Percent	Cumulative Percent
Food and Beverage	14	31.1	31.1
Chemical products other than petroleum	10	22.2	53.3
Textiles	6	13.3	66.7
Paper products	1	2.2	68.9
Metals	12	26.7	95.6
Petroleum products	2	4.4	100.0
Total	45	100.0	

Source: Author's field survey- November, 2006

Table 4.1 shows the distribution of responses from the various manufacturing sub-sectors involved in this study. The food and beverage group of industries formed 31.1 per cent of the response, industries in the chemical group formed 22.2 per cent of the respondents and industries in the basic metals group formed 26.7 per cent. The rest of the distribution is as follows: the textiles industries constitute 13.3 per cent of the response, petroleum products, 4.4 per cent and the paper products constitute the remaining 2.2 per cent of the response.

Table 4.2 Size and Location of Manufacturing Industries

% within Size of Manufacturing Industries

		Location of industry			
		Light Industrial Area (%)	Heavy Industrial Area (%)	Outside (%)	Total (%)
Size of Industries	Large Sized Companies	5.0	95.0		100.0
	Medium Sized Companies	53.3	26.7	20.0	100.0
	Small Sized Companies	30.0	20.0	50.0	100.0
Total		26.7	55.6	17.8	100.0

a. Source: Author's Field Survey- November, 2006

Of the 45 manufacturing industries surveyed, 25 (55.6 per cent) were located in the heavy industrial area, 12 (26.7 per cent) in the light industrial area and the remaining 8 (17.8 per cent) located in areas outside these two main industrial areas.

Ninety five per cent (19) of the large sized industries were sited in the heavy industrial area while the remaining 5 per cent (1) were sited in the light industrial area. None of the small industries included in the survey was located in the heavy industrial area. 53.3 per cent (8) of the medium sized industries were located in the light industrial area, 26.7 per cent (4) in the heavy industrial area while 20 per cent (3) were sited outside the light and heavy industrial areas. However, 50 per cent (5), forming the majority of the small industries, were located outside these two main industrial areas while the remaining 50 per cent were distributed in the light and heavy industrial areas as 30.0 and 20.0 per cent respectively.

A chi-square test (X^2=27.13, df =4, $p<0.000$) shows that there is a strong relationship between size of industries and location of these industries- an indication that the citing of an industry is highly influenced by the size (Refer to appendix 7a for output of chi-square test).

Table 4.3 Distribution of Manufucturing Industries according to Location

% within Manufacturing Subsectors

		Location of industry			
		Light Industrial Area (%)	Heavy Industrial Area (%)	Outside (%)	Total (%)
Manufacturing Subsectors	Food and Beverage	35.7	50.0	14.3	100.0
	Chemical Products other than Petroleum	30.0	50.0	20.0	100.0
	Textiles	16.7	66.7	16.7	100.0
	Paper products		100.0		100.0
	Metals	25.0	50.0	25.0	100.0
	petroleum products		100.0		100.0
Total		26.7	55.6	17.8	100.0

a. Source: Author's Field Survey- November, 2006

Thirty six per cent of the food and beverage industries were located in the light industrial area of Tema while 50 per cent were sited in the heavy industrial area and the remaining 14.3 per cent outside the two main industrial areas. 50 per cent of the chemical industries were in the heavy industrial area, 30 per cent in the light industrial area and the remaining 20 per cent outside the main industrial areas. 66.7 per cent of the textiles were sited in the heavy industrial area, 16.7 per cent each in the rest of the areas.

The rest of the distribution is as follows: 50 per cent of the metals were in the heavy industrial area, 25 per cent in the light industrial area and the remaining 25 per cent sited outside the two main industrial areas. All of the petroleum and the paper industries included in the survey were located in the heavy industrial area.

A chi-square test (X^2=3.922, df =10, p>0.05) shows there is no relationship between the various manufacturing sub-sectors and the location of the industries. This implies no particular area is allocated to only Textile manufacturers nor chemicals or any of the manufacturing sub-sectors. Rather, these industries are interspersed when it comes to the various manufacturing sub-sectors.

Table 4.4 Distribution of Manufacturing Industries according to Size

% within Manufacturing Subsectors

		Size of Manufacturing Industries			
		Large Sized Companies (%)	Medium Sized Companies	Small Sized Companies	Total
Manufacturing Subsectors	Food and Beverage	50.0	28.6	21.4	100.0
	Chemical Products other than Petroleum	40.0	50.0	10.0	100.0
	Textiles	50.0	33.3	16.7	100.0
	Paper products	100.0			100.0
	Metals	25.0	33.3	41.7	100.0
	petroleum products	100.0			100.0
Total		44.4	33.3	22.2	100.0

a. Source: Author's Field Survey- November, 2006

Of the manufacturing sub-sectors surveyed, 20 representing 44.4 per cent of the industries were large sized companies, 15 representing 33.3 per cent of the industries were medium sized companies and 10 representing 22.2 per cent were small sized companies.

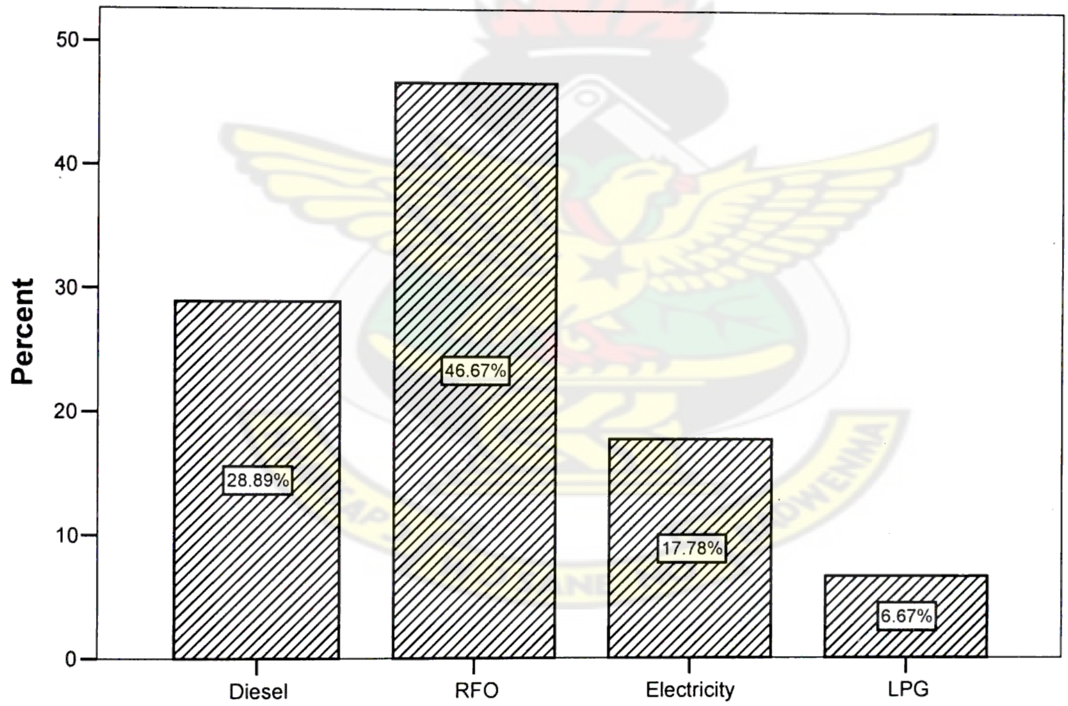
Within the manufacturing industries results from the table above shows that the petroleum products and paper industries included in the survey were large sized industries. 50 per cent of the food and beverage industries were also large size, 28.6 percent medium sized and the remaining 21.4 per cent were small sized industries. Majority (50 per cent) of the chemical industries was medium sized, 40 per cent were large sized and the remaining 10 per cent were small sized industries. The rest are 41.7 per cent of metals belong to the small sized industries, 33.3 per cent were classified as medium sized industries and the remaining 25 per cent classified as large sized companies.

A chi-square test (X^2=8.684, df =10, p>0.05) shows no relationship between manufacturing sub-sectors and size of the industries.

4.2.1 Main Energy sources used by Manufacturing Sub-sectors

Manufacturing is an important part of the Ghanaian economy and energy is a vital input into the manufacturing. In fact, every manufacturing plant uses at least one type of energy in their production process.

Fig. 4.1 Main Energy Sources used by Manufacturing Industries



Source: Author's Field Survey- November, 2006

The chart above depicts the main energy sources being used by the various manufacturing sub-sectors included in the study. The most highly used energy is residual fluid oil (46.67 per cent) whilst the least utilized energy is Liquefied

Petroleum Gas (6.67 per cent). 28.89 per cent of the manufacturing industries interviewed use Diesel while the remaining 17.78per cent uses Electricity. However, there were instances where some industries (5 industries) use the LPG as back up fuel.

Most of the industries (91.1 per cent) use the energy for process heating, 4.4 per cent for process drying and the remaining 4.4 per cent for machine drive. 95.2 per cent of the industries that use RFO as main fuel use it to generate heat while the rest of the 4.8 per cent is for process drying. According to the survey results, (100 per cent of the industries that use) diesel is mostly used for process heating. 66.7 per cent of the industries that use LPG as main fuel are for process heating while 33.3 per cent is for process drying. However, the industries that use LPG as substitute fuels or alternative fuels use it to drive machines, start ignition in addition to the process heating and drying.

Reasons assigned for the choice of a particular energy included the design of their boilers and furnaces (40 per cent), its comparatively low price (33.3 per cent) and the readily availability of the fuel (26.7 per cent). The distribution is as shown in table 4.5.

Table 4.5 Reasons for choice of main Fuel[a]

% within Main fuels used by Manufacturers

		Reason for choice of fuel			
		Cheapest Fuel (%)	Readily available fuel (%)	Furnances & Boilers can only use this fuel (%)	Total (%)
Main fuels identified	Diesel		46.2	53.8	100.0
	RFO	71.4	14.3	14.3	100.0
	Electricity		37.5	62.5	100.0
	LPG			100.0	100.0
Total		33.3	26.7	40.0	100.0

a. Source: Author's Field Survey- November, 2006

Test shows that most industries (40 per cent) choose fuel on the basis of the design of their equipment and for that matter the purpose for which the fuel is required for. However, another factor which they (33.3 per cent) take into consideration is the cost of the fuel and then the availability of the fuel (26.7). Test to show if there is any relationship between fuel type and reason for choice of a particular fuel showed a high significance level of $p < 0.001$ (Refer to appendix 7d). Among the petroleum products used by the manufacturers, RFO appears to be the cheapest; this is followed by LPG and diesel. Although LPG and electricity appears to be cost competitive, the relative stability of electricity prices makes it a preferred option for many manufacturers.

A chi-square performed to test whether there is any significant relationship between fuel type used by industries and uses of these industries gave a $X^2 = 16.398$, df=6 and p- value of 0.012. This implies the choice of fuels is also influenced by its use by the manufacturer. (Refer to appendix 7e). Results from a chi-square test reveal that the size of manufacturing industry and location of these industries did not influence the choice of a particular fuel as main energy source. All $p>0.05$. However, there was a very weak relationship ($p= 0.045$) between manufacturing sub-sector and choice of main fuel.

4.2.2. Distribution of Gas users across the various manufacturing Industries

LP Gas is in its natural gaseous form under normal atmospheric pressure. It becomes liquid under moderate pressure, a state more compact than that of its gas form. Stored in sturdy tanks, LP Gas is a compact liquid that is highly portable and can be used wherever clean-burning fuel is needed. This property of LP Gas enables its use in diverse locations, sizes and nature of operations.

Of the eight industries identified to be using LPG as their main fuel, 12.5 per cent are in the food and beverage industry, another 12.5 per cent belong to the chemical industry, 25.0 per cent in the textile industry, 37.5 per cent in the metal industry and the remaining 12.5 per cent in the paper and petroleum industry. This results show that as small as users are, LPG users are found in almost all the manufacturing sub-sectors. A chi-square test indicates that there is no association between manufacturing sectors and LPG utilization- an indication that LPG is used in almost all the sectors of the manufacturing industry (Refer to appendix 7i. LPG is used in many applications in the industrial sector namely: drying, heating, catering, ceramic production, powering industrial ovens, kilns and furnaces as well as in powering forklift trucks in warehouses. Many industrial forklifts are LP-gas powered because LP gas provides enough power to do heavy lifting while generating reduced fumes and pollutants in confined warehouse spaces. Process use, most of it in the form of process heating, accounted for more manufacturing consumption of LP gas than any other application.

Generally, 87.5 per cent (7) of all the industries using the gas are large sized companies with only 12.5 per cent (1) being small sized companies. Within the large sized industries, 65 per cent of the respondents were not using the gas while the remaining 35 per cent were using the gas. None of the medium sized industries was using the gas. However, one representing 12.5 per cent of the small sized industries were identified as using the gas. The distribution is as shown in the table below.

Table 4.6 Distribution of LP Gas Consumers according to Size of Industries

% within Users of LPG

		Users of LPG		
		Non-LPG Users (%)	LPG Users (%)	Total (%)
Size of Industries	Large Sized Companies	35.1	87.5	44.4
	Medium Sized Companies	40.5		33.3
	Small Sized Companies	24.3	12.5	22.2
Total		100.0	100.0	100.0

a. Source: Author's Field Survey- November, 2006

Pearson chi-square (X^2=7.715, df=2, p=0.021) shows that size of industry and use of the gas are dependent of each other. Industrial consumers i.e. manufacturing plants, require bulk tank installations and vaporizers to meet higher delivery rates and consumption. Bulk tank installations come as a more practical option than installing a huge number of commercial cylinders especially when storage space and area is a major consideration for the consumer. For bulk installation, LPG is delivered to the consumer in bulk by tank trucks. Initial cost of these bulk installations and vaporizers are very high and thus has prevented many medium and small sized industries from the use of the gas which is stored in the bulk tank. Also, large areas are required for setting up of the bulk tanks; hence industries with relatively small compounds have found it inconvenient.

Table 4.7 Location of industries that use Gas

% within Users of LPG

		Location of industry			
		Light Industrial Area (%)	Heavy Industrial Area (%)	Outside (%)	Total (%)
Users of LPG	Non-LPG Users	32.4	45.9	21.6	100.0
	LPG Users		100.0		100.0
Total		26.7	55.6	17.8	100.0

a. Source: Author's Field Survey-November, 2006

As shown in the table above, all the industries that use Gas are located in the heavy industrial area. A chi-square test(X^2=7.784, df=2, p=.02 shows that there appears to be a relationship between the use of the Gas and location of industries. The likelihood of using the gas declines with distance. This is an indication that the differences in use or non use of LPG are not due to chance variation which implies that industries that use LPG or do not use LPG and location of these industries are interdependent. It is well known that LP Gas has no transportation limitations. That is, LP Gas can be readily transported by tankers without the need to uneconomically extend pipelines to new geographical regions at an additional cost to the tax payer. Unfortunately, due to transportation costs, customers farthest from the major supply sources were identified not to be using the gas since it adds additional cost to their production cost, hence reducing their profit margin. All the industries that use the gas are sited near TOR, the production site. This will reduce the cost of transportation.

4.3 Environmental Considerations

This section takes a look at CO_2 as emission being generated as a result of energy use in the United Kingdom. In the UK Government's Standard Assessment Procedure (SAP) for Energy Rating for Dwellings (2005 edition) the following information is given.

Table 4.8: Alternative fuels CO_2 Emissions

Fuel	Emissions Kg CO_2 per KWh
LPG	0.234
Oil	0.265
Smokeless Solid Fuel	0.392
Electricity	0.422

Source: UK LP Gas Association 2006 Energy Review

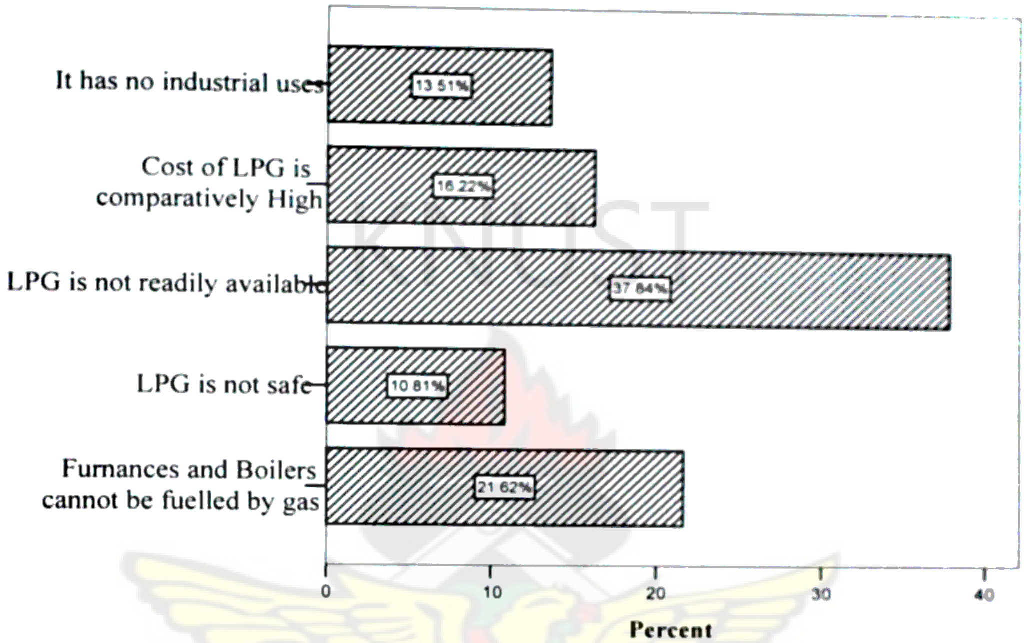
Emissions from energy production and consumption play a major role in air pollution. From table 4.8, it can be shown that the contribution of LPG to global greenhouse gas emission is relatively small. It can be calculated that these fuels emit more CO_2 percent than LPG, as follows oil emits 13.2 per cent more CO_2 than LPG, smokeless solid fuel emits 67 per cent more CO_2 than LPG and electricity emits 80 per cent more CO_2 than LPG.

Though the figures shown are that of the United Kingdom, distances that pollutant gases travel means that pollution is an international problem. Because energy use patterns translate into greenhouse gas emissions, the industrial sector stands as one of the country's environmental culprits. Hence greater LPG use means projected reduction in carbon dioxide emissions. It is becoming clear that efforts to reduce GHG emissions must increase conversion to lower-carbon energy sources.

4.4 Reasons for Non-Utilization of LP Gas

LP Gas has demonstrated health and environmental benefits compared to other conventional fuels, but the rationale for using LP Gas-fired units have met serious challenges especially in the industrial sector. Respondents outlined some of the reasons for non-use of the gas as unavailability of the gas, inability of their furnaces and boilers to be fuelled by the gas, comparatively high cost of the gas and the fear of the gas catching fire (safety issues). The distribution is as shown in the graph below:

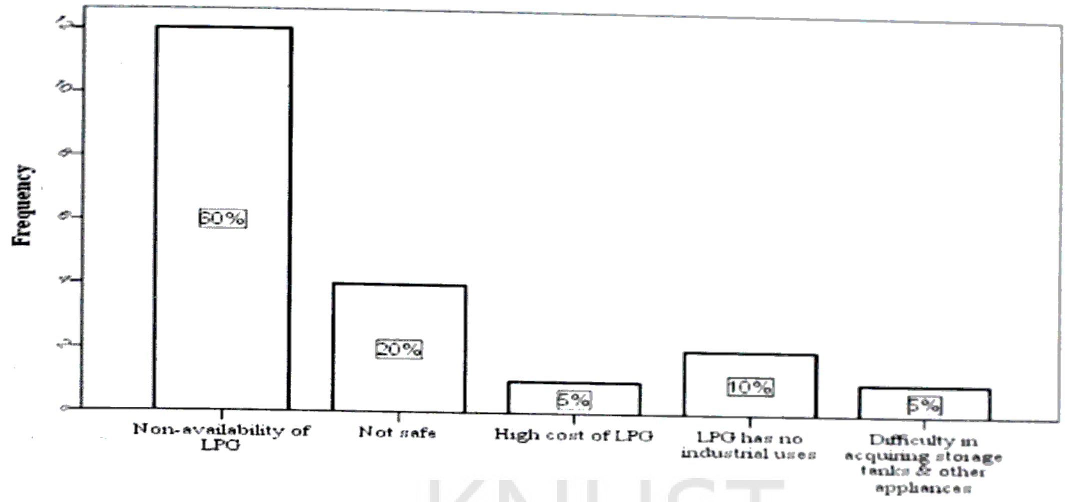
Fig. 4.2 Reasons for non- use of LP Gas



Source: Author's Field Survey-November, 2006

There are many factors that influence an industry, firm or plant's ability to adapt to a particular fuel. Thus the underutilization of LP Gas is not confined to just one constraint. Thus for example, the readily availability of the LP Gas alone, might not ensure high utilization of the fuel. A mixture of constraints will have to be tackled to ensure high utilization of the fuel.

Fig. 4.2b OMCs perspectives on critical problems in using LPG as Industrial fuel



Source: Author's Field Survey, 2006

4.4.1 Lack of awareness of its applications

A key obstacle to the widespread utilization of LP Gas in the industrial sector is that most people are unaware of its applications in this sector. Evidence from the study suggests (Fig. 4.2a) that as much as 13.6 per cent of manufacturers were unaware of the industrial applications of the LP Gas. Ten per cent of the OMCs were also unaware of the industrial applications of LPG. This has resulted in widespread underutilization of LPG as fuel for industries. LP Gas is perceived as fuel for cooking.

Even amongst decision-makers and some government employees, there is lack of awareness of the potential benefits to the manufacturer and technologies of installation of bulk tanks. Thus industrial consumption of the LP Gas in this sector is unheard of to many of the interviewees. This lack of awareness is severely limiting the utilization of LP Gas in this sector that can enhance productivity and reduce the use of more polluting sources of energy.

Some studies have revealed that knowledge about energy issues plays a central role in influencing attitudes to energy technologies. A London survey on microgeneration technologies showed how the lack of knowledge about costs prevented people from considering the installation of micro generation technologies in their dwellings. As argued by Sharckley et al (2004), who in particular refer to carbon storage and sequestration technology, major difficulties arise when presenting technical issues which are remote from people's everyday experience and for which people have no immediate reference point.

While such problems do arise with any new technology or industry, this problem coupled with unwillingness of policymakers to acknowledge this fuel is not just for the household, deters many potential users from considering the use of LP Gas as industrial fuel.

4.4.2 Safety Concerns

One of the obstacles to gas use, is safety or at least, the perception that people have towards the safety of working with the gas (refer to fig.4.3.2). The respondents' knowledge of LP Gas is poor as demonstrated by perceptions of safety. Twenty per cent and 10.8 per cent of OMCs and manufacturers respectively were of the opinion that LPG is not safe for industrial applications. These perceptions are contributing to public opposition to industrial usage of LP Gas and jeopardizing the ability to increase consumption in this sector. This very important finding makes gas safety very important.

Analysis reveals three main hazards with different degrees of restrictions, for instance pure LP Gas is odourless and invisible, distinctive odour is usually added to warn of its presence. Escape of LP Gas may be noticeable by smell. In one case, when the liquid evaporates, the cooling effect on the surrounding air causes condensation and even freezing of water vapour in the air. This effect may show itself as frost at the point of escape and thus make it easier to detect an escape of LPG. Efforts have been made to communicate the hazards to stakeholders in the LP Gas industry together with information on precautionary measures.

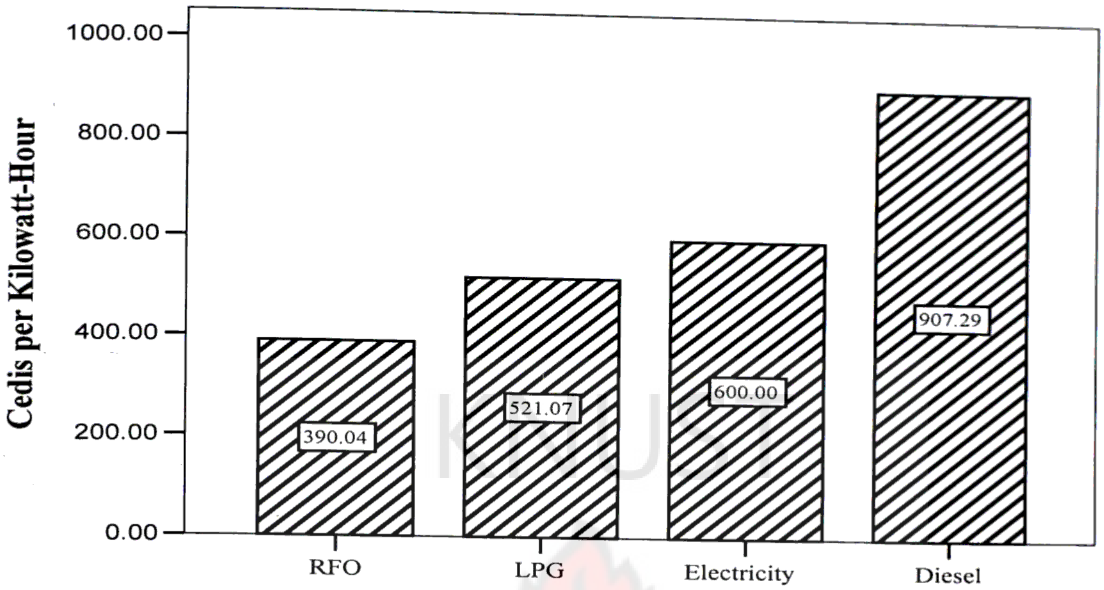
Ninety per cent of the OMCs interviewed indicated that no major accidents have occurred at their workplace as a result of the LPG. However, 10 per cent have experienced fire outbreak from the leakage of the gas. Some interviewees outlined some precautions in place that are applied to common hazards as the presence of fire extinguishers or protection equipment at the workplace, routine checks on appliances, safe storage of the gas in bulks and cylinders.

Gathering information from the suppliers or OMCs, some safety systems and procedures put in place include daily inspection of terminals, regular checks of tankers to ensure vehicles and LP Gas systems are working correctly, regular site inspection and operation of the automatic shutdown and alarm to emergency services, training of drivers and employees on safety and operation. Studies reveal that even though these accidents were unlikely to occur, the probability of occurrence increases during the transfer of the product; this therefore means that trained and competent personnel should be present during this transfer for prompt action in emergency situations. Also, visitors and employees have been advised not to smoke or use matches or lighters at the workplace; a measure referred to by all respondents.

LP Gas can be dangerous if not correctly installed, maintained and used. If these three factors are properly attended to then it is a safe, clean and efficient energy service (Steward, 2004). "LPG is a very safe fuel. But as with any energy source, there are steps to take to further ensure safety" (WLPGA, undated).

4.4.3 LP Gas Prices

Fig. 4.3 :Cost per Kilowatt-Hour of Different Energy Sources

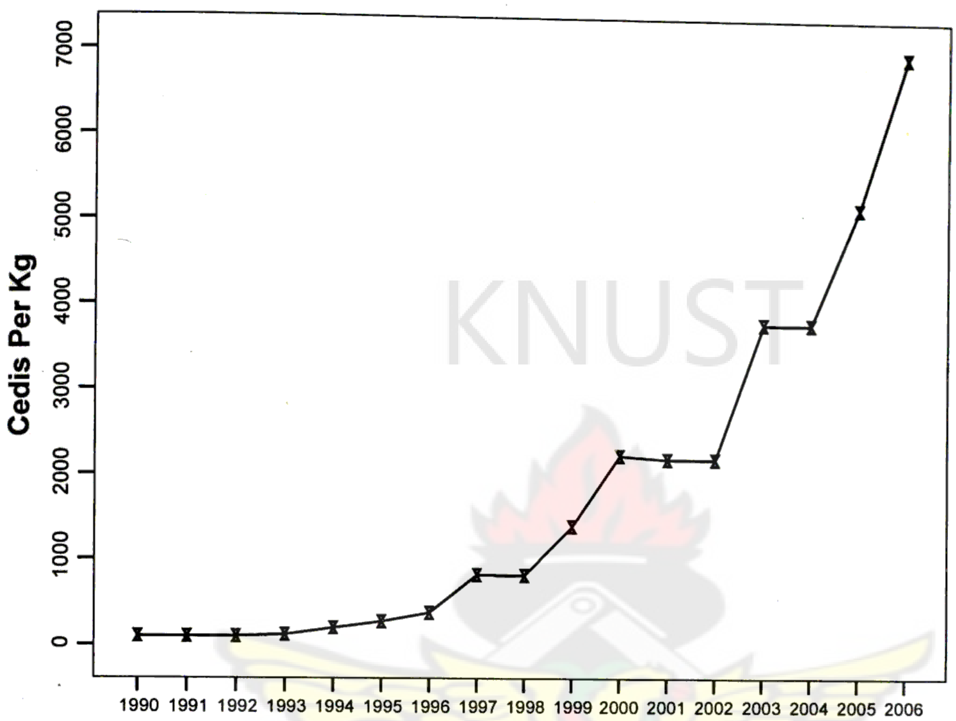


Source: Author's Field Survey- May, 2007

Assuming all the energy resources are used to generate electricity in the manufacturing industries, the cost of the unit cost of the various energy sources used by the manufacturer is as shown in figure 4.3. The most expensive fuel used by the industries is diesel (907.29 cedi per kilowatt-hour). This is then followed by hydroelectricity (600.00 cedis per kilowatt-hour), LPG (521.07 cedi per kilowatt-hour) and RFO which is 390.04 (cedi per kilowatt- hour). From the graph, diesel is almost twice the price of the gas. Also, electricity appears to be more expensive than the gas. Despite the cost advantage of LP Gas over electricity and diesel, studies (figure 4.1) show that the preference for the diesel (28.89 per cent) and electricity (17.78 per cent) exceeds that of the gas (6.67 per cent). The question then is if cost is to influence the behaviour of the manufacturers, why then will they choose hydro electricity and diesel over LP Gas?

However, such direct cost comparisons ignore the issue of price volatility. LPG is subject to international price trends which fluctuate on a monthly basis, but overall have been trending upwards (Appendix 6).

Fig. 4.4 LP Gas Prices per Kilogramme (1990-2006)



Source: Author's Field Survey- May, 2007

Estimated LPG Prices as at December of each year

The price of LPG changed over four times within 2006 alone (Refer to appendix 6). Within this period, LPG price increased over 36 percent with the highest price of 7586 cedi occurring in June, 2006. However, the price dipped by about 8 percent to its current price of 6965.52 cedi as at September 2006. Thus, there is high price volatility with respect to the gas. This price volatility results in uncertainty about the gas price levels that influence investment planning. Uncertainty is the enemy of planned, rational and forward looking investment in any industry. Business firms, energy and non-energy intensive, make investment decisions based on expectations about prices. If decisions are made on the expectation of low (or high) energy prices, and the energy market varies sharply from these expectations, firms may make inappropriate investment and business decisions. This uncertainty has a number of potential implications for firms. For example it might cause them to invest in different types of equipment than they might otherwise (Henning et al, 2003). Even those firms that expect volatility may be adversely affected by simply putting off a decision until the market is more stable. The economy would most likely perform better with stable or predictable energy prices, than when the price of energy fluctuates greatly.

This contrasts with electricity, generated domestically from hydro power and hence is widely regulated. Consumers can thus be confident that electricity prices will remain stable and increase, if at all, in a predictable and modest way. For electricity, the key point is one of stability: electricity prices are largely unchanged over a long period, partially due to it being highly domestically generated and hence, regulated. In these circumstances it is unsurprising if these price movements have given rise to consumers' dissatisfaction with the price of LPG they purchase. It is therefore a significant omission to seek to interpret levels of consumer dissatisfaction with the cost of LPG alone, without taking account of the context of prices volatility.

The high cost and high volatility of LP gas prices has been a great concern for some industrial consumers (6.22 per cent). Lower profitability due to high gas prices might force some industrial units to burn other fuels, such as fuel oil. Higher prices in gas usually cut down industrial usage especially when fuel cost forms a larger percentage of production cost. Essentially, if prices go high enough, a significant portion of the industrial usage (the most price-sensitive class) will be driven out of the market.

The end product of volatile and soaring energy prices will be inflationary pressures that continue to challenge the country's business as they struggle to the new economic conditions. The rising prices for LP Gas will result in increase in input costs for many businesses, both large and small. Since energy is a key input in the production process, businesses face sharp increases per unit in their goods and services (Velázquez, 2006). Establishments' revenues are likely to be impacted in the face of high gas prices. They must shift more of their revenues to cover expenses. This action will decrease their profitability, result in job losses and reduce the competitiveness of their industries. Facing an increasingly unequal playing field, the extreme volatility of LP Gas prices will only create larger financial burdens.

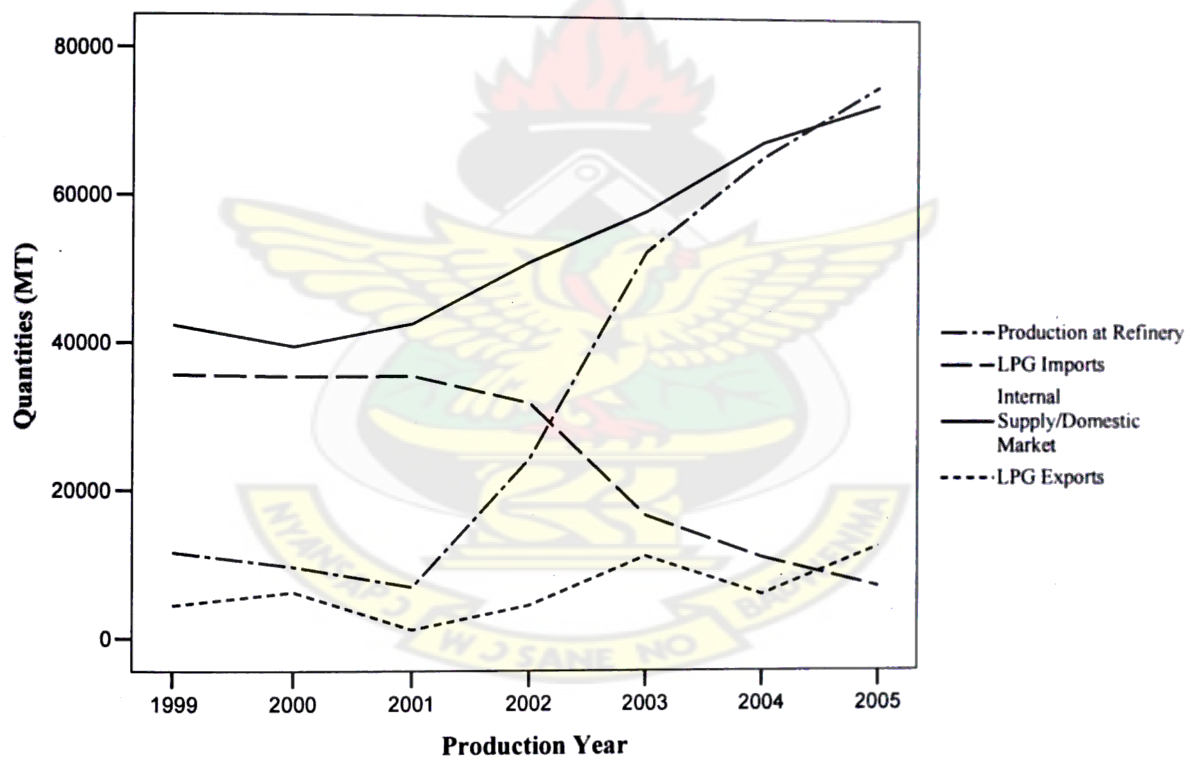
Another aspect of the problems of LPG relative to other fuels is that manufacturers must maintain large storage tanks. This can prove to be an added expense beyond the price of the fuel. Appliance installation costs will also have an effect on the total costs. Consumers when purchasing an appliance will often put upfront purchasing and installation costs ahead of ongoing running costs in their decision making, and this may be particularly so for small sized industries. This has implications for energy affordability impacting on production cost due to higher running costs resulting from either choice of fuel, and/or efficiency of the appliance. Examination of fuel-switching capability of natural gas in 2002 by value of shipments categories and employment size show that the ability to switch increases on average from smaller to larger establishments. Thus, fuel switching capability out of natural gas seems to correlate with size, regardless of industry (EIA, 2006). This is in consistent with the result of the study where almost all the industries that were found to be using the LPG were large sized companies.

4.4.4 Availability of LP Gas

Thirty eight per cent of manufacturers attributed their inability or unwillingness to use the gas to unavailability of the fuel or uncertainty in the supply of the gas. This fear was confirmed by the OMCs where as much as 60 per cent of them identify the availability of the fuel as a major problem to its use in this sector. This confirms Africa Gas Initiative Report that, LPG demand in most Africa countries is driven by supply constraints. This is because the refinery, the only source for domestic supply production is limited by the refinery's size and LPG production from refinery has proved largely insufficient to meet growing demand and has more often than not been complemented by imports through inadequate, costly transported and storage facilities.

From 2003 to 2005, production of LPG from the refinery has more than doubled the year 2002 production figures with imports reduced to about only a quarter of the year 2002 figures. The rise in plant output is also attributed to the installation of the RFCC plant. With the RFCC in place TOR is able to extract more value added products like LPG. It is observed that the yearly consumption of LPG has increased significantly from levels 42,363 Metric Tonnes in 1999 to 72,768 Metric Tonnes in 2005. Demand is therefore seen to have almost doubled over this period. As illustrated in figure 4.5, total domestic sales of LP Gas have increased by 84.33 percent comparing 2000 and 2005 figures. The domestic demand of LP Gas is met by both import and plant production from the refinery of crude oil at TOR. From figure 4.5, import of LPG is seen to have played a key role in meeting domestic demand at the initial stage of introduction of the gas into the country. Between 1999 and 2002, imports of LPG were greater than plant production (Production at the Refinery). Until 2002, over 70 percent of LPG used in the country was imported. This means more of the country's foreign exchange was spent on the imports of the LP Gas. The reduction in imports of LPG from 2002 onwards is due to the installation of Residual Fluid Catalytic Cracking Unit (RFCC), which adds value to the otherwise low Straight Run Fuel Oil (SRFO). The high import dependence poses a severe burden on the country's foreign exchange earnings and a concern for security of energy supply. About one third of the export earnings of the country are spent on importing crude oil and petroleum products, which is equivalent to about 10 per cent of the GDP (GSS, 2001; UN-energy, 2006).

Fig. 4.5 LPG Production, Imports, Exports and Internal Supply



Source: Author's Field Survey (Prepared on the Basis of TOR Energy Balances (1999-2005)

There is inadequate refining capacity in the country to meet the national LPG requirement as shown in the Figure 4.5 where import has supplemented internal demand. Generally LPG supply to households is characterized by frequent shortages and long queues in retail outlets. The inability of the capacity of the refinery to meet consumption requirements constitutes a major constraint to the supply of LPG and poses problem of assuring reliability of supply of LPG to industrial consumers in particular and the national consumption as a whole.

The inadequacy of existing bulk storage infrastructure to meet the growth in demand reduces the possibilities to bring the product close to industrial consumers. Current limited storage capacity at the refinery continues to constrain local consumption as well as export (T & M Business Link, 2006). Clearly if LPG is to be a practical option then there must be an adequate network of supply depots so that industry operators can be confident that they will have ready access to refuel without significant inconvenience to their operations.

Shift of the industrial consumers to the use of the LP Gas will result in increasing imbalance between LPG consumption and domestic production, which will result in growing importation of the LP Gas. The dependence on fossil fuels has created a wide variety of problems for non-oil producing developing countries, as well as for some industrialized countries and economies in transition (Reddy et al, 1997). However, because LPG is derived from petroleum refining, utilization by industries will do little to diminish our dependence on these fuels.

4.4.5 Technical Considerations of Furnaces and Boilers

Interviews with industrialists illustrated that while prices, supply certainties, and environmental issues were important motivators of behavior change, design of furnaces and boilers is what ultimately facilitate or prevent participation in the use of gas. 21.62 per cent of respondents attributed their inability to use the gas to the design of their furnaces and boilers. In industries, existing energy-intensive equipment such as furnaces, kilns and boilers have long lifelines and require substantial amounts of capital to replace, which slows the rate of investment in a more energy-efficient technologies. Consistent with the observations of IFC (2007), if firms have made a substantial investment in equipment that has a long service life, they are likely to continue using such equipment until the end of its useful life before replacing it with a more energy-efficient technology. Such barriers are exacerbated when industry production is already at risk due to global competition and other economic conditions. This is the case for many industries addressed in this study.

An examination of the relationship between the use or non use of LPG and constraints identified yielded the following results:

Table 4.9 Examination of Constraints identified by Industries to the Utilization of LP Gas

% within Users of LPG

		Major contraints to LPG use in the manufacturing			
		Non-availability (%)	High Rises in LPG Prices (%)	Conversion of Furnances and Boilers to gas fuelled appliance (%)	Total (%)
Users of LPG	Non-LPG Users	59.5	10.8	29.7	100.0
	LPG Users	62.5		37.5	100.0
Total		60.0	8.9	31.1	100.0

a. Source: Author's Field Survey-November, 2006

When industries were grouped into non-users and users, highest number of respondents in both groups identified unavailability of the fuel as a major constraint- 59.5 and 62.5 per cent respectively. Non availability of LPG appears to be the most critical constraint faced by both groups. 37.5 per cent of users and 29.7 per cent of the non-users mentioned the conversion of their furnaces and boilers as a major constraint. Comparatively high prices of LPG appear to be the least constraint mentioned by both groups. However, none of the gas users saw price of the fuel as a major constraint. In the case of the non-LP Gas users, 10.8 per cent saw the price of the fuel as a major constraint. The asymptotic significance of the chi-square statistics is far greater than 0.05. This is an indication that the differences in use or non use of LPG are due to chance variation. Thus an industry that use LPG or do not use LPG faces the same constraints when it comes to the gas utilization. There is no relationship between the consumption of LPG and constraints to LPG use.

A chi-square test to test if location of an industry, size of an industry, type of manufacturing sub-sector or the applications of the fuel has any effect on the constraints identified gave all p> 0.05 with the exception of the size industries which has a p-value of 0.023. Thus constraints identified correlate with size regardless of industry and location of the industries. The distribution is as shown in table 4.10.

Gas use requires larger investments. This has deterred some industries, mostly small and medium sized industries and made them opt for easier, smaller investments projects using electricity and oil. This helps explain why most small industries were not using the gas.

Table 4.10 Relationship between the Size of Manufacturing Industries and Major Constraints identified

% within Major contraints to LPG use in the manufacturing

		Size of Manufacturing Industries			
		Large Sized Companies	Medium Sized Companies	Small Sized Companies	Total
Major contraints to LPG use in the manufacturing	Non-availability	55.6	18.5	25.9	100.0
	High Rises in LPG Prices		100.0		100.0
	Conversion of Furnances and Boilers to gas fuelled appliance	35.7	42.9	21.4	100.0
Total		44.4	33.3	22.2	100.0

a. Source: Author's Field Survey- November, 2006

Majority of industries (55.6 per cent) who attributed their inability to use the gas to unavailability of the fuel were large sized companies. Price hikes were of least concern to these large sized industries. Interestingly, none of the small sized industries attributed their inability to use the gas to price hikes. Rather they attributed it to unavailability of the gas and the design of their equipment. Greater portion of the respondents who identified the design of their boilers and furnaces as constraint were medium sized companies.

4.4.6 Policy Considerations

The main driving force for the introduction of LP Gas into the Ghanaian economy was the concern for the household sector which where solely dependent on biomass (firewood, charcoal and crop residue). The potential in market share of LP Gas, which was by then flared at the refinery, would not be limited by supply. Thus, the potential of LP Gas for improving security of energy supply and reducing greenhouse gas emissions was evident under the same conditions as other recognized alternative fuels. Promoting gas consumption for industrial use was not a priority for the government at the time. Much of government policies had placed emphasis on domestic or residential consumption of the fuel to the neglect of the other sectors, most especially the industrial sector. Thus agencies responsible for formulating, coordinating, implementation and monitoring energy policies have focused solely on residential use of LP Gas. Thus until recently, LP Gas has only been perceived by many as only good for the household.

Government may well have their constraints on implementing stricter policy for LP Gas as household fuel. Understandably, government was faced with supply constraints. LP Gas produced at the refinery could only meet the needs of the household sector. Extending its use beyond this sector will mean increased importation of crude oil and its subsequent adverse effect on the economy. In addition, LP Gas being imported into the country was until recently, highly subsidized, a rise in oil prices poses a heavy financial burden on the Government. Thus, increased importation in the face of subsidization would limit the opportunities of public spending and diverts funds away from infrastructure development and poverty reduction projects.

4.5.0 Linkage between LP Gas users and potential Natural Gas users

Apparently, there is a strong relationship($X^2 = 11.32$, df=1, $p<1$) between LPG consumers and potential natural gas users. Of the 37 establishments identified not to be using the LPG at the moment, 35 indicated they do not intend to be users of the natural gas just a year after it comes into operation. The remaining two indicated their willingness to use the natural gas just a year after it comes into operation. In the case of those using LPG at the moment, the number broke even with 4 indicating their readiness to use the natural gas just a year after it comes into operation with the other four stating that they are not yet ready to use the natural gas. Respondents were further asked about the use of the gas in the next five years. Result shows that 97.7 per cent of the respondents saw themselves as users of the natural gas in the next five years.

The combustion processes that use LPG are very similar to those that use natural gas. Use of LPG in industrial applications may require a vaporizer to provide the burner with the proper mix of air and fuel. LPG is fired as a primary and backup fuel in industrial boilers and space heating equipment and can be used to generate heat and process steam for industrial facilities and in appliances that typically use natural gas. LPG has been used as a precursor in new areas allowing market development at a lower risk/cost. When/if natural gas becomes available through the establishment of local distribution networks as the economy matures, LP gas is itself usually displaced. LPG is an option in regions of declining natural gas supply (UNECE working paper on gas, 2004).

4.6.1 Manufacturers' priorities on energy options

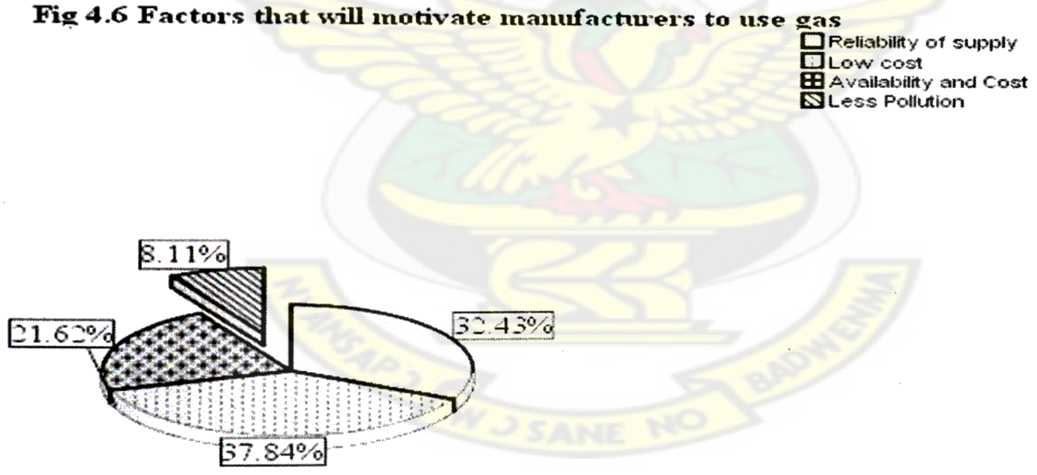
Knowing factors that affect consumer decisions on energy-related purchases and lifestyle behaviours can increase the accuracy of market-penetration estimates and aid in modeling the potential for energy technologies. And whether the nations' energy institutions are linked in the public mind with environmental problems is important information for policy makers seeking to make decisions that accurately reflect the public will (Farhar, 1993).

The research also attempted to investigate priorities on energy options. Respondents outlined a variety of factors that will motivate their choice of gas as fuel for production. Of key importance were gas prices, followed by reliability of fuel supply and then environmental concerns. Thirty eight per cent of the establishments will chose to use gas if the price is comparatively less expensive, 32.4 per cent will use the gas if supply becomes reliable. Energy investments can be very risky; as such investors prefer places where the uncertainties are minimized (RCEER, 2006). Both energy and non-energy intensive firms make investment decisions based on expectations about prices. Rising energy costs and greater volatility in energy prices can have a negative effect on industries. Hence, it is not surprising most of the industries identified price of the gas as major factor to the deployment of the gas.

Twenty two per cent answered that they will use the gas taken into consideration its reliability of supply and advantageous price.

However, 8.1 per cent stated that they will choose to use the gas because of its environmental benefits. Environmental concern among respondents is relatively small. Apparently it is not one of the topmost concerns. The most important concerns are the cost of the gas, followed by the availability of the gas. The proportion favouring environmental protection over adequate gas supplies and cost of the gas is 8.7 per cent. 21.6 per cent of respondents believe that adequate supply and lower prices go together. Despite recent high concern for the environment, majority of manufacturers value high costs of the gas (37.8 per cent) and reliability of gas supply (32.4 per cent) over efforts to conserve the environment. Support for low gas price and adequate gas supply show that manufacturers place less emphasis on protecting the environment.

Fig 4.6 Factors that will motivate manufacturers to use gas



Source: Author's Field Survey-November, 2006

Table 5.0 Crosstabulation of Main fuels other than gas and Factors that will motivate manuafcturers to Use Gas

Count

		Factors that will motivate manuafcturers to Use Gas				
		Reliability of supply	Low cost	Availability and Cost	Less Pollution	Total
Main fuels used by Manufacturers	Diesel	7	3	0	0	10
	RFO	4	10	3	3	20
	Electricity	1	1	5	0	7
Total		12	14	8	3	37

a. Source: Authour's Field Survey-November, 2006

Reducing the cost of energy required to run their business was the primary motivator of behavioral change regarding energy use for interview respondents. Conservation and environmental protection were considerations in decisions about energy use for a few respondents. Interestingly, those who spoke most forcefully about environmental impacts use RFO as their best available option, despite their misgivings about emissions and fuel consumption. Several respondents are now using RFO in their regular day-to-day operations. While cost is the primary motivator, a few respondents related that the implications of RFO use are more complex than simple economic savings.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

It is important to promote diversity as a long-term safeguard against over-dependence on any particular energy source. Poor energy supply results in high cost of doing business, making products uncompetitive in the global market, inability of manufacturers to meet deadlines, and low levels of plant's output. These adversely affect every economy and results in loss of income and employment. Thus there is the need to develop other alternatives to the country's energy sources.

All over the world, attention is being focused on the use of gas as the fuel for the century and Ghana is no exemption. Efforts are well underway to transport natural gas through a pipeline known as the West Africa Gas Pipeline (WAGP). WAGP will transport Natural Gas from Nigeria to Benin, Ghana and Togo. Meanwhile, there exist another gas, LP Gas already in the country but enjoys very little popularity as industrial fuel. In spite of the benefits LPG can bring to the industrial sector, in particular for those activities which require clean, easy to control fuel, such as the food industry, glass and ceramics, drying of textiles etc., LPG remains mostly a household energy. The amount used in the industrial sector is small to the point of being insignificant.

This paper raises some of the issues that surround the question, "Why is LP Gas not used as industrial fuel although it has industrial applications?" The researcher examines issues with respect to availability of the LP Gas, the price of the LP Gas, environment and safety issues of the LP Gas. Because studying an issue from different perspectives often sheds new insights into a problem and serves as a means of cross checking results, the problem was analyzed using data sets from different stakeholders using different research designs and strategies.

The researcher finds a wide range of factors, suggesting that there are many factors that influence an industry, firm or plant's ability to adapt to a particular fuel. The study suggests that problems of LP Gas utilization are thus not confined to just one constraint, although the mixture of constraints that the firms face will vary from one plant/industry to another.

The study reveals the under listed points as some of the major factors hindering LP Gas use in the country:

I. Low level of awareness

There is lack of LPG potential benefits to the industries and technologies of installation of bulk tanks. Industrial consumption of LPG in this sector is unheard of to many of the respondents.

II. Insufficient policy and institutional Framework

Clearly, there is no policy or institutional framework on LPG utilization by industries. Much of government or regulatory policies emphasis has been placed on domestic/ residential LPG consumption to the neglect of the other sectors, most especially the industrial sector. Agencies responsible for formulating, coordinating, implementing and monitoring energy policies have focused solely on residential consumption of LPG.

III. Supply Constraints

LPG consumption in the industrial sector has remained idle in this sector because of supply constraints at the production level. Supply of LPG in the country has been characterized by intermittent shortage due to capacity of refinery and inadequacy of the existing bulk storage infrastructure to meet demand. Thus for industrial consumers, who require higher delivery rates and consumption inadequate supply will pose much burden to its energy security.

IV. Cost of initial installation

For industrial consumers (manufacturing plants), they require bulk tank installations and vaporizers to meet higher delivery rates and consumption. Initial cost of bulk tank installations is very high and thus has prevented many small and medium sized industries from using it.

V. Volatile LPG Prices

High volatility of LPG prices has hindered many industries from using the LPG. These fluctuations in LPG prices will adversely affects the production cost of manufacturers and hence affects its ability to compete on the international markets and its profit margin. Firms take decisions on energy based on their expectations on fuel prices, reliability of fuel supply and to some extent environmental issues.

Evidence also suggests that there are gains to be made in the industrial utilization of LP Gas. Some of the potential benefits include: LPG can be stored, transported and used virtually anywhere in the country. It does not require gridlines; LPG burns cleanly without smoke or residual particulate matter, thus avoiding the serious health hazards other fuel might cause to the health of the workers; LPG burns cleanly and appliances require less maintenance; Manufacturing plants running on LPG produce much less carbon dioxide than the other conventional fuels. But it is not clear whether environmental and safety benefits alone give the manufacturer enough incentive to use LP Gas.

Agreeably, it is less secure, compared to most industrial fuels and will only add to increase the country's dependence on imports from unstable sources. Nevertheless, LP Gas projects should not only focus on household, but also on industries most especially, industries that may not have access to the natural gas because of accessibility. The use of LPG would improve the country's energy mix and minimize its dependence on RFO and other polluting fuels. LP Gas should play a role in industrial fuel in Ghana because it is superior to most conventional fuels with respect to public environmental impact and public health. Government support for the use of the LP Gas should be based on the beneficial environmental impact of LPG as compared to alternative fuels.

5.2 Recommendations

These recommendations take into account the factors for underutilization of LPG by manufacturers and the potential benefits to be derived from its utilization as a nation. Accordingly, it is recommended that attention should be focused on the following specific areas:

5.2.1 Short Term Recommendations

- **Encourage Scientific Research on Industrial Energy Consumption**

This study is the first attempt to provide reliable and meaningful information as to why there is almost insignificant penetration of LP Gas use in the industrial sector and the potential benefits to be derived from its consumption in this sector. This study needs to be followed by more work, as further improvements are possible. Future studies could be more meaningful for the benefits of all if sensitivity and confidentiality issues could be overcome to allow for more detailed, complete, reliable and open database to be developed. The methodology used here, which is constrained by sample size and data limitations, can be improved.

In this frame, it is recommended that Government should support scientific research in the field of LPG utilization in the other sectors of the economy, making results available to the public through the various communication channels. It is recommended that cost-benefit analysis regarding the use of LPG in industry should be conducted. Would industrial utilization of LPG have a significant impact on households? Policy makers, OMCs, industrialists and other stakeholders should make a concerted parallel effort to improve the quality and availability of the manufacturing industry energy consumption data. Lessons drawn will be useful Governments, industrialists and others to improve upon forecasting of gas utilization in the industrial sector and provide realistic bases for target setting and effective regulation.

- **Awareness Creation**

This study has brought to bear the limited knowledge of the industrial applications among Ghanaian consumers. Public awareness is instrumental to help convince the public of the benefits of LP Gas. Awareness programmes also have an important role in promoting cleaner fuels, by highlighting the dreadful effects of air pollution on the environment in general and specifically the adverse sequence on human health. Furthermore, awareness creation has a major role of facilitating the issuing, adoption and implementation of regulations and legislations to ban polluting fuels. Educational campaigns should be carried out to ensure that people become aware of the industrial applications of LP Gas and also ensure that environmental, health and safety regulations are observed. Government should allocate funds to develop awareness campaigns in the field of cleaner fuels in general and LP Gas in particular.

- **Promote Environmental Quality**

Fuel combustion contributes much of the Greenhouse Gases that are linked to climate change. Information, data and results of air quality monitoring should be gathered and made available to the public. As noted from other studies, LPG emits less carbon dioxide than diesel and residual fluid oil (RFO). LPG could play a key role in mitigating climate change and other environmental problems related to the combustion of fuels. Based on this, national policy should encourage the use of gas as industrial fuel to mitigate or avoid damage to the environment. The environmental benefits of LP Gas should be highlighted through awareness creation.

- **Concerns about LPG Safety**

Another major constraint to LPG use in the industrial sector is the low priority given to it by manufacturers. This issue is often submerged by the perception that LPG is not safe and it is only good for the household where it is used in small quantities and the hazards are comparatively minimal. Perceptions about safety remain a deterrent to many consumers. Perceptions based on misinformation need to be corrected. Effective codes and standards are needed to ensure that these concerns are addressed in equipment designs, operations and maintenance procedures. It is recommended that where LPG is deployed safety training is particularly important. Government should work in partnership with OMCs and publish information on the safety of LPG.

- **Encourage Diversity in Energy Sources**

A broad concern for many nations is how to encourage fuel diversity in the market place. Fuel diversity is the key to stable energy prices and long-run energy affordability. It is important therefore to promote diversity as a long term safeguard against over dependence on any particular energy source. LPG use in the industrial sector should be promoted in parallel with natural gas to complement conventional sources and other renewables.

Africa has failed so far to exploit the huge natural gas flared off in the Gulf of Guinea region. Billion of cubic feet flared annually for no use. We should aim to curb energy poverty in Africa and pay attention to the considerable potential of the Liquefied Petroleum Gas (LPG). It should be noted that natural gas and LPG are cleaner healthier fuel; Natural gas and LPG can fill the energy gap in our areas and natural gas and LPG can help combating desertification through reducing deforestation in Africa.

There is increasing concern that the availability of natural gas will affect the LP Gas market. However, LP Gas operators could be encouraged to take advantage of natural gas communication campaigns which would educate the public on the benefits of using gas. It is also important to note that because of the cost involved, natural gas pipeline will only be installed in areas like Tema and Takoradi, where construction cost is minimal. This means there are many areas like Kumasi which will not be on the natural gas network for sometime soon and LP Gas is the most suitable in such areas. It is recommended that LPG be considered as part of an integrated energy solution along with other energy carriers for domestic energy needs.

5.2.2 Medium Term Recommendations

- **Revision of Policy**

An important obstacle to the wider use of LP Gas is the fact that energy policy rarely recognizes its advantages, reinforcing the view of LP Gas as a household fuel.

It is recommended that the significant role that LPG can play and should play in meeting the country's energy needs be recognized. Government could take steps ranging from policy statements to legislative measures to extend its use beyond the household. Policy makers need to keep in mind the many areas where LPG can contribute to the objectives of the energy policy. The Policy should allow fuels with distinct advantages to compete fairly with other energy sources in order for their benefits to be fully realized.

- **Creation of conducive investment climate**

Another factor affecting gas utilization is capital availability to efficiently build infrastructure. This challenge can be met by promoting foreign investments. Government could encourage utilization of the gas in the industrial sector through policy and strategies that would make it more accessible in the market. Policy makers are urged to pay special considerations to policy measures that improve investments climate through more favourable legal and regulatory reforms.

Private sector involvement is essential to mobilize resource for the development of the LPG industry and more importantly, alleviate the budgetary burden on the state. It is important that Government device policy measures, provide institutional and other support services to enhance the capacity and capability of the private sector thereby promoting confidence for the private sector or OMCs to invest in physical infrastructure (particularly storage tanks, transportation and distribution equipments). Subsidies on other competing fuels should be removes to allow for level playing fields. This will minimize the issue of the government incurring more dept and encourage private investment in the LPG industry. Private investors should be made to see it as a market opportunity to invest.

- **Infrastructure Development**

Another important reason for the underutilization of LP Gas is its availability. The refinery capacity of the country should be increased. Limited capacity of the refinery has led to frequent shortages. There should be new investments in the refinery capacity, either through expansions at existing sites, or through construction of new facilities. Additional storage will help insulate consumers from economic effects of volatile prices and from temporary supply disruptions.

Industrial consumers should pre-buy LPG at a certain agreed prices and store it. Such price stabilization programmes (advanced purchase and fixed price contracts) will help mitigate the impact of price volatility. Admittedly, they may pay higher or lower prices compared to those who buy the LPG at the market price but would not be subject to price volatility. They would achieve a benefit from the certainty associated with paying a fixed price. Given the clear benefits of enhanced fuel storage, interest groups (governments, retailers, industries etc.) should invest in additional storage facilities.

5.2.3 Long Term Recommendations

- **Regional cooperation and integration in the Energy sector**

African energy policymakers and decision makers should continue to highlight the importance of fostering cooperation among the African countries for the welfare of the African continent. This besides attracting capital for setting up joint projects in the fields of producing and refining crude oil and natural gas, with the view to create an integrated oil and gas industry in Africa.

The uneven distribution of energy resources, the small-size of energy markets and the difficulties for an individual country to mobilize the huge capital investment required for infrastructure is a major constraint to the optimal development of gas projects. Regional cooperation and integration can help in a cost-effective way to enhance the feasibility of large energy projects through realizing economies of scale. This justifies the need for regional energy cooperation and integration across Africa.

Potential growing energy demands and the necessity for regional oil producers to utilize natural gas resources have resulted in the development/planning of cross-border pipelines in Africa. A notable example is the construction of the West Africa Gas Pipeline Project. But this needs to be made operational in order for them to achieve the objectives for which they have been created.

- **Price Volatility**

The global oil situation indicates that oil prices are now on a higher level and higher oil prices have certain negative impacts on poor oil importing African countries. It is therefore recommended that Africa promotes the exploration of oil. Also, efficiency measures especially in vehicles, public transport should be put in place and general subsidies on oil should be removed.

Most of the refineries in Africa are old and in need for major overhauling and upgrading in order to increase out put capacity and produce good refined products compatible with international standards. These refineries are not evenly distributed around the continent, for example along the east coast of Africa from Somalia to Durban there is only one simple refinery in Mombassa, Kenya with a rated capacity of 90,000 Bbl/day but operating significantly lower than that.

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APPENDICES

Appendix 1

Table 4.2: Manufacturing sub-sectors

Industrial Grouping	**Number of industries Identified**	**Number included in the Sample Size**
Food	14	10
Beverage	5	5
Chemical Products other than Petroleum	15	10
Textile	7	7
Paper and Printing Products	1	1
Basic Metal Non-Ferrous Industries	3	3
Cutlery & Non-Ferrous Metal Products	9	9
Iron and Steel Products	6	6
Petroleum Refineries	2	2
Cement & Other Non-Metallic	3	3
TOTAL	65	56

Appendix 2

QUESTIONNAIRE FOR OIL MARKETING COMPANIES TO ASSESS THE POTENTIAL OF GAS AS INDUSTRIAL FUEL

COMPANY NAME:

ADDRESS:

PHONE:

FAX:

YEAR ESTABLISHED:

No. OF EMPLOYEES:

Availability of LPG:

1. Is your firm engaged in the marketing of LPG? [ ] Yes [ ] No
2. If yes, indicate the year your company started dealing in LPG................................
3. Can you indicate the average quantity of LPG that your firm supplies to the retail outlets monthly/ annually? [ ] Yes [ ] No
4. If yes, specify the quantity per annum.......................................

   (***Please indicate the unit of measurement)***
5. Do you supply any industry with LPG? [ ] Yes [ ] No

   (If no, go to question 12)

6. If yes, please specify the industry and quantities supplied to them:

INDUSTRY	Quantities Supplied

7. How long have you been supplying the industries with the LPG?

[ ] Less than 5 years [ ] 5-10 years

[ ] More than 10 years [ ] Not sure

Handling of LPG:

8. What are the possible accidents that may occur in the delivery of LPG to the industrial consumer?...

....

9. Have you experienced any of such accidents before? [ ] Yes [ ] No

10. What are the safety measures put in place to prevent accidents?.............

....

....

11. Is LPG too dangerous to be used in large quantities, especially as industrial fuel? [ ] Yes [ ] No

General Comment of Respondent

12. Comment on the availability of LPG especially as fuel alternative for the industrial consumer……………………………………………………………………

……………………………………………………………………………………………

13. Please comment on the safety of LPG as industrial fuel…………………………

……………………………………………………………………………………………

14. In your opinion, what is the critical problem in introducing LPG as industrial fuel?……………………………………………………………………………………

……………………………………………………………………………………………

15. In your opinion what can be done?………………………………………………

……………………………………………………………………………………………

Thank you for your cooperation.

Job Title: Date:

APPENDIX 3

QUESTIONNAIRE FOR MANAUFACTURING INDUSTRIES TO ASSESS THE POTENTIAL OF GAS AS INDUSTRIAL FUEL

COMPANY NAME:

YEAR ESTABLISHED:

PHYSICAL LOCATION:

ADDRESS:

PHONE:

FAX:

INDUSTRIAL ACTIVITY:

No. OF EMPLOYEES:

General Views on fuels:

1. What are the sources of energy for the production process in this establishment?

   [ ] Electricity [ ] RFOs [ ] LPG [ ] Diesel

   [ ] Others (**specify**)

2. Specify the percentage from these sources [ ] Electricity [ ] RFOs

   [ ] LPG [ ] Diesel [ ] Others (**specify**)

3. What explains the choice of the main fuel used by this establishment?

   [ ] Prices of fuel [ ] Availability of fuel

   [ ] Calorific value of fuel [ ] Safety of fuel

   [ ] Applications of the fuel

4. What is the average level of your expenditure on energy annually/monthly...

5. What percentage does fuel contribute to cost build up of production annually/monthly...

6. Is this significant in terms of total cost of production?

   [ ] Yes [ ] No

7. Does energy type affect output per period of time? [ ] Yes [ ] No

8. If yes, indicate which of the energy types has the highest output per period of time? [ ] Electricity [ ] RFOs [ ] LPG [ ] Diesel .
[ ] Others (**specify**)

9. Does energy type affect quality of output? [ ] Yes [ ] No

10. If yes, indicate which of the energy types has the best effect on the quality of output ? [ ] Electricity [ ] RFOs [ ] LPG [ ] Diesel
[ ] Others (**specify**)

11. Have you heard of the construction of the West African Gas Pipeline?
[ ] Yes [ ] No

12. Do you see this establishment as a user of the natural gas next year?
[ ] Yes [ ] No

13. What will motivate this establishment to use the natural gas?...............................
....

14. What will hinder the use of natural gas by this establishment next year?
....

Usage of LPG:

15. Is LPG used in the production process in this establishment?
[ ] Yes [ ] No

If no, go to question 26

16. Indicate how this energy type is used:
[ ] Process heating (eg Kilns, Furnaces, Ovens, Boilers)
[ ] Process cooling and refrigeration
[ ] Process drying
[ ] Machine drive (eg motors or pumps, engines, generators)

[ ] Electro-chemical processes

[ ] Others (Specify)

17. Why do you use LPG?

[ ] It is Less expensive [ ] It is safe to use

[ ] It has high calorific value [ ] It is readily available

[ ] Appliances at this establishment can only use gas

[ ] Others (Specify)

18. Enter the quantity purchased by and delivered to this establishment monthly/annually……………………………………………………………………………

…………………………………………………………………………………………

19. Enter total expenditures for the quantity reported in the question above……………………………………………………………………………………

20. For how long can the quantity indicated above meet your usual needs?

…………………………………………………………………………………………

…………………………………………………………………………………………

21. What are the advantages of using LPG?……………………………………………

…………………………………………………………………………………………

22. What do you think are the major constraints hampering LPG use by industries?.

…………………………………………………………………………………………

…………………………………………………………………………………………

Reliability of supply:

23. Rate the supply of LPG from your suppliers [ ] Excellent [ ] Good

[ ] Satisfactory [ ] Poor

24. Are there occasional shortages in supply? [ ] Yes [ ] No

25. If yes, how does the occasional LPG shortage in the country affect production?..

....

26. What reasons are given for the shortage by your suppliers? ....

....

27. How does this establishment deal with shortages and interruptions of LPG supply?..

....

Handling Of LPG (Safety Issues)

28. Name the common accidents that occur from the use of LPG

29. Has this establishment experienced any such accidents from the use of LPG?

[ ] Yes [ ] No

30. What are some of the measures put in place to prevent such accidents?

....

....

Non-LPG Users:

31. Why is this establishment not using LPG in the production process?

....

....

32. What would make you use/change to LPG?..

....

33. What do you think are the major constraints hampering LPG use by industries?

....

....

34. Specify the name of any other energy source purchased or consumed in this establishment..

....

35. If yes, indicate how this energy type is used..

....

36. Indicate why this energy type is used by your company..............................

....

37. Enter the quantity purchased by and delivered to this establishment annually...

38. Enter total expenditures for the quantity reported in the question above.........

....

Thank you for your cooperation.

Job Title: Date:

APPENDIX 4

RISK ASSESSMENT RECORD

STEP 1 IDENTIFY THE HAZARD	**STEP 2** WHO MIGHT BE HARMED AND HOW	**STEP 3 (i)** LIST EXISTING PRECAUTIONS	**STEP 3 (ii)** RISK RATING	**STEP 3 (iii)** IDENTIFY ADDITIONAL PRECAUTIONS NEEDED

RISK ASSESSMENT FOR……………………………………………….DATE………...

CARRIED OUT BY…………………………………………………………………….

APPENDIX 5

Fuel Prices on the Ghanaian Market

Fuel Type	Description	Cost ¢
Diesel	Per Litre	8066.47
Residual Fuel Oil	Per Litre	3763.52
LPG	Per Kilogram	7258.57
Electricity	Special Load Tariff-High Voltage (per Kwhr)	403.00 - 382,000

Source: Author's Field Survey-May, 2007

For the purposes of comparison, the above named fuels were converted to cedis per kilowatt-hour using the following conversion factors:

1 Kilowatt-hour of Electricity = 3413 BTU

1 Gallon of Residual Fuel Oil = 149,690 BTU

1 Gallon of Diesel = 138,690 BTU

1 Gallon of LPG = 95,475 BTU

But, LPG in Ghana is measured in Kilogramme and not in Volumes (i.e. Liters or Cubic meters). Therefore the following conversions were done:

Density of LPG = $0.54 kg/m^3$

Formula for Density = $\frac{\text{Mass}}{\text{Volume}}$

Therefore, the volume of 1Kg LPG = 1.85185185 approximately, $1.852m^3$

$0.001m^3$ = 1liter

Therefore, $1.852m^3$ = 1852 liters

1 Gallon = 4.54609 liters, approximately, 4.55 liters

Hence, 1852 liters = 407.03 Gallons of LPG

If 1 Gallon of LPG = 95,475 BTU

Then, 407.03 Gallon of LPG = 38,861,189.25 BTU

1BTU = 2.93×10^{-4}Kwh

Therefore, 38,861,189.25BTU = 11386.33 Kwh

Hence, cost of LPG per kilowatt-hour = 0.64cedis per kilowatt-hour

As stated earlier, 1Gallon = 4.54609 liters, approximately, 4.55 liters

Therefore, 1liter = 0.22 Gallons

If 1Gallon of Residual Fuel Oil = 149,690 BTU

Then, 0.22 Gallon = 32931.8BTU

From above, 1BTU = 2.93×10^{-4}Kwh

Therefore, 32931.8BTU = 9.6490Kwh

Hence, cost of RFO per kilowatt-hour = 390cedis per kilowatt-hour

1 Gallon = 4.54609 liters, approximately, 4.55 liters

Therefore, 1liter = 0.22 Gallons

If 1 Gallon of Diesel = 138,690 BTU

Then, 0.22 Gallons = 30511 BTU

From the equation, 1BTU = 2.93×10^{-4}Kwh

Therefore, 30511BTU = 8.94Kwh

Hence, cost of diesel per kilowatt-hour = 902.29cedis per kilowatt-hour

APPENDIX 6

LPG Pricing Trend

Effective Date	Exchange Rate (¢:$)	Ex-Refinery	Taxes	Margins	Ex-Pump
3-Nov-90	330.00	42.42	31.38	26.20	100.00
19-Nov-90	330.00	42.42	28.58	29.00	100.00
03-Jan-91	360.00	21.21	51.79	27.00	100.00
29-Mar-91	360.00	21.21	51.79	27.00	100.00
06-Feb-92	400.00	21.21	51.79	27.00	100.00
19-Sept-92	400.00	21.21	51.79	27.00	100.00
06-Jan-93	400.00	21.21	51.79	43.00	120.00
10-Feb-93	550.00	21.21	51.79	43.00	120.00
15-Jan-94	925.00	88.44	56.36	55.20	200.00
02-Feb-95	1,135.00	125.74	61.18	88.94	275.86
02-Feb-96	1,460.00	160.28	61.18	122.54	344.00
07-May-96	1,640.00	196.28	61.18	122.54	380.00
01-Feb-97	1,750.00	607.92	61.18	159.30	826.40
01-Jan-98	2,260.00	607.92	61.18	159.30	826.40
23-Feb-98	2,300.00	581.83	87.27	159.30	826.40
12-Oct-98	2,350.00	488.48	73.27	258.25	820.00
1-May-99	2,450.00	565.66	84.85	269.49	920.00
1-Jun-99	2,500.00	604.33	90.65	275.01	970.00
6-Sep-99	2,600.00	700.00	105.00	275.00	1,080.00
11-Dec-99	3,400.00	934.78	140.22	325.00	1,400.00

Effective Date	Exchange Rate (¢:$)	Ex-Refinery	Taxes	Margins	Ex-Pump
18-Mar-00	4,100.00	1,642.18	246.33	351.49	2,240.00
19-Apr-00	4,100.00	1,350.00	202.50	347.50	1,900.00
23-Feb-01	7,050.00	1,650.00	-	550.00	2,200.00
17-Aug-01	7,224.98	1,434.78	215.22	550.00	2,200.00
1-Nov-01	7,214.95	1,347.83	302.17	550.00	2,200.00
28-Dec-01	7,244.95	1,217.00	282.61	700.00	2,200.00
17-Jan-03	8,800.00	2,356.52	453.58	990.00	3,800.00
1-May-03	8,650.00	1,800.00	1,010.00	990.00	3,800.00
18-Feb-05	9,100.00	4,693.88	(396.34)	1,402.46	5,700.00
8-Aug-05	9,115.00	4,235.11	(465.15)	1,406.46	5,172.42
3-Oct-05	9,055.46	4,235.11	(465.15)	1,406.46	5,172.42
6-Jan-06	9,120.00	4,235.10	(464.73)	1,406.46	5,172.41
17-Feb-06	9,140.00	4,534.96	(420.18)	1,372.46	5,517.24
3-May-06	9,145.00	5,134.66	(330.22)	1,402.46	6,206.99
20-Jun-06	9,175.20	6,224.55	(166.74)	1,528.40	7,586.21
4-Aug-06	9,175.20	6,224.55	(617.96)	1,528.40	7,134.99
25-Sep-06	9,220.00	6,055.08	(617.96)	1,528.40	6,965.52

APPENDIX 7

OUTPUT OF CHI-SQUARE TEST

Appendix 7a: Chi-Square Test of distribution of industries according to size and location

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	27.130	4	.000
Likelihood Ratio	29.925	4	.000
Linear-by-Linear Association	.359	1	.549
N of Valid Cases	45		

Appendix 7b: Chi-Square Test of manufacturing sub-sectors and location of industries

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.922	10	.951
Likelihood Ratio	5.006	10	.891
Linear-by-Linear Association	.691	1	.406
N of Valid Cases	45		

Appendix 7c: Chi-Square Test to establish the relationship between manufacturing sub-sectors and size of these industries

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.684	10	.562
Likelihood Ratio	9.643	10	.472
Linear-by-Linear Association	.499	1	.480
N of Valid Cases	45		

Appendix 7d:Chi-Square Tests for main fuel and reason for choice of fuel

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	32.646	9	.000
Likelihood Ratio	38.037	9	.000
Linear-by-Linear Association	1.176	1	.278
N of Valid Cases	45		

Appendix 7e: Chi-Square Test to test the relationship between main fuels and uses of the fuel

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.398	6	.012
Likelihood Ratio	11.684	6	.069
Linear-by-Linear Association	5.365	1	.021
N of Valid Cases	45		

Appendix 7f: Chi-Square Test main fuels used by industries by location

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.495	6	.745
Likelihood Ratio	4.567	6	.600
Linear-by-Linear Association	.001	1	.982
N of Valid Cases	45		

Appendix 7g: Chi-Square Test to establish a relationship between manufacturing sub-sectors and users of LPG

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.555	5	.473
Likelihood Ratio	4.507	5	.479
Linear-by-Linear Association	2.661	1	.103
N of Valid Cases	45		

Appendix 7h: Chi-Square Test to establish the relationship between users of LPG and size of manufacturing industries

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7.715	2	.021
Likelihood Ratio	9.721	2	.008

Linear-by-Linear Association	4.293	1	.038
N of Valid Cases	45		

Appendix 7i: Chi-Square Test of manufacturing sub-sector by LPG

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.265	4	.371
Likelihood Ratio	4.168	4	.384
Linear-by-Linear Association	2.708	1	.100
N of Valid Cases	45		

Appendix 7j: Chi-Square Test to establish a relationship between LPG users and potential Natural Gas users (a year after completion of WAGP)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.320	1	.001		
Continuity Correction[b]	7.790	1	.005		
Likelihood Ratio	8.689	1	.003		
Fisher's Exact Test				.006	.006
Linear-by-Linear Association	11.069	1	.001		
N of Valid Cases	45				

Appendix 7k: Chi-Square Tests to establish a relationship between LPG users and potential Natural Gas users (Five years after completion of WAGP)

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.730	1	.030		
Continuity Correction	.726	1	.394		
Likelihood Ratio	3.563	1	.059		
Fisher's Exact Test				.178	.178
Linear-by-Linear Association	4.625	1	.032		
N of Valid Cases	45				