ANALYSIS OF ENERGY CONSUMPTION PATTERNS AND CARBON FOOTPRINTS OF SELECTED UNITS OF THE KENYA DEFENCE FORCES: LESSONS AND POLICY IMPLICATIONS

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Z50/65255/2010

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THEREQUIREMENTS FOR THE AWARD OF DEGREE OF MASTER OF ARTS IN ENVIRONMENTAL POLICY OF THE UNIVERSITY OF NAIROBI, KENYA

NOV 2020

DECLARATION

I declare that this is my original work and has and it has never been published or presented for a Degree award in any other university.

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DEDICATION

I dedicate this work to all those who positively contributed to its successful completion. Special thanks to **Prof Nicholas O. Oguge, Prof Richard M. Mulwa** and **Prof O Anyango** for the unwavering support and encouragement during the study period of study. Appreciation to my family and friends who stood by me all the time, The Kenya Defense Forces allowing access to data and for clearing the study to be conducted.

ACKNOWLEDGEMENT

I would like to acknowledge The Centre for Advanced Studies in Environmental Law and Policy (CASELAP), and to my supervisors, for their patience and consistent follow-up.

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AU	African Union
ASAL	Arid and Semi-Arid Lands
Btu	British Thermal Units
CDM	Clean Development Mechanisms
CH4	Methane
CO_2	Carbon Dioxide
CO	Carbon Monoxide
DEFRA	Department for Environment, Food and Rural Affairs
DECC	Department of Energy and Climate Change
DPKO	Department of Peace Keeping Operations
DFO	Defense Field Operations
EE	Energy efficiency
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
EMECC	Energy Management and Energy Conservation Committee
EMECP	Energy Management and Energy Conservation Programme
EPA	Environmental Protection Agency
EPRA	Energy and Petroleum Regulatory Authority
ERC	Energy Regulatory Commission
ERB	Energy Regulatory Board
ETS	Emission Trading systems
EMS	Energy Management Systems
GDC	Geothermal Development Company
GDP	Gross Domestic Product
GESIP	Green Economy Strategic Implementation Plan
GHG	Green House Gases
GWh	Giga watts hours
IAD	Institutional Analysis Development

IPPs	Independent Power Producers
KAP	Knowledge Attitude and Practices
KDF	Kenya Defence Forces
KIPPRA	Kenya Institute for Public Policy Research Analysis
KenGen	Kenya Electricity Generating Company
KETRACO	Kenya Electricity Transmission Company
KNBS	Kenya National Bureau of Statistics
KPLC	Kenyan Power and Lighting Company
KWH	Kilo watt hour
LPG	Liquid Petroleum Gas
MDGs	Millennium Development Goals
MEA	Multilateral Environmental Agreements
MEMR	Ministry of Environment and Mineral Resources
MOE	Ministry of Energy
MTP	Medium-Term Plan
MWh	Megawatts hour
N_2O	Nitrous oxide
NCCACC	National Climate Change Action Plan
NCCS	National Climate Change Strategy
NDMA	National drought Management Authority
NEAP	National environmental action Plan
NEMA	National Environmental Management Authority
PPPs	Public-Private Partnerships
PV	Photovoltaic (solar)
RE	Renewable Energy
REA	Rural Electrification Authority
SDG	Structural Development Goals
SES	Socio Ecological System
SO_2	Sulphur Dioxide
TWh	Terra watts hour
UNEP	United Nations Environment Programme
UNFCCC	U.N. Framework Convention on Climate Change

US	United States
USD	United States Dollar
USAID	United States Agency for International Development
UN	United Nations
UNDP	United Nations Development Programme
WEC	World Energy Council
WHO	World Health Organisation

ABSTRACT

Energy costs accrued from various sources have continued to top the Kenya Defence Forces (KDF) budget expenditure to approximately an eighth of its annual budgetary allocation. This has had a direct reflection on environmental degradation in various forms depending on the energy type in use. This study undertook baseline studies on three energy types used in three military barracks, namely grid electricity, Liquid Petroleum Gas (LPG) and petroleum. The study objectives were to: (i) Establish the energy consumption trends in three selected sites from 2011 to 2015, (ii) Analyse associated cost in relation to annual budgetary allocation, (iii) Establish the footprint of the energy use and (iv) Evaluate the regulatory framework governing energy consumption in the Kenya Defence Forces. Elinor Ostroms' The Integrated Socio-Ecological Systems Theory informed the study. A descriptive cross-sectional survey was conducted with both qualitative and quantitative approaches. Primary data was collected using questionnaires administered to key informants, extraction matrices and energy audits while secondary data was derived from existing policies and audited financial records. Questionnaire survey was conducted by purposive sampling to obtain an informed sample. Due to the confidential nature of the information that is contained in this study, the classified information was converted into percentages for presentation and discussions. Similarly, and real identities of study sites are coded; Site A, B and C.

There was evidence of a steady rise of 50% between 2011 to 2015 accompanied by a monetary cost implication of 3.750 units (7.4%) from 2011 to 6.343 units (8.9%) in 2015. Translating to 7.34% of the total budgetary allocation being spent on energy bills from 2011 – 2015. The amount of Carbon dioxide (CO_2) emissions remained insignificant at an average of 1,500 unit MW in the period under study. KDF has an Energy Management and Environmental Conservation Programme (EMECP) handbook. The researcher has recommended a comprehensive review of the policy.

CHAPTER 1: INTRODUCTION

Energy plays a central role in revitalizing a country's economy. The values of clean energy cannot be over emphasized as it can drive a country to the edge of innovation and growth. The Government of Kenya in the Green Economy Strategic Implementation Plan- 2016 – 2030, GESIP (2016) sites that the advantages of Renewable Energy may range from its competitive nature with other types of energy to improved grid reliability and cost effectiveness. RE sources are also sustainable and environmentally friendly.

The United Nations Framework Convention on Climate Change (UNFCCC), directed governments to aim at developing national policies and strategies that encourage changes in unsustainable consumption, UNFCCC (1992) specifically, nations were to develop a domestic policy framework that will encourage a shift to more sustainable patterns of production and consumption. Activities to promote this included encouraging environmentally sound use of new and renewable sources of energy and sustainable use of renewable natural resources (Strandenaes, 2012).

Militaries are the most capable, and dynamic institutions that can spearhead innovation/research, and at the same time fulfil their core mandate of ensuring national security. Globally, many militaries require a lot of energy for use in various sectors like transport, operation of heavy machineries. Most essential is that the energy should be portable to sustain them in different theaters of war. A Military environmental policy should typically include principles for environmental protection, goals of minimizing environmental damage, minimization of waste streams, and recognition of the importance of environmental planning. Most countries globally intersect their military budgets and climate security by striving to reduce their own greenhouse gas emissions. Each Military Services should have specific "green" benchmarks aimed at environmental conservation.

This study requires an understanding of the production and consumption trends of various energy types that can be used for military operations without compromising its primary role and mandate of securing the nation. According to the World Energy Council (2013), there are numerous sources of energy namely; coal, Petroleum, wind, nuclear, hydropower, natural gas, biomass, peat, marine, geothermal and solar energy, but for the purpose of this study, a brief introduction on Petrol and natural gas, Hydroelectric power, biomass, wind and solar are discussed literature review to provide an understanding on the sources, production, consumption trends, advantages and disadvantages.

The Green Economy Strategic Implementation Plan- 2016 – 2030, GESIP (2016) is Kenya's master plan towards a low carbon, resource efficient, equitable and inclusive socio-economic transformation. It emphasises unsustainable jobs, demographic changes, and sustainable production and consumption as main drivers to Kenya's green economy agenda.

Kenya has embraced the fact that, renewable energy is a central pillar in revitalizing the national economy, and that it has the potential to drive the country to the edge of innovation and growth.

The Kenya Defence Forces has also energy conservation strategies by adopting an Energy policy populated as The Energy Conservation handbook which guidelines of substantially increasing the use of RE in order to create sustainable and independent energy supply for its future needs, while considering the initial cost, accessibility and environmental sustainability. KDF understands its energy requirements and provides guidelines on achieving carbon neutral status to realize a low carbon foot print as well as reduce the cost of energy.

The Kenya Army has approximately 40 installations. The installations in their respective locations depending on their sizes and energy needs, consume energy in the form of grid electricity for lighting and other forms of administration, LPG gas for cooking, petroleum and diesel for motors and engines and hydroelectricity for lighting. These forms are expensive and may give rise to significant carbon emissions if not utilised efficiently. According to the National Climate Change Action Plan (NCCAP) (2013), economic transportation needs bear the largest wholesome growth in emissions.

This thesis seeks to address the energy use patterns in the KDF and dissect the existing energy policy in its strengths and weaknesses when it comes to answering the question, "*Energy demand versus existing sources*" in KDF "*Sustainability and efficiency in energy consumption and production in the face dwindling financial resources"* in line with Government of Kenya energy policies.

1.1 Statement of the Research Problem.

In FY 2010/11 energy audit observations by certified KDF energy managers from the Research and Development branch revealed questionable bills paid per annum as energy bills. KDF (2011) Questions about sustainability of the cost of energy became inevitable especially in the face of a restricted budget. Factors like increased operations and force expansion are directly proportional to increased energy demand. The audits cited increasing demand, cost of energy, fuel types in use and

described their application as inefficient. Inadequate knowledge base and the absence of previous studies were alongside need for an Energy policy.

To address this gap, the need to analyse energy consumption trends, costs and carbon emissions became necessary to influence energy efficient strategies and sustainable consumption options without compromising KDFs core security mandate while conserving the environment.

1.2 Main Research Questions.

What kind of energy management strategies and alternative renewable energy sources can be utilized to achieve optimal energy efficiency and use by the Kenya Defence Forces?

1.2.1 Research Sub Questions.

a. What are the energy consumption trends in selected sites from 2011 to 2015?

b. What proportion of annual budgetary allocation is used on energy costs?

c. What are the environmental implications in terms of CO_2 emissions of the consumption patterns?

d. What is the current regulatory frameworks governing energy consumption in the KDF and how can it be improved?

1.3 General Objective.

To determine energy consumption, cost, footprint and establish need for Energy policy for KDF.

1.3.1 Specific Objectives.

a. To establish the energy consumption trends in three selected barracks in the years between 2011- 2015

b. To establish proportion of the annual budgetary allocation used by this energy consumption.

c. To determine the CO_2 emissions associated with the trend.

d. To evaluate the existing regulatory frameworks governing energy consumption in the KDF.

1.4 Justification of the Study.

KDF (2011) in an energy audit report of its services revealed that KA energy bills were using up to approximately an 8th of the entire budget allocation on Electricity, Petroleum Oil / lubricants and LPG. The report also established that 57% of the energy bill was accrued by only 20 electricity meters out of the over 200 Kenya Power and Lighting (KPLC) installed meters. Questions about future sustainability of the scenario in the face a reducing budget and increasing demand became inevitable. The absence of previously conducted studies on energy consumption and expenditure in the KA made it impossible for any interventions.

Expenses of most military budget in order of priority are Operational, Logistical, Training and other cost budgeted for on an estimated priority scale of 4:3:2:1 respectively on a 10 units' scale. Therefore, for an energy bill to consume approximately an 8th of the budget funds, it means that 15% would go into energy bills, leaving only 80% for the priority expenses (Operational, Logistical and Training) if no mitigation/intervention was taken, the trend would escalate in the face of force expansion and inflation.

In view of the above, this thesis reports on an analysis of energy consumption trends, costs and footprint in the years preceding 2015 in three selected barracks in order to reveal prevailing trends and costs in the period following audit observations made in 2010/11. This time frame of before 2015 is explained by availability of audited records as at the time of data collection. The thesis also

justifies the fact that cost, consumption and carbon credits will continue to escalate if no action is taken to mitigate or reverse the trends.

This report aims to establish a basis onto which other studies in the KDF may be conducted. It will provide sustainable guidelines to positively influence the cost Vis a Vis consumption as well as environmental conservation for the KDF without undermining its security mandate. Solutions discussed include reviews on comprehensive energy and environmental management policy, change of perceptions and creating awareness in environmental conservation, employing greener sources, grid electricity management, solar energy installation, purchase of energy efficient equipment, and training personnel as ways in which when effectively implemented, shall result in declining trends in carbon footprints, cost, and consumption.

1.5 Scope and Limitations of the Study.

The scope and limitations of this study involved;

1. **Study Scope;** the study scope did not the three services of the KDF and therefore may not necessarily represent a holistic representative of consumption levels and trends of the KDF especially owing to the fact that KDF is involved in deep operations outside the borders in Somali and other undisclosed site which may not have representation in the data collected. In this view the data collected was a representative of the Kenya Army and not KDF. However, the policy discussions were being aired with an all-inclusive KDF approach.

2. **Lack of previous studies in this field;** The study was slowed down by the absence of previous studies conducted on other militaries especially in the Sub Saharan Africa which could have provide ground for comparison with the finding of this study. The only studies available were for the US Department of Defence which is almost in comparable to the KDF which is a third world military with restricted resources, poor infrastructure and lacking sufficient policy frameworks. Plenty of reference materials was from the US Army.

3. **Reporting of findings;** due to high confidentiality and nature of handling military data which is highly classified, it was impossible to disclose the actual names of the study sites as well as the actual figures obtained from the study. And as a result, percentages were used to

provide measure of trends as well as cost which may not paint the real picture of energy use and consumption.

4. **Security clearance to conduct the study;** this influenced a lot the level of the researcher's indulgence into data collection, reporting and presentation of the information obtained.

5. **In availability of researcher and study continuity;** due to unavoidable circumstances bordering on duty deployment, the researcher was in available for full time concentration on the study leading to prolonged study time and lost concentration.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Massive literature has been accumulated on the subject of energy sources, production, consumption, demand and distribution, not to mention efficiency, reliability and sustainability in the precincts of climate change, environmental degradation and planet conservation. This section seeks to review literature on importance of energy, global perspectives of energy use, production vis a vis demand, energy consumption perceptions of other militaries around the world, Kenya's strategies, frameworks and policies on energy consumption and production, Energy use and management in the KDF, a Theoretical and conceptual analysis of Elinor Ostroms Theory of Socio–Ecological Systems and finally the Study challenges and limitation. This review will be approached in the prisms of energy types, trends, cost and CO_2 emission and available interventions.

2.2 Global Overview on Energy Sources and Consumption Trends

Energy is considered, on a worldwide basis, as essential to the development of a nation. The five modern energy sources are petroleum, coal, natural gas, nuclear energy and hydroelectricity. For many decades, and especially in the years of 1970 and 1980, the governments concern and focus towards energy were chiefly economical. Many countries key investments concentrated on energy infrastructure works such as hydroelectric power plants, transmission networks, and water reservoirs. Fernando (2016). However, with time, the global consciousness and environmental concerns have gradually evolved as summarized by landmarks like Stockholm declaration in 1970's, United Nations Conference about Human Environment (1972), the United Nations World Committee about Environment and Development (1983), the Rio Summit Agreements (1992), the Kyoto Protocol (1997), and Rio+20 (2012). These posed a challenge to many countries from the European Union to promote country growth, raise social and economic standards to their populations while keeping a close eye on the environment. This implied making use of the least invading and damaging practices as possible to conserve nature and the environment.

2.3 Perspectives on Energy Efficiency

Energy efficiency (EE) is a vital area of interest of the economics of energy basically because an "energy resource" is supposed to reduce the consumption of primary or manual energy sources and achieve commendable savings in terms of time and cost. The WEC Report (2013) onEnergy Efficiency Technologies states that objectives for energy efficiency should reach circumnavigate beyond the normal technical solutions to accommodate financing, innovation, cost-effectiveness, acceptance, and environmental impact assessment. Cost-benefit analyses should form basis of energy efficiency to promote and encourage understanding of the potential profits and benefits. To achieve energy efficiency results by governments, long-term commitments, demonstrated by the financing frameworks ought to prevail.

In Sub Saharan economies (except South Africa), the energy intensity went down by approximately 2.5 % per annum since the year 2000, however it remained notably higher than the North Africa and increased two fold in the global average platform. Researched benefits from carrying out Energy Efficiency (EE) policies can be able to save approximately 139 MW (16.7 per cent) in capacity requirements and 634 terawatts hour (TWh) in the amount of power produced translating to 16.6 %, UNEP (2017).

Energy efficient policies are absent in most African governments and if not then the ones that have succeeded were not known to the researcher at the time of study. This is replicated in the KDF where by the energy policy is not strong enough to achieve energy efficiency. The underlying factors in achieving energy efficiency will be greatly discussed in chapter 4 of this study.

2.4 Militaries and Energy Budgets.

The United States of Americas' Department of Defence's (USDoD) carbon emissions and footprint rates it as the world's highest single user of power. Its consumption is proved to be more than any other state owned or private institution and even greater than one hundred individual government economies, Tommey (2015). The US Army consumes over a whopping 30,000,000 MegaWatt Hours (MWh) of electricity every year, at an approximate cost to the tune of US $2 billion a year. A striking similarity with Kenya's Defence Forces is that almost 98 percent of its electricity is

produced from the civilian power market, making it slightly vulnerable to incidences of broad-scale power outages that are caused by over demands, accidents, as well as cyber-attacks. Tommey (2015) further describes the national power grid as unreliable, vulnerable and fragile, noting that over dependence on it by the US military exposes vital military, critical and homeland defence operations at unacceptable risk of unreliable power. In a day, US DOD consumes 395,000 barrels of oil, almost equivalent to the consumption of the entire country of Greece.

Tommey (2015) paints a picture of an enormous expanded US DOD with a huge budget and has no possible constraints on expenditure and no other military in the world can match, unlike in our study we have an African Military from a third world country that has a host of budgetary constraints that directly affect its freedom of expenditure. None the less this literature points us to the fact that a military's over reliance on a National grid for power puts critical homeland defence missions at a vulnerable unacceptable risk due to outages.

Rodriguez (2012) in his work, *Foreign Military bases with RE sources* states that any steps taken towards climate change and global warming mitigation must be appreciated and supported positively to reduce undesirable effects. Special emphasis to the fact that it is important for research initiatives to be implemented are enhanced alongside the fact that military forces should be made aware of the importance of good and proper use of energy and alternative renewable energy to reduce the number of human casualties in war zones. He further states that in as much as other developing and third world countries may not be able to harness the huge capital investment like U.S. Army, the Public and private sectors of these countries can adopt the numerous new green energy solutions and technologies. With the development of these new innovations, they can play part in the contribution to their home economy, homeland and state security, and environmental conservation without necessarily feeling the pinch of starting big.

The greatest and most important source of energy in operations is solar energy. This is based on the fact that there are approximately 310 sunny days per annum and the solar radiation effects is averaged at approximately 6.5 kilowatt-hours (KWH) for every square meter every day and the best suitable solution is the installation of photo voltaic solar power devices, this is according to Rodriguez (2012) in his work, *Foreign Military Bases with Renewable Energy Sources*.

Solar panels are the most potable and easy to transfer and in the eventuality that the military camp requires to be relocated, they can simply be easily disconnected and reassembled newly in another location. On the other hand, Wind energy may pause a great challenge since first of all the portability is not commendable in the bases: also great height of the windmills above the land surface may expose them and give them away as easy target to the enemy forces because. In as much as they may be located inside the base perimeter fence, their effective height is designed to be suitably place at a much higher altitude than that of the perimeter wall that surrounds the military bases. In the KDF, studies aimed at determining probable suitable and alternative green energy sources solutions that can drive energy demands are far from being actualized. A few attempts have been made in regard to harnessing solar energy for lighting but this is far from influencing any significant production as well as steps in achieving energy efficiency in the whole force. There is a study gap that may require recommendation for future studies but also this study help reduce the literature gap relating to studies conducted in the KDF energy use chronicles.

Nuttall (2017) in his report *Energy and the Military; convergence of security, economic and environmental decision making* reviews the leading role of The United Nations (UN) in putting in a lot of effort to reduce drastic harmful effects of climate change impacted by human and modernization activities.

The United Nations (UN) peacekeeping operations have a manning strength of approximately 115,000personnel deployed in about 16 countries by the end of 2012 and this habitation has given rise to 55 percent of the total carbon emissions of the whole UN system, UNEP (2012). Again we get to see that the greatest portion of emissions for peacekeeping operations are as a result of air travel at 46%, followed by energy production at 26% and transport and road vehicles at 15%. Decisions arrived at regarding uptake of renewable energy sources were passed recently and also energy efficiency efforts were being dealt with at the single mission level. These were found lacking in general UN-wide policy despite the great potential for cost-savings UNEP, (2012b, p. 27).

The Department of Peace Keeping Operations (DPKO) in the recent years however came up with a policy of mitigation of its environmental human related impacts in all of its peace keeping operations, the policy framework involved reduction of its energy use for the various field missions in Africa and the Middle East, and also put into consideration other environmental conservation

objectives following the core values and the indications of the Millennium Development Goal 7 to embrace the pillars or environmental preservation and sustainability. From the year 2009, two new policies were populated and adopted: the core one is referred to as the Environmental Policy for the UN Field Missions, adopted at the office of the DPKO and by the Department of Field Operations (DFO), the second outfit being a Global Field Support Strategy adopted in the General Assembly, UN (2010) UNEP, (2012). These are the two significant and mandatory policies that are emphasized in many areas of environmental sustainability of UN mandated peacekeeping operations. The parameters involved include camp citing and management issues like the use of clean water, disposal of generated wastewater, general solid and hazardous waste management, wildlife conservation, and efficient energy use and management. The prompt uptake of the new policies is geared towards enhancing the least environmental standards and providing operational guidelines for all field operations and missions. The adoption of the Energy Management and conservation programme handbook by the KDF can be equated to the UN move to adopt energy policies in the field. KDF may experience difficulty in cascading the guidelines to the lower levels in their hierarchy but it can then borrow a leaf from what the UN has done when it comes to implementing energy policies for the purpose of increasing potential. In fact, the KDF may stand a good chance to implement the policy because their military installations are more permanent than the UN bases out there which are uncertain of how long they may stay.

UNEP, (2012) in *Greening the Blue Helmets* emphasizes that the major hindrance to the uptake of energy efficiency initiatives and renewable energy innovations in the missions is the absence of the knowledge about the length the mission will take. The time is often unknown in advance and consequently a future-based cost-benefit analysis of renewable energy technologies is not easy to predict. Cost- benefit analysis evaluations for UN missions are largely inherent on time. The benefits and return on investments for any renewable energy project in most cases is a few years after the initial installation. In most cases the technologies to be employed or used are often selected on the basis of the projected length of the mission, which is typically six to twelve months, while the average stay time of a peace keeping mission is far longer, typically seven to 10 years. Observations and experience witnessed from the establishment of most UN peacekeeping operation have described energy and energy efficiency measures points to have a cost-recovery payback time of one to five years. Unlike the UN missions which are not permanently embedded and are bound to close and evacuate anytime. KDF has the advantage of having permanent installations and hence should exploit the advantage to invest in RE projects since the Cost-benefit profits are sure to be

achieved and there is no uncertainty of having to pack and go. This study to an extend discusses levels to which the installations in their regions focused for study can take advantage of the natural resources naturally present like solar and wind to initiate funding proposals for these investments which will go a long way in to supplementing on energy demand versus energy sources available. Nuttall (2017) have fronted views that energy/defence interactions should apply in policy, strategy and tactics, and that it is important like the UN has environmental policies for field missions, any military should seek to have environment / energy policies to govern their goals towards achieving SDG7, affordable and clean energy.

Enumerating the benefits of renewable energy to the US Army, Tommey (2015) indicates that the decisions made to transition or change from the traditional conventional, fossil-fuel resources of electricity generation possess a lot of advantages, in the civilian world as well as the military. The sheer acknowledgement and accommodation of these gains has spread from a small section of the population spheres to a much greater spectrum of the country given the location and distribution of domestic military installations, such profits and benefits are multiplied and manifested across the largest federal agencies. Furthermore, the technology transfer from the US Army to other domestic civilian entities provides more benefit of aggressive and rapid growth of renewable energy innovations in military settings. In a similar way, if the KDF would embrace and invest in energy projects to generate power from wind, solar and even biomass, the nearby communities would enjoy the benefits of shared power and eventually it may multiply to have significant outputs to be able to feed in to the main grid of the country hence they begin to reap benefits and get huge returns on investments. This part of the literature review can generate further areas to be recommended for study in the KDF.

2.5 Energy in the Kenyan Context

Kenya's economic and Gross Domestic Product (GDP) growth and improved life style for its population calls for a sufficient and dependable supply of energy. In the Kenyan economy, energy is considered as an important component for the growth of the economic growth and improvement of its citizens' living standards. The current challenges and bottlenecks in energy supply mostly are low access to modern power options and services, expensive energy, disrupted supply and elevated cost of energy investments, NEMA (2015). Biomass which is inclusive of agriculture waste, wood fuel and charcoal together with petroleum and electricity are the 3 main sources of energy in the

country. The same sources are similarly required in the KDF for use and therefore this shows a similarity in energy use both for the Military and the rest of the country. So, here the military does not exist in a vacuum and its energy sources are not unique.

2.5.1 Energy Demand and Consumption Patterns in Kenya

In Vision 2030, Kenya has envisioned becoming a middle income economy and as it endeavours to do so; it faces difficult task of fulfilling its energy needs due to the high demands in growth to power the economy as a result of increasing populations and dwindling resources, Kenya Vision (2030). To meet the increasing demand and avoid overdependence on conventional sources, it is inevitable that the country needs to establish new policies and investment frameworks to achieve sustainable reserves of energy without compromising the totality of its future goals. The main actor in achieving this mandate is the energy sector. The potentially smaller contributors to this sector are Hydro-electricity, petroleum and renewable energy. The most dominating sources used in the commercial sector are petroleum and electricity due to increased demand from transport, lighting and powering of equipment. However, dry wood fuel is the most used fuels in Kenya by the majority of the population. Energy sources in Kenya are characterized as industrial / commercial and non-commercial. The industrial energy includes petroleum products like gasoline and lubricants and electricity, while non-commercial includes biomass, solar energy and to an extent, wind power and biogas. 14,353.8 tonnes of oil were used in Kenya in the year 2009 while the total initial power supply was 18,215.99. Hence petroleum fuel is most consumed and accounts for nearly 28.57% of the final energy consumption in Kenya while hydroelectricity and other combustible renewables accounts for about 3.11 percent and 67.65 percent of the total final energy use according to the Kenya Institute for Public Policy Research (KIPPRA) (2010).

The highest consumer of petroleum products is the locomotive industry which includes land, water and air transport followed closely by the manufacturing industries, power production and agriculture, respectively. 70% of Kenya's total net sales of gasoline products over the years is the transport sector as compared to the manufacturing sector, which used less than 20% of the total net domestic sales of gasoline products, KIPPRA (2010). This study expounds on measuring the levels of energy use coupled with a trend and the findings in chapter 4 will give a clear picture of military energy use versus budget allocation.

2.5.2 Energy Types and Sources in Kenya

With a normalized nominal GDP of USD 55 billion in 2015, Kenya is the rated among the top five largest economy in sub-Saharan Africa with a per capita power consumption is 161 kilo watt hour in 2014as compared to Nigeria's' 126 kWh and has a per-capita GDP nearly 3times greater. Kenya's Energy sector is having an encouraging history of public and private actors and is rated one of the well-governed in East and Central Africa. It is well endowed with good and sufficient energy resources, as proven by its good track record as one of the low cost developers of geothermal power in the world.

Renewable energy sources and imported fossil form the better part of Kenya's energy sources. These resources include hydroelectricity, biomass, geothermal, solar and wind (about 0.01%). In 2009 the overall built electricity capacity was 1,429 MW (Hydro-electric 52.1%, followed by geothermal energy at 13.2%, Conventional Thermal at 32.5%, and finally wind and others at 2.2%). From a national perspective, 69% of majority households use wood fuel for cooking. The current RE power production is only 5% of the total potential as stated by the World Health Organisation (WHO), and The United Nations development Programme (UNDP) (2009)

Kenya has high potential for sufficient energy production from geothermal, wind, solar and hydro sources as discussed below;

a. **Hydro Resources-** it is the earliest recognised and developed national owned resources dating back to the 1920s is hydro- electric power. The large scale hydropower schemes development started earnestly with the commissioning of the Kindaruma hydropower station in 1968 followed in succession by Kamburu in 1973, Gitaru in 1978 then Kiambere ten years later in 1988 and Turkwel in 1990. Since then, the largely run-of-the-river Sondu-Miriu power plant on the Kisii escarpment overlooking Lake Victoria at 60 MW and a trailing power plant Sangoro with 20 MWe at the tailrace canal of the main plant are currently the last major development of the large hydros despite various studies having been carried out. The Sessional Paper Number 4 on Energy effectively raised the capacity of small hydros to include up to 3 MWe systems. The classification of hydropower is expressed in the document then is as follows:

	Category	*Power Range*
i.	Pico Hydros	< 5kWe
ii.	Micro Hydro	+5kWe – 100 kWe
iii.	Mini Hydros	+100 kWe – 1000 kWe
iv.	Small Hydros	+1000 kWe – 3000 kWe
v.	Medium Hydros	+ 3000 kWe– 30000 kWe
vi.	Large Size Hydros	+30,000 kWe

The 5 main basins of Kenya's drainage ecosystem consist of: Lake Victoria; Tana River; Rift Valley;Athi/Sabaki River; and EwasoNg'iro North River. The five basins contain the largest of the country's hydro resources for power generation. Kenya's developed and installed hydropower capacity is above 800 MW. The potential for small and micro-hydro system is estimated at 3,000MW nationwide.

Approximately 15% of the electricity production in all African countries comes from hydropower sources. According to the World Energy Council (2013). Some of the benefits of Hydropower are low operating costs, no CO_2 emissions and simple proven technology while the disadvantages involve high capital expenditure, relocations due to fluctuating climate, and significant land requirement for power plants. Its zero CO_2 emissions translates to negligible carbon foot prints hence low environmental pollution.

b. **Geothermal -** Geothermal power consist of the heat enclosed inside the earth's crust that may be harnessed and developed in the form of steam geysers and hot water to be used for energy generation and other direct consumption applications. Africa's East Africa Rift valley region contains the most concentration of geothermal energy potential that can be used for power generation, UNEP (2017).12.2 % of the electricity generation in Kenya is accounted for by geothermal energy production, NEMA (2015) and contains a potential of up 10,000 MW supplied across twenty (20+) prospect regions mainly within the Kenya tertiary rift system as compared to other neighbouring countries. In the table below compares Ethiopia and Djibouti to Kenya, UNEP (2017). Direct consumption of geothermal resources in Africa in the year 2015 was at approximately 683GWh/yr. from six major countries namely; Kenya, Ethiopia South Africa, Algeria, Egypt, Tunisia and Morocco.

Utilization of geothermal power by KDF is mostly through the normal power grid power supply.

c. **Wind–**the development of wind energy in Kenya rose from 25MW in 2012 to at least 1,246MW in 2018 as a result of Private investor companies, encouraged by the friendly Feed-in Tariffs Policy (946 MW) and the Least Cost Power Development Plan (300MW). The Government of Kenya established the Renewable Energy Auction system for all projects above 10MW. Some of the targeted and developed wind projects on grid or off grid as listed below;

i. Marsabit; North Horr Boys' Secondary School – **200W**
ii. Kinangop; wind park – **60MW**
iii. Habasweni ; Mini grid – **50kw**
iv. Kajiado; St Patterson Memorial Secondary School – **3kW**
v. Ngong; KenGen wind Park – **25MW**
vi. Loiyangalani; Lake Turkana wind power – **300MW**
vii. Marsabit; mini grid – **500kW**

Kenya's Wind Resource Atlas was updated in the year 2013. This was as a result of data harnessed from 95 wind sensor data loggers established in various parts of Kenya. The high wind speed sensors were constructed to a height of between 20 - 40 meters above ground surface level. In continuity of updating the Wind Resource Atlas, a wind profile was established and it gives a clear strategy for Kenya to develop its immense wind resource.

1. Solar– Solar energy is highly available renewable energy resource that can be available for direct (solar radiation) and indirect (biomass, wind and hydro-oceanic currents etc.) forms. It is the radiant light and heat emanating from the Sun and can be collected using a range of continuously evolving technologies such as Solar heating, molten salty power plants, photo voltaics, solar thermal energy, and artificial photosynthesis are some of the range of abundant technologies that are evolving for use in the harnessing of solar energy's radiant light experienced in Kenya which is directly located at the equator. Solar oriented renewable energy innovations are broadly characterized as either passive or active depending on their capabilities to capture and process solar energy or convert it into solar

power. There is a strong growth of solar use around East Africa and this may be attributed to the reduced cost of solar panel manufacturing, and changes in global, regional and national legislation geared towards support of renewable energy that are likely to regulate this growth. The benefits of solar power include high availability, quick and easy installation, suitable for remote areas while the drawback range from intermittency, grid collection challenges and use of toxic materials.

d. **Biomass–**About 87% of Kenya's' domestic energy consumption demand is obtained from biomass and especially wood fuel, which is estimated to provide about 90% and 85% of both rural and urban domestic households' energy demands, respectively. The unhealthy demand for wood fuel has resulted in to substantial land pollution, degradation and deforestation. The government needs to increase access to new energy supply services in order to reduce the levels of wood fuel dependency. NEMA, SNA report to UNFCC (2015).Shell international (2007) purports that the adaptation and use of biomass technology in Kenya has remained extremely unpopular in their feasibility study, 'Promoting Biogas Systems in Kenya', they report that a high number of the biogas digesters operated below their required capacity, were left idle or incomplete and underused or misused after construction. The Shell foundation (2007) report further reported that only about 30% of the over two thousand biogas plants earlier constructed were working at the time of the study. It is estimated that the country has approximately twenty thousand biogas systems, as follows:

i. **17,000 constructed bio digesters in 36 counties of Kenya in five years**, under the Government of Dutch sponsored, Kenya Biogas Programme.

ii. **Approximately 1,000 bio digesters build by Energy Centres' and local artisans** – a number of the Energy firms have good biogas training units, and have been involved in research and promotion of skills support to institutions and clients.

iii. **2,000 digesters constructed by domestic and private biogas investors**, like the Japanese Takamoto, Taita biogas ltd, Sustainable Energy Strategies and Afrisol, among others, Shell Foundation (2007).

e. **Petroleum and natural gas;** is the most important and largest energy source for modern society and is used in both automobiles and industries. Some of the challenges the world has to cope with regarding the use of petroleum are the environmental impacts associated with climate change; the limits of available reserves and Disputes to get access to petroleum in certain regions. High carbon foot prints have also been realised by use of petroleum and its products. Natural gas is similarly the greatest contributor in the world energy economy, the cleaner of the fossil-based fuels, abundant and flexible. The extraction, processing and transport of gas usually require huge upfront capital. According to WEC (2013), the natural world gas reserves grew by 36% in the last twenty years and also its processing and production increased by 61%.

2.5.3 Kenya's Power Sector Challenges

In as much as significant progress has been achieved by Kenya's power sector over the years, challenges in the financing of the sector as well as development of commercial capital are still evident and they include;

a. **An uncertain financing industrial ecosystem for capital**. Unfair loan tenure and interests from the too greedy Commercial banks. Unproportioned burden from the tariff structures on financing especially for solar and wind projects.

b. **Opaque processes which complicate securing finances difficult**. The absence of a standard approach to Government of Kenya Letter of Support and unfair approaches to project selection complicate the process of securing financing.

c. **Inadequate funding models for government owned investments.** According to KenGen's balance sheet, the company cannot take on significantly more debt to finance its much needed expansion needs.

d. **Unaffordable financing for off grid private developers**. As a result of more technologies that are innovative and smaller scale financing, there has been challenges of securing affordable financing for private sector players and their needs as stated by United States International Development Programmes (USAID) (2016).

The challenges facing KDF in as far as energy consumption is concerned have not been discussed in any known literature. However, there is an insight on the challenges expected in the EMECP handbook and non-conclusive explanations of guidelines on how the challenges are expected to be handled. This study aims to use the data collected from key informants to address some of the challenges in KDF energy use.

2.5.4 Environmental Concerns on Energy Consumption in Kenya

Petroleum products and gas handling have impacts that mainly occur either on land, offshore, deep sea, on continental shelves, in Arid and Semi-Arid Lands (ASALS), animal parks wetlands, forests and or other related fragile ecosystems. The environmental impacts may vary depending on their state (petroleum or gas). They may occur as direct, indirect, or cumulative impacts. NEMA, (2014).

The various stages of the value chain where the impacts are likely to occur are as listed below;

a. The effect of drilling and field exploration activities (Upstream).
b. Exploration upstream (Seismic geological surveys - onshore and offshore).
c. Transportation and production of especially fuels (Midstream).
d. Refining, processing, retailing and distribution (Downstream).
e. Decommissioning or restoration of fuel oil fields and natural wells and other midstream.
f. Downstream shipping facilities.

The impacts that may be of significance in this study include:

a. Grave degradation on bio diversity hotspots and wildlife ecosystems.
b. Acute impacts of the oil and gas operations on forestry resources.
c. Change of land use.
d. Onshore and offshore waste management and oil developments.
e. Impacts of oil and gas activities on Water Resources.
f. Life threatening impacts of oil and gas activities on water and fisheries resources.

2.5.5 Carbon Emissions and Climate Change in Kenya

The NEMA (2015) SNC report to UNFCC commonly reported on the following greenhouse gases; were Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O) and partly fluorinated hydrocarbons (HFCs) that are not considered under the Montreal Protocol. Nitrogen Oxides (NOx), Carbon Monoxide (CO) and Sulphur Dioxide (SO2) are some of the indirect greenhouse gases.

Kenya's total greenhouse gas emissions in the year 2000 were 54,955 Gg CO2 equivalent to approximately 55 million tons of CO2. The total amount of CO2, CH4, N2O and hydro fluorocarbons emitted were 28,499 Gg, 15,726 Gg, 10,611 Gg and 118 Gg respectively, totalling to 54,955 Gg CO2 equivalents. Carbon dioxide was the greatest contributor to greenhouse gas emissions followed by methane. NEMA SNC report to UNFCC (2015 p. 5) the figure below shows the various gases and their total contribution to the total comprehensive GHG emissions for Kenya.

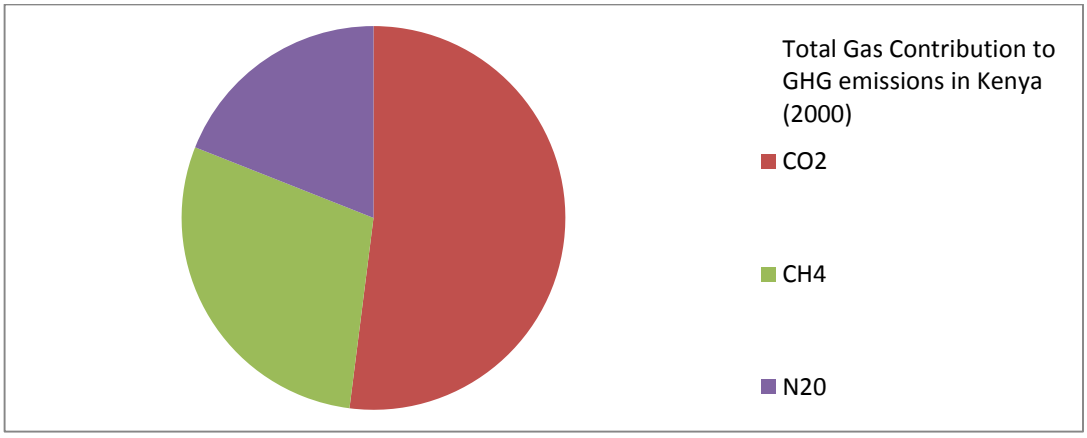

Figure 1: Total Gas Contribution to GHG emissions In 2002 In Kenya, Source; NEMA (2015)

Research on the levels of GHG emissions in the Kenya Defence Forces have not been undertaken before and therefore this research will reveal to a certain degree the amount of GHG emissions that KDF is emitting. However, the researcher will only focus on evaluating the level of CO2 emissions only in the KDF since it is the dominant and most common GHG amongst other gases as seen above.

In Africa, Kenya is rated second in place to South Africa in terms of ownership of great diversity of wildlife and also in mammalian species diversity. Approximately 70 to 80% of the gross tourism

earnings are generated from wildlife-based tourism. This contributes 11 % of total official employment to 25 % of GDP, NEMA (2015).

2.6 Interventions in Climate Change

Solar, geothermal, winds, biomass, hydro and tidal are renewable energy resources that exhibit natural replenishment cycles and are technically researched to be inexhaustible and are not resourced from fossil or nuclear fuel. There are no greenhouse gases and other polluting emissions that are generated from their production. However, the cost of the development of these renewable energy technologies is very high. Their increased consumption can result into economies of scale and increased use, especially in the third world and developing continents like Africa where energy consumption is increasing and many renewable energy resources are found in plenty, UNEP (2017). For instance, Africa has a wealthy and variety of renewable energy resources unevenly placed across the continent. It has a good wealth of renewable energy, with a fairly powerful wind power potential in Northern, Southern and Eastern Africa, solar irradiation ranging from 5 to 7 kWh/m2 all year round, and large tracts of land suitable for biofuel production as outlined by UNEP (2017) in the "Atlas for Africa Energy Resources".

1. **Renewable Energy-** The African continent has potential to become a renewable energy gold mine because of the abundant solar and wind resources. There is an increase in the attention given to growth of renewable energy potential development in Africa lately as investors and world leaders explore new frontiers in green energy. Africa has been the least among the continents in the benefit from the $7 billion annual Clean Development Mechanisms (CDM) market. From the time the European Union began trading "carbon credits" through its Emissions Trading Scheme (ETS) in 2005; approximately 27 of the 1,156 Clean Development Mechanisms projects listed in the scheme have been established in Africa, Boer (2013). The greatest investment in renewable energy sources judging from Global trends have been in solar, wind, biomass and biofuel. (See figure 2).

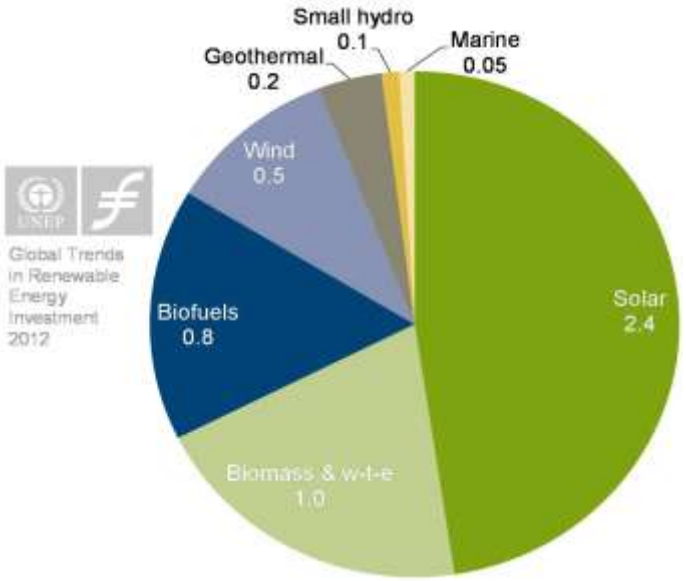

Figure2; Global new investment in Renewable Energy by sector, 2011. Source; Mc Crone (2012)

In the Kenyan context, it is inevitable to enhance deliberate steps to enhance the uptake of renewable energy innovations by providing sufficient financial incentives as well as credit facilities for all consumers and providers of energy in this sub sector, KIPRA (2010).

2. GESIP - According to The Kenya Green Economy Strategy Implementation Plan (GESIP) (2016), Kenya's transformation to a green economy relies on adequate provision for policies and institutional regulatory frameworks. The plan emphasises uptake of eco-innovations in different sectors to induce a momentum shift to sustainable consumption and production. It further emphasises that different sectors should need to interrogate their existing framework with a goal ecologically innovating their policies, legislation and strategies to create sustainable wealth, avail green jobs and protect the environment.

2.7 International Frameworks

1. **Sustainable Development Goals (SDGs)** -The 17 SDGs or Global Goals are a universal guideline to bring poverty to an end, environmentally preserve the earth, and nurture sustainable peace and sovereign prosperity among states. SDGs were formulated at the United Nations Conference on Sustainable Development in Rio de Janeiro, Brazil, in 2012. They are an enhancement and continuation of the MDGs and provide a strong commitment by nations to accomplish what was began by MDGs while acknowledging the

incorporation of hard pressing challenges on the globe today. Their main objective is to provide a packaged set of universal objectives that can solve the present dominating economic, political, and environmental sustainability challenges facing all the nations worldwide, UNDP (2012).

In Kenya, SDGs were assimilated in January 2016 and steered commendable changes in the country in less than 2 years. The background of this study is guided be 3 SDGs namely: SDG7; Affordable and clean energy, SDG 12; Responsible production and consumption and lastly, SDG 13 which promotes climate action. On SDG 7, Kenya's has made efforts to acquire green and affordable energy which does not only involve hydroelectricity, but also solar, wind, and thermal energy. Adopting latest technologies will go a long way to bring down the cost of hydro-electricity used in the country significantly. On SDG 13, despite word wide efforts to reduce the greenhouse effect, global warming is impacting close to permanent climatic changes that call for immediate deliberate action. Kenya also has its generous share of greenhouse gas emissions from commercial industries and abundant petroleum engines and this also calls for immediate attention.

2. **African Union (AU) Agenda 2063** -is a50-year plan of shared framework for inclusive growth and sustainable development for Africa. Its Aspiration no. 1 intends for Africa's inclusive growth and sustainable development, with share prosperity capable of managing its own growth and transformation by 2063. It also taken into consideration the Sustainable Development Goals (SDGs) and the beyond 2015 Development Agenda, Agenda 2063 (2015).The African Union has also adopted an African Climate Change Strategy in 2011 and well as the East African Community, Climate Change Policy, Strategy and Master Plan (2011) that have been enhanced and adopted in the spirit of promoting sustainability. These policy documents provide the priority agenda in the region, which defines the East African Nations' climate change policies and strategies.

3. **East African Community (EAC)** - The EAC Climate Change Policy has an overall objective of guiding Member States and relevant stakeholders on the uptake and adoption and implementation of collective efforts to deal with Climate Change in the region while adhering to sustainable economic and social growth. The Policy provides guidance on Climate Change adaptation and mitigation to cut down on the environmental vulnerability of

the East African region and enhance adaptive and mitigation capacity as well as socio-economic resilience of vulnerable populations and ecosystems. Adaptation of all nations to Climate Change adaptation is of priority to the EAC region in view of the enhanced vulnerability of the region to the consequences of Climate Change, bearing in mind the emerging associated challenges on food security coupled with poverty and reduced funds available for combating Climate Change, EAC Secretariat (2010).The EAC Climate Change Master-Plan and the Climate Change Strategy to gives a long-term vision and a foundation for Member States to implement comprehensive frameworks and strategies for adapting to and mitigating Climate Change in line with the EAC Protocol on Environment and Natural Resources Management and with international climate change agreements. Its vision is to ensure that: "The People, the Economies and the Ecosystems of the EAC Partner States are climate resilient and adapt accordingly to Climate Change".

2.8 Kenya National Frameworks

The Constitution of Kenya (2010) establishes base for population, adaptation and mitigation rules / legislation, policy and regulatory frameworks and strategies by guaranteeing the fundamental right to a clean and healthy environment under the Bill of Rights. In addition, Vision 2030, is the country's development blue print which puts together key flagship Programmes, Projects, Policies and Acts with tenets of adaptation and mitigation. These include:

1. The National Policy for the Sustainable Development of Northern Kenya and other Arid Lands.
2. The Integrated National Transport Policy (2010).
3. Environmental Management and Coordination Act (EMCA, 1999).
4. The National Disaster Management Policy, 2012.
5. The Water Act, 2002.
6. The National Drought Management Authority (NDMA), (2012).
7. The Energy Policy and Act (2004).
8. The Agricultural Sector Development Strategy 2010-2020.
9. The Second National Environment Action Plan (NEAP, 2009-2013).
10. Threshold 21 (T21).
11. The Kenya Forestry Master Plan 1995-2020.

The main institutions in Kenya that have the leading roles and responsibilities on climate related responsibilities, policy and regulatory framework, plans and strategies include;

1. The Ministry of Environment and Mineral Resources (MEMR)
2. Ministry of Planning and National Development
3. Ministry of Finance
4. Ministry of Agriculture
5. Ministry of Energy (MOE)
6. Ministry of Water and Irrigation and
7. County governments.

The Kenya National Climate Change Action Plan (2013 -2017) emphasises on the Government of Kenya's commitment to mitigating Climate Change and its impacts on development by enforcing low carbon climate resilient environment creating an enabling policy and regulatory framework, adaptation and mitigation.

Kenya's Vision 2030 (2007) aims to drive the country into a world competing, prosperous, industrious and vibrant economy with improved quality of life and with prospects to transform Kenya into a newly industrialised middle-income nation.

2.9 The Kenya Defence Forces

The Kenya Defence Forces is committed to responsible energy use and sound environmental management. It recognizes the importance of sustainable utilization of resources and a healthy environment for quality of life, economic prosperity and environmental safety and health. Hence it endeavours to continuously improve in using energy in the most efficient and cost effective manner and ensure environmental sustainability in line with Kenya's' Vision 2030.

KDF has an energy handbook called the Energy Management and Environmental Conservation Program (EMECP) (2014). It is divided into three parts.

Part I is the Statement which provides a commitment for successful implementation of the program.

Part II is a framework which outlines the objectives, organization, reporting and training towards EMECP.

Part III is a mini strategy which consists of energy and environment management systems, promotion of energy efficiency and environmental conservation, renewable and alternative energy sources, reduction of CO2 emissions (Carbon Neutral status), and possible funding sources.

The guiding objectives include;

a. To source and optimally utilize energy cost effectively.
b. Promote the use of sustainable energy sources, achieve and maintain a carbon neutral (green) status.
c. To participate fully in the Government Energy and Environmental Campaign in line with Kenya vision 2030.
d. To promote environmental sustainability in the utilization and management of resources.

The adequacy of the handbook will be discussed in detail in the research findings and discussions.

2.10 Gaps Literature Review

Literature has revealed heavy studies on Military and energy being conducted only on the US Army in terms of energy consumption, trends and climate change but the absence of studies about the same on sub-Saharan militaries leaves a lot to be desired. Tamasin (2012) states that climatic change and global warming are facts and any steps taken towards their mitigation should be considered positive. His study enforces this research which seeks to bridge the knowledge gap and addresses positive steps towards mitigating climate change. The WEC Report (2013) states that to achieve efficiency, long term commitment by financing frameworks should prevail, this translates to energy policies. Most institutions have policies whose efficiency cannot be measured or have not been put to test. The study will look into establishing the strengths and weaknesses of EMECP (2012).

Militaries should exploit RE sources that are portable and can serve in field operations. This calls for research to establish best suited RE sources for different military bases by virtue of the common roles or activities performed in these bases. This study will act like a feasibility study on helping the KDF to identify best suited RE sources for the sites under study. KDF is not different from the UN which has taken steps to put in check the impacts of human interactions in Peace Keeping bases by introducing energy conservation policies in Peace Keeping missions.

Ostroms' (2010) theory of Socio-Ecological Systems which brings into perspective the concept of Cost-Benefit Analysis, stake holders, scope, community involvement, levels of policy interactions, sources of energy, uses, and impact on environment while investing on RE projects should be the guide to institutions while making Energy policies. This study will dissect the EMECP (2012) of the KDF and establish whether the SES theory hierarchies are reflected.

Military liaison with existing Government Energy Departments on best way forward in combating climate change has not been covered in literature. The only near link of liaison is demonstrated when aligning their policies and activities to comply with Government rules and regulation. However, governments should look up to militaries to feed them with research and innovation strategies for uptake. This study may not heavily delve into this angle but recommends further research be done on how best Governments can tap into military rich research.

According to KIPPRA (2010), sources of energy and their trends in consumption over the years are vital to provide guidance to decision makers. However, the literature does not demonstrate any trends that have been established in military energy consumption. This study to and extend provides an insight on military energy trends and policy implications.

NEMA (2015) discusses environmental concerns and carbon emissions at national level and describes their origin as well as mitigation measures. However, it does not give any insights on co2 emissions generated by military and its impacts. Conservation of biodiversity is greatly discussed in the literature and the effects of pollution and land degradation on the environment; however literature on how military activities can impact on environment is minimal. Effects of activities like the use of mines and explosives and its effects on land degradation, setting up military camps on forest land close to wildlife while waging war on the enemy and nuclear war should be researched on in relation to climate change. In as much as this study may not explore heavily on how KDF

activities have affected certain environments, it may recommend comprehensive future research on the matter, NEMA (2010)

2.11 Theoretical Framework

Elinor Ostroms' (2010) Theory of Integrated Social-Ecological Systems (SES) provides a perspective in which human activities may have positive outcomes for the environment and community. In this theory, Socio-ecological systems are used to emphasize the integrated concept of humans in nature and to stress that the delineation between social systems and ecological systems is artificial and arbitrary. SES theory incorporates ideas from theories relating to the study of, sustainability, and vulnerability and has been developed in order to provide promising impact on problems of sustainable development.

The world is currently threatened by considerable damage to or losses of many natural resources, including fisheries, lakes, and forests, as well as experiencing major reductions in biodiversity and the threat of massive climatic change. All humanly used resources are embedded in complex, social-ecological systems (SESs), McGinnis (2014)
Social ecology pays explicit attention to the social, institutional, and cultural contexts of people-environment relations. This perspective emphasizes the multiple dimensions (physical environment, social and cultural environment, personal attributes), multiple levels (individuals, groups, organizational) and complexity of human situations (cumulative impact of events over time). A SES is comprised of feedbacks among human values, perceptions, and behaviours and biophysical components of the ecosystems in which people live, resulting in a trajectory towards sustainability GallopÃ-n, (2006).

An advantage of the SES framework it applies to a relatively well-defined domain of common-pool resource management situations in which resource users extract resource units from a resource system. The resource users also provide for the maintenance of the resource system according to rules and procedures determined by an overarching governance system and in the context of related ecological systems and broader social-political-economic settings. The processes of extraction and maintenance were identified as among the most important forms of interactions and outcomes that were located in the very centre of this framework, as illustrated in slightly different forms in Ostrom's (2007, 2009) initial work.

A critique to the SES theory is that it was originally designed to be relevant to common-pool resources. However, many Socio Ecological Systems also generate public goods and services, most notably the ecological or ecosystem services like electricity and fuels on which many markets depend for continued operation. Related problems of balancing resource use and systems maintenance occur in social-technical systems, for which outcomes range from private consumption goods to complex infrastructures shared by members of widely dispersed communities e.g. electricity generating companies and distribution frameworks etc. So the question of how broadly the SES framework can be usefully applied remains an open ended.

When it comes to application to any type of policy situation in which individuals and communities craft new policies as partial solutions for changing policy problems, The Institutional Analysis and Development (IAD) framework / theory was designed to supplement The SES theory. When applied to resource management issues, the natural tendency within the IAD framework is to treat the dynamics of a resource system as a mostly exogenous force, that is, as a driver of changing circumstances and not something directly under the control of the actors making policy in those settings. This separation between natural processes as drivers and policy processes as the core analytical concern make the IAD framework seem directly relevant to the dynamics of complexly coupled human-natural or social-ecological systems.

In 2010, changes were made to the SES theory in the interests of generalizability by extending the SES framework to apply to complex SESs in which multiple sets of actors consume diverse resource units extracted from multiple interacting resource systems in the context of overlapping governance systems. Ostrom (2010). These changes resulted in the transformation of Socio Ecological Systems (SES) theory into now applied "Theory of Integrated Social-Ecological Systems (SES)"

To illustrate one use of the SES framework, the question: When will the users of a resource invest time and energy to avert "a tragedy of the commons"? as argued by Garrett Hardin (1968) earlier argued that users were trapped in accelerated overuse and would never invest time and energy to extract themselves. A theoretical answer to this question is that when expected benefits of managing a resource exceed the perceived costs of investing in better rules and norms for most users and their leaders, the probability of users' self-organizing is high.

Environmental sustainability begins with a country's policy regimes and strong institutions to implement these policies. The adaptive capacity of a country especially to climate change lies in local institutions which normally have horizontal and vertical networks Carl Folke(2005).Horizontal networks refer to relations between people of the same scale while the vertical networks refer to actors of different scale and level. The military has got both networks interacting under an overall top -down command hierarchy with the policy makers at the top and the implementers are at the bottom of the pyramid.

Embedding resilient doctrines in environmental conservation among soldiers at the lower scale and level in the hierarchy system highly depends on formulation of sound environmental policies that are implementable. At the same time a feedback system from bottom to top should be available to provide guidance to the policy makers on the best policies and investments to adopt. Researchers, investors and other stake holders should be able create inputs to policy makers on sustainability or vulnerability of projects in order to maintain adoptive capacity to climate change in the KDF and the country at large.

Ostroms' (2010) Theory of Integrated Social-Ecological Systems (SES)can be used to define the variables under sustainability concepts under which KDF can optimise use of energy sources in the phase of a restricted budget to avoid excessive unnecessary consumption, reduce cost, optimise use, explore alternative sources as well as conserve the environment. Multiple first tier components / categories such as political settings, governance and resources systems, resource units and actors cascade into multiple variables at second and thirds tier levels as will be discussed and derived under the methodology section if this study.

2.12 Conceptual Framework

In a Socio-economic, political ecosystem, resource units form part of resource systems and are inputs into policy interventions and policy formulations which provide feedback to resource units. Governance systems set conditions for policy interactions and outcomes and also define and set rules for actors. Through policy interactions/interventions feedback between governance systems and actors is available.

The Figure below demonstrates how the variables may interact in a circular flow chart form.

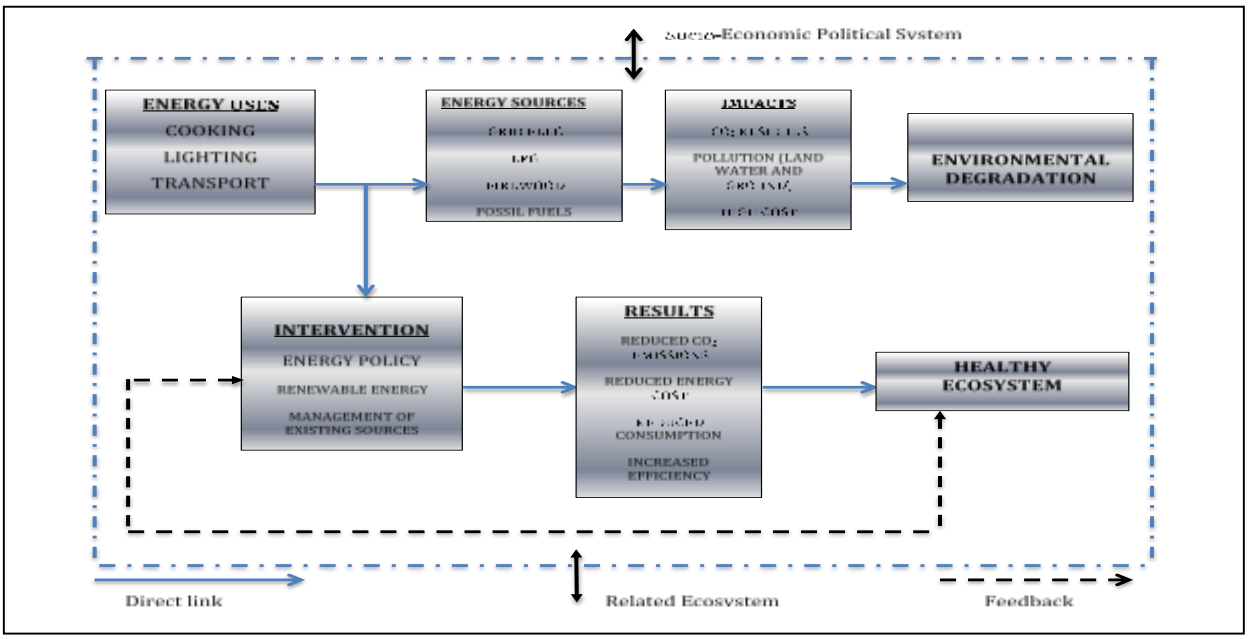

Figure 3: Conceptual framework depicting flow of variables in KDF energy use. Source; Author (2019)

CHAPTER 3: METHODOLOGY

1.1. Introduction

This chapter explains the research model, specification of unit of analysis, study design, study sites, study methods, data sources, data collection and data analysis in accordance to the requirements of the study objectives. 3 major energy sources namely; electricity, petroleum and Liquefied Petroleum Gas (LPG) were investigated in this study.

3.2 Study Area

Traditionally, it is the nature of military installations to exist as barracks. A barracks is a building or group of buildings where soldiers or other members of the armed forces live and work. Barrack population and size vary depending on core functions and location. Some of the functions that barracks can engage include General administration, Training, Artillery, Armoured, Logistics, Engineering, Naval and Air bases. In this study, the study site shall be known as Military Installation. It shall be used as a unit of analysis to help understand possible energy consumption trends and establish related cost as dictated by objectives 1 and 2.

3.2.1 Study Site

The choice of study site was conducted by deliberate sampling of three (3) military barracks located in different regions in the country and possess differences and similarities in the study variables and attributes to suit the study methodology and as well as provide equal representation of the rest of the 22 barracks. The selected barracks possess different functional mandates, population sizes and other characteristics as described below. In view of the above the 1st tier variables (Political settings, Governance systems, Resource systems, Resource units, Actors, Actions / interactions and related ecosystems) under study were further subdivided into 2nd and 3rd Tier for ease of understanding as described in section 3.3 For intelligence and security reasons the real names of the barracks have been withheld and coded as Sites A, B, and C.

The sites share similar variables in terms of governance systems under the KDF hierarchy (Energy Act 2006, KDF Act 2012), power generation and distribution companies (KenGen, KPLC and KETRACO) The resource units consist Electricity, LPG and Petroleum used for transport Lighting,

automobile operations and cooking. While the users, policy makers and investors remain Barrack Occupants and KDF respectively and the dependency is high. The anticipated environmental impacts in the selected sites revolve around increased carbon emissions, environmental degradation, pollution and deforestation and the cost of energy remains high despites despite policy interventions geared towards cost reduction and low carbon emissions. Additional unique differences of the three sites are as follows;

SITE A: is a medium sized training camp with an approximate population of atleast three hundred (300) soldiers. It is located in the North Eastern region of Kenya and exhibits semi-arid environment with great solar potential throughout the year.

SITE B: Is a training institution in the North rift region of Kenya with a high population hence high demand on energy, and located in good prevailing sunny and windy conditions.

SITE C: Is a purely administrative urban installation in the Metropolitan Nairobi region with a high number of residential and commuting soldiers.

The results from the three selected barracks shall be a representative of all other barracks of similar characteristics across the country. The researcher generally used the three military installations as a representation of all the installation. Results obtained from the three barracks bear a representation to a ratio factor of 1: 42. This means that figures obtained from the 3 sites were multiplied by 42; it bears a representation of the Kenya Defence Forces in terms of quantities of energy used, as well as cost and carbon emissions since all variables remain constant as describes above.

3.3 Study Variables

The study site description as discussed in 3.2 and in the literature review, can be reinforced by Ostroms' (2010) Theory of Integrated Social-Ecological Systems (SES) whereby study variables can be clearly defined as shown in the table below.

1st TIER VARIABLES	2nd TIER VARIABLES	3rd TIER VARIABLES
Political settings	Kenya Government energy sector	Constitution of Kenya
	Kenya Defence Forces hierarchy	Kenya Army
		Kenya Air Force
		Kenya Navy
Governance systems	Energy Act (2006)	Energy Regulatory Commission
	Kenya Defence Forces Act (2012)	KDF energy policy
Resource systems	Power generation companies	Kenya Electricity generating Company (KenGen)
	Power distribution companies	KETRACO and KPLC
Resource units	Electricity LPG Petroleum	Transport &Automobile operations Lighting Cooking
Actors	Users	Occupants in military barracks
	Policy makers	KDF leadership
	Investors	RE companies
	Location of actors and resources	Military barracks
	Dependence on energy resource	High
Actions / interactions / outcomes	Impact	Increased carbon emissions Environmental degradation Pollution and deforestation
	Cost of energy	High
	Energy policy	Cost reduction, Low carbon emissions Environmental conservation
	Mitigation measures	Management of existing sources Efficient utilisation Reduction of GHG emissions Increased use of RE Knowledge Attitude and Practice (KAP)
Related ecosystems	Pollution patterns Climate patterns	Change of climate High carbon footprints

Table 1: Study derived variables in accordance with E Ostroms' Integrated SES Theory. Source; Author (2019)

3.4 Study Design

In order to address the prevailing research problem and adequately provide the evidence needed to drive this study, a descriptive cross-sectional study that applied both qualitative and quantitative approaches are as used in Appendix 10.1 Study questionnaire and Appendix 10.2 Data collection matrix. Descriptive- cross-sectional because the study seeks to establish the energy attributes, trend, cost and behaviour of energy consumption in 3 (three) selected barracks over a 5 year long period, (2011- 2015) the findings of the energy use pattern over this period provided assistance in description of population, consumption in relation to risk factors involved like climate change and pollution which eventually was used to derive intervention measures to mitigate against severe impacts.

3.5 Data Type and Sources

The researcher used cross-sectional data which involved both primary and secondary data on the on the trends and cost of energy in the selected military installation and quantity of energy consumed yearly as well as at the end of the five-year period. Primary data were collected from Energy audit reports as well as procurement bills over the five (5) year period. Questionnaires surveys were used to ascertain bio data and common practices of the study population while relevant secondary data were obtained from desk literature.

3.5.1 Data Sources

Table 2 gives a summary of the link to the data sources in relation to the study goals.

GOAL	DATA SOURCE	DETAILS OF DATA TO BE COLLECTED	PURPOSE OF THE DATA COLLECTED
Determination of energy attributes and consumption trends.	Energy audits (from R&D department) energy bills. Questionnaire survey	Forms of energy used for the five (5) years in the three military sites and the resulting quantities.	data obtained was used to give focus on energy attributes and trend scenarios in energy consumption.
Determine proportion of annual budgetary allocation used by energy consumption.	Energy tariffs to obtain cost from consumption trends. Treasury allocations to KDF from 2011 – 2015.	Cost of energy used for the five (5) years Total budgetary allocation to KDF.	To examine the cost of energy vs budgetary allocation.
To determine CO2emissions.	Convert energy trends to carbon emissions using conversion tables.	Carbon emission levels	To examine environmental concerns.
To evaluate the existing regulatory frameworks governing energy consumption in the KDF.	Energy Management and Environmental Conservation Programme.	guiding policies or guidelines on energy use in the Kenya Defence Forces	To establish the strengths and weaknesses in the policy.

Table 2: Data sources in relation to study goals Source: Author (2019)

3.5.2 Data Collection

The primary data sources include military inventory ledgers, previous energy audits and procurement documents like awarded tenders, energy bills, and Local Purchase orders (LPOs).The secondary data sources on the other hand included literature review on energy alternatives available.

Each study objective attracted data conversion measures as follows;

a. **Study Objective 1- determining the energy consumption trend in the three study sites**;

The main sources of energy were electricity, bulk gas, firewood and petroleum. Electricity data existed in kwh, bulk gas data was in tonnes, and petroleum was tabulated in litres. For the purpose of uniformity and in order to obtain a common convertible, acceptable and universal unit, the **mwh,** the ***2012 guidelines to DEFRA/DECC's ghg conversion factors for company reporting*** conversion tables were used change the raw data content existing in different units, litres (l), tonne (t) and kwh as follows; DEFRA/DECC's (2012)
Conversion of Litres of Petroleum to ***mWh****http://www.kylesconverter.com/energy,-work,-and-heat/litres--atmosphere-to-megawatt-hours*

1) Conversion of bulk gas lpg to mwh1 = 14,447,204.9 mwh https://www.unitjuggler.com/convert-energy-from-mtlng-to-mwh.html

2) Conversion of electricity kwh to mwh ; 1 kwh = 0.001 mwhhttps://www.unitjuggler.com/convert-energy-from-kwh-to-mwh.html.

NB. Real, processed statistics from this objective will be converted into percentages for discussion.

b. **Study Objective 2 – Determining cost of energy vs. budgetary allocation**

Energy costs from existing energy billing documents, tenders, and payment vouchers were extracted using data extraction tool (Appendix 7) to determine the cost of energy of the quantities established in objective 1. Extraction of Budgetary allocation figures from the treasury web portal from the years 2011 – 2015.

NB. Real, processed statistics from this objective will be converted into percentage unit costs for discussion.

c. Study Objective 3 - Determination of CO2 emissions from consumption trends in Objective 1

For CO_{2e}(carbon dioxide) the2012 Guidelines to DEFRA/DECC's GHG Conversion Factors for company reporting was used to convert quantities of energy consumed into carbon footprints and the following extracts were used. DEFRA/DECC'S (2012).

1) Conversion of Litres of diesel to carbon footprints: Annex 1; table 1d; diesel (100% mineral diesel) in kWh scope 1, Co2 (0. 26774) DEFRA/DECC'S (2012P 10 of 54).

2) Conversion of Bulk gas LPG to carbon footprints; Annex 1; table 1d LPG scope 1 CO2 (0.22974) DEFRA/DECC'S (2012 p 10 of 54).

3) Conversion of electricity kWh to carbon footprints; Annex 3 table 3c 2010 scope 2,3 (0,51694) DEFRA/DECC'S (2012p 15 of 54).

4) Determination of fuel properties and conversion to the common unit; Annex 11 fuel properties DEFRA/DECC'S (2012p 47 of 54).

NB. Real, processed statistics from this objective will be converted into percentages for discussion.

d. **Objective 4** – ***Evaluation of existing regulatory framework in KDF*** **-** Cost benefit analysis as well as content analysis from past studies and existing literature (EMECP) was used to justify best management practices for grid electricity and suitable alternative options to adopt in order to realize lower carbon emissions and cost.

3.5.3 Sampling Frame

The study approach was based on non-probability sampling in accordance with objective requirements. Purposive sampling of respondents in each site with the sample size dictated by the population sizes. The aim of this was to get an informative sample and not necessarily a generalizable one. A total of 200 informants were interviewed but only 150 interviews were incorporated for use. An elimination criterion was based on the following factors:

a. The incorrigible manner in which most questions were responded to.

b. Legibility limitations and lack of response on certain questions by the respondent.

The following groups of persons were targeted for interview at all management level (top to bottom);

a. The Formation Commanders

b. Commanding Officers

c. Staff officers

d. Residents

e. Technical experts in various fields e.g. Engineers, Combatants, Trainers, and Managers.

3.6 Data Analysis

Data collected in objective one on energy consumption was subjected to regression analysis to obtain trends using Microsoft (MS) version 2007 Excel.

The final results and findings (outcome) were converted into percentages and presented in form of bar graphs, pie charts, frequency tables and narratives.

Due to the confidential nature of military information, kindly note that the findings will not bear real figures extracted from processed data, but instead percentages and rounded up whole unit codes with be used to draw a representation of the real figures.

CHAPTER 4: RESULTS AND DISCUSSION

In this Chapter, the findings are presented in five sections in line with study objectives as follows; Section 4.1 covers an introduction of the respondents and gives a summary of their demography and energy attributes 4.2 covers an analysis of trends in energy consumption for the three sites,4.3 consist of an assessment of cost of energy in the three sites culminating into an evaluation of budgetary allocation of KDF versus energy expenditure. In section 4.4, the study establishes the environmental implications in terms of CO_2 emissions of the consumption patterns in objective 1, in section 4.5 the researcher evaluates existing institutional frameworks governing energy consumption in the Kenya Defence Forces and their effectiveness and in section 4.6 explains possible interventions that can be employed to achieve sustainability.

4.1 Introduction and Demography

A structured questionnaire (appendix 10.2) directed to policy makers, unit commanders, officers and the average soldier across the ranks was administered to extract bio data and study participants views on energy use management. A total of 150 respondents successfully completed the questionnaire(s) out of the 200 originally administered for the study. This represented (75%) response rate which the study considered adequate for the analysis. Out of them (72%) were male while (28%) of the respondents were female. The gender inequality was attributed to the fact that the males seemed to be much more informed when it came to energy matters and demonstrate affirmative action in the various projects in the respective military areas. The results implied that there was access to higher education in the military as majority of the respondents (56%) had at least above secondary education while the undergraduate education was (44%) as shown in the table below. 90% of the respondents had knowledge of Renewable Energy.

Education level	**Frequency (*f*)**	**Percentage (%)**
Primary	19	13
Secondary	47	31
Undergraduate	44	29
Postgraduate	31	21
Others	9	6
Total	**150**	**100**

Table 3 Education Level Of Respondents**. Source;** Author (2019)

4.1.1. Perceptions and practices on Energy Management.

At least (90%) think it is a good idea to reduce the consumption; they practice the same by switching off unused lights**.** Switching off appliances on standby is a way of reducing energy consumption. They understand that appliances on standby can account for 10% of an electricity bill and that switching off just one appliance at the wall could save 45 kilograms of greenhouse gas.

94% believe and state that cconserving energy, by taking actions like insulating or weather-stripping your home and purchasing Energy Star certified (high efficiency) appliances, is usually the smartest, most economical and most potent environmental action you can take. Cleaner, greener energy supplies may provide the cleanest supplies of needed electricity, but minimizing the energy we need is still the first step to take before selecting the cleanest, greenest supplies. They know that whenever you save energy, you not only save money, you also reduce the demand for such fossil fuels as coal, oil, and natural gas. That less burning of fossil fuels also means lower emissions of carbon dioxide (CO2), the primary contributor to global warming, and other pollutants.

89% are convinced that the Kenya Army should actually reduce power consumption.
They stated that they would like to reduce energy costs in order to counter the rising fuel costs. They know the importance of having efficient and cost-effective heating system. They were

interested to find out about renewable technology on micro-generation and low-carbon technology and how it can be used to generate their own energy in their homes which can help them to save money and reduce carbon emissions.

55% are convinced that the Kenya Army was thus far not very active in providing the energy information. In fact 45% seemed unsure on the precise information that should have been given by the Army in thus regards.

Some stated that the increasing popularity of energy policy of KDF energy-saving initiatives like reducing the use of fire wood showed that, not only is there an overwhelming need for KDF to conserve energy and start to preserve natural resources, they placed a great deal of interest around the army in finding out the best ways to save power on an individual level.

90% of personnel were familiar with forms of RE like the wind and the sun. They understand that biomass is one of the most plentiful and well-utilized sources of RE in the world and that the most common biomass used for energy is wood from trees and has been used by humans for producing energy for heating and cooking for a very long time.

The respondents (95%) stated that electricity and or thermal energy was useful in as long as it was renewable energy because it is sustainable and universal. They know that RE facilities generally require less maintenance than traditional generators. More importantly, they know that RE produces little or no waste products such as carbon dioxide or other chemical pollutants, and has minimal impact on the environment. According to them, RE projects can bring economic benefits to many regional areas, like projects located away from large urban centres and suburbs of the capital cities.

4.2 Trend in Energy Consumption.

As discussed in chapter 2 under military energy budgets in 2.4, Over reliance of a military on the national power grid renders the Force fragile and vulnerable to conduct critical military and homeland defence missions due to uncertainty and extended power outages caused by increased demand, accidents and to some extend cyber-attacks. Tommey (2015). He further states that 98% of the US Armies electricity comes from making it highly susceptible. The US Department of

Defence's energy footprint makes it the world's largest single consumer of energy—more than any other public or private entity and more than one hundred individual countries. The DoD uses over 30,000,000MegaWatt Hours ("MWH") of electricity per year, at an [annual] cost of over USD 2 billion. In the analysis of KDF's Energy consumption trends, electricity emerged as the commonly used among the three sources analysed i.e. petroleum and LPG A striking similarity in Energy consumption is evident as the consumption rises steadily from 2011 to 2015. Electricity and Petroleum are commonly used in militaries.

The line graph below demonstrates that levels of electricity and petroleum consumed steadily expressed a 50% rise from 2011 to 2015 in the three study sites.

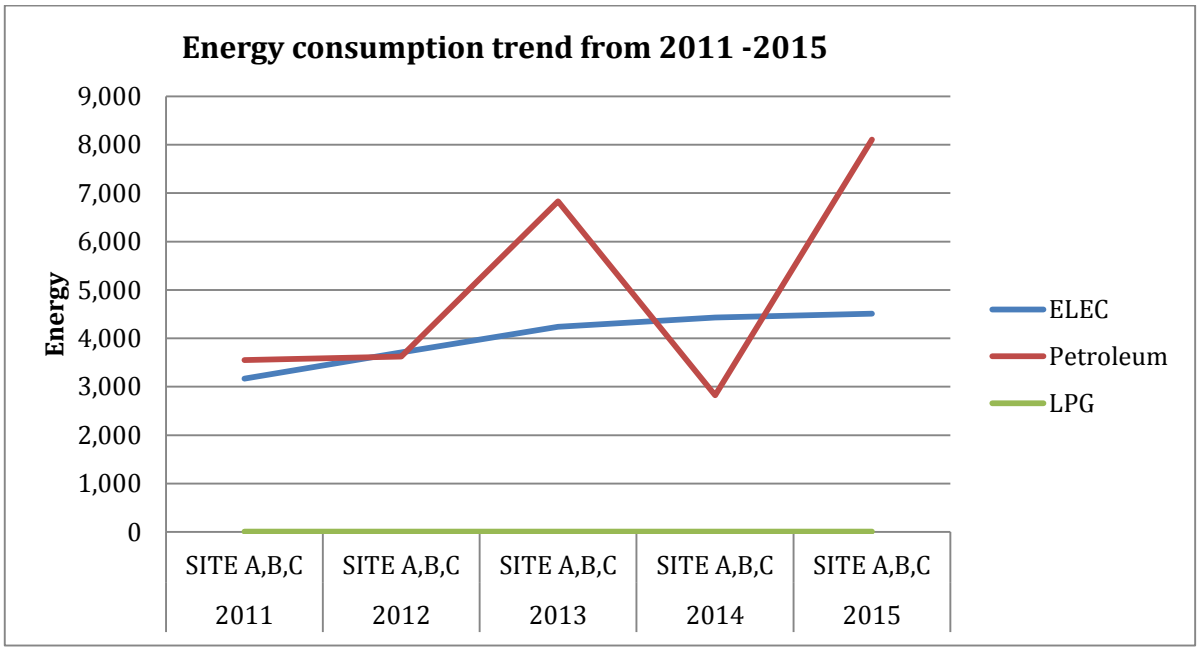

Figure 4: Trend In Energy Consumption In Sites A,B And C From 2011 To 2015.Source; Author (2019).

Petroleum on the other hand is the largest and most important energy source for modern society. Besides providing the fuel used in the thermoelectric power plants, it's a key energy source, other fuels are petroleum-derived such as gasoline, kerosene, and diesel, used both in automobiles and in the industries. The chemical industries are highly dependent on petroleum, since products such as plastics, asphalt and synthetic rubber are by-products extracted from petroleum. Historically the petroleum consumption has been rising – in the decades of 1970 and 1980. Fernando (2016) The

US Army burns 395,000 barrels of oil per day—about as much as the entire country of Greece. Cameron (2015)

Petroleum fuels constitute a major source of commercial energy in Kenya. It is the second largest source of energy in the Kenyan economy accounting for 22% of total primary energy consumed after wood fuel (Economic survey 2000). This is so because Kenya is a dualistic economy with a highly monetized, modem economy and a non-monetized, traditional economy. Maina (2002)

Translated to give a reflection of the overall energy consumption in all military installation of the KDF, the bar graph below shows percentage consumption of the three sources combined. An overall steady rise is seen in the electricity consumption from approximately 45% in 2011 to 55% in 2015 and 51% in 2011 to 63% in 2015 for petroleum consumption. The levels of LPG consumed remained insignificant.

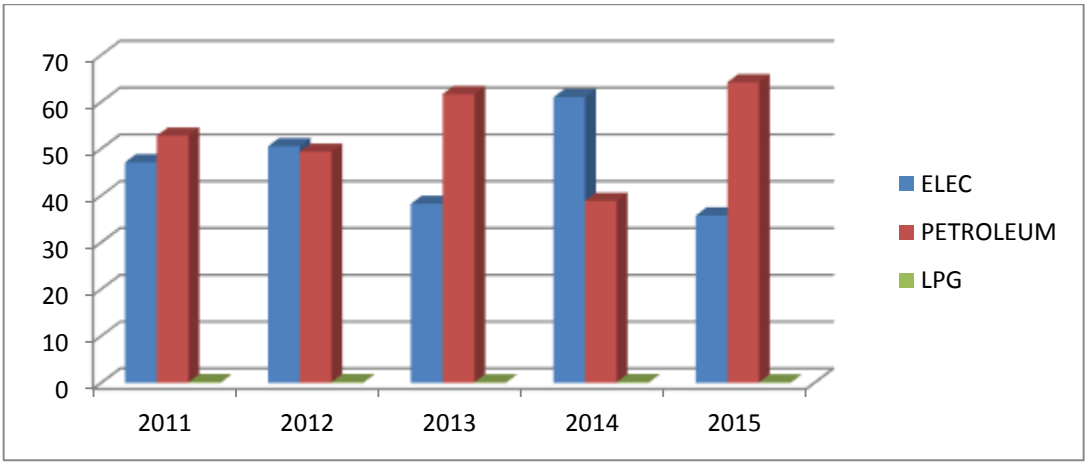

Figure 5: Percentage Energy Consumption in KDF from 2011 to 2015 Source: Author; (2019).

The increasing trend of petroleum consumption in the KDF can be attributed to the transportation requirements as well as running stationary automobiles such as generators and boilers. In his study, 'Gasoline Demand Analysis in Kenya', Maina (2002) found out that income is a statistically significant factor in determining demand for gasoline. He suggests that increase in income will increase consumption of gasoline through increased mobility i.e. increased stocks of automobile and increased miles travelled per vehicle. The income effect on petroleum consumption is a manifestation of the need for mobility by Kenyans. His argument directly augments the findings of

increased energy consumption in KDF which can be compared to the need for movement by the military from point A to point B which can only be supported by the availability of fuel. Such that without fuel the movement is restricted. He further suggests that to conserve the environment, Establishment of motor vehicle standards and technical measures aimed at controlling and reducing vehicular emissions should be employed.

LPG use is preferred over traditional fuels due to its clean burning characteristics, high calorific value, easy transportation as it can be liquefied, ozone friendliness, and is therefore, a solution to environmental degradation which is a major concern. In Kenya, use of LPG is dominated by two primary end-use applications; cooking and lighting fuel in residential and commercial establishments and as process fuel in industrial manufacturing operations. Out of the total LPG consumed in the 2000, it was estimated that the domestic sector used 57.5%, while the commerce and industrial sector accounted for 38.3%, Akinyi (2008).

In the study findings the amount of LPG used is almost insignificant < 1000 MWh and cannot match the humongous consumed Petroleum and Electricity, Akinyi (2008) further clarifies that in Kenya, LPG remains a **'lesser-used' but desired fuel source** in most households. Although the total LPG consumption in Kenya has increased over the years, raising from 37.3 thousand tonnes in 2000 to about 50 thousand tonnes in 2005 the per capita consumption is still low, estimated to be 14kg per capita by year 2005, an improvement on the per capita consumption of 1.3kg per capita registered in 2003. Its low consumption in the KDF can be attributed to high pricing as well as its bulk nature hence in society it is easily substituted by wood fuel or charcoal. A comparison between consumption of LPG and fuel wood/charcoal demand and supply is however hampered by lack of reliable data. The low consumption of LPG particularly in households has been of concern to the Government which has attempted to promote LPG use to no success. This trend is replicating itself in the KDF and can as well be attributed to market forces.

In Chapter two, Tommey (2015) explains how the US DOD is the largest consumer of power and has the highest Carbon emissions. On the contrary it may not be easy to Say that KDF is the greatest consumer of power in Kenya since this may require further studies comparing consumption trends by other Ministries in order to confirm the same.

4.3 Cost of energy.

Nuttall (2017) in "Energy and the Military: Convergence of Security, Economic, and Environmental Decision-Making" states that over the past decade, some factors that have shaped military energy decision-making include the increased focus on the costs of military energy. According to him, in FY 2011, US DoD consumed 890 trillion British thermal units (Btu) of energy, roughly 1% of U.S. energy consumption and 80% of U.S. federal energy consumption (EIA, 2012), at a cost of $19.3 billion (US DoD , 2012). The US DoD spent approximately 90 percent of these FY2011 energy costs on petroleum products. Also in FY2011, DoD consumed roughly 117 million barrels of petroleum (Schwartz et al., 2012), approximately 2% of total U.S. petroleum consumption in 2011 (analysis using EIA 2012). In FY 2011, jet fuel alone accounted for nearly 60% of total DoD energy consumption, while all petroleum-based fuels supplied about 80% (EIA 2012).

Despite a 4% decrease in DoD's petroleum consumption between FY 2005 and FY 2011, the agency's petroleum expenditures over the same period rose 381% in real terms due to rising oil prices. While still a relatively small portion of DOD's total spending (2.5% in FY 2011), the $17.3 billion spent on fuel in FY 2011 is large in absolute terms. Since 1990, the DOD's cost of buying fuel has increased faster than health care, personnel and every other major DoD budget category. Additionally, petroleum price volatility has negatively impacted DoD operating budgets and created large unfunded obligations.

Kenya in the same context depends heavily on imported oil. This import dependency teamed up with the vulnerability of domestic oil prices to international oil market prices and weakening of the Kenya Shilling against high-powered currency makes oil prices to have profound impacts on the Kenyan economy, Maina (2002).

The KDF does not exist in isolation of the market forces affecting petroleum prices, in Figure 4below an increasing trend is observed in the costs of petroleum as well as electricity. This rise can be attributed to increased demand, inflation as well as price elasticities.

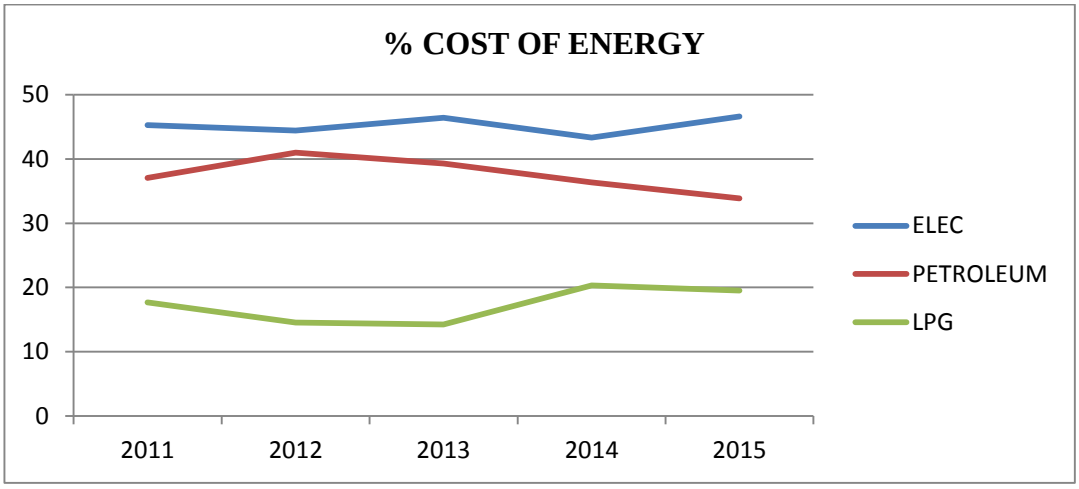

Figure 6: The percentage cost and of energy trending from 2011 to 2015in KDF. Source: Author (2019).

However, Maina (2002) argues that the price elasticities of demand for gasoline are low and statistically insignificant when it comes to analysing the cost of energy. Meaning that price policies alone cannot reduce or increase gasoline consumption. He argues that if consumption of gasoline is to be restrained or if wasteful & environmental hazardous consumption practices are to be reduced, then additional measures are required alongside the pricing policies. These may include; tax policies and public transport services policies. That increased taxes on gasoline increases the total motorist cost of operation and consequently people can switch to public transport. The government should oversee comprehensive public awareness campaign on fuel conservation and environmental management. Other measures to go together with pricing policies include adjustment of import duties to favour importation of fuel efficient and environmental friendly automobiles. This may see placing high import duties on vehicles that are too old and with inefficient engines, Maina (2002).

In Kenya Petroleum prices may also hike by way of transportation cost. The further you are from the fuel pipeline deport, the more it will cost for you to get a unit of fuel. In Kenya the fuel prices are regulated by the Energy and Petroleum regulatory authority (EPRA) (2019). Every 14th day of every month a press release is issued on the fuel prices. The fuel prices are cheaper in Mombasa where the receiving depot is, but as you move inland towards furthest corners from the Coastal town, the prices have gone up by almost Kshs 15.

The Kenyan government also in a bid to protect the environment coupled with balancing the estimated elasticities of demand for gasoline efficiency regulates the age of fleet being imported It is also important to note that energy management or environmental considerations may not necessarily motivate the government measures to allow importation of used motor vehicles.

Policies to improve road and communication systems may go a long way towards reducing unnecessary intra and inter-city journeys. For example, the chronic traffic congestion in major cities like Nairobi and the great deal of African cities can be greatly relieved with better and increased telephone services.

Sources of electricity in Kenya are hydro, thermal oil, geothermal and co-generation, with hydro being the highest contributor of electricity. Kenya National Bureau of Statistics (KNBS) data shows that all consumer categories recorded an increased demand in electricity with domestic, commercial and industrial, and rural electrification increasing by 10.8, 7.6 and 3.5% respectively, KIPPRA (2010). Standby generation involves use of generators during times of high demand on utilities to avoid extra "peak-demand" charges or during periods of power shortage and outages in order to ensure continuous supply of power. This scenario also applies to KDF where vital military installations have got high powered generator backups to supplement electricity outages. Electricity and petroleum are the greatest contributors to the aggregate cost of power in the KDF. In the fig below a percentage cost of LPG, petroleum, and electricity is seen between 2011 and 2015.

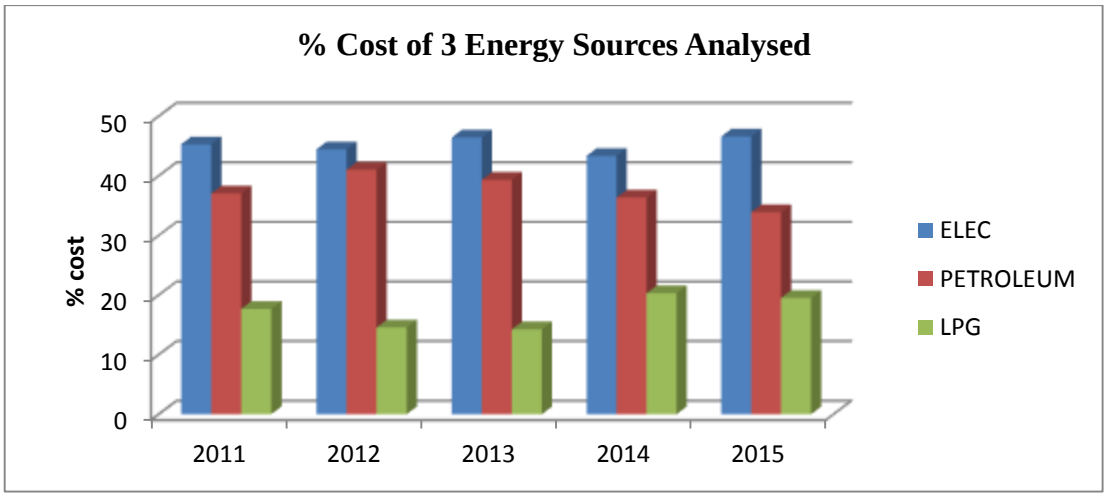

Figure 7: Percentage individual cost of 3 energy sources analysed from 2011 to 2015. Source; Author (2019).

An average of 7.34 % of the budgetary allocation to the KDF can be attributed to petroleum, LPG and electricity energy bills. This means that 92.6% of the budgetary allocation is available for other priority expenses of the KDF budget e.g. Operational, Logistical and Training. How sustainable this is a topic that can be recommended for further studies in a different study all together. The table below explains the above deductions.

SER	YEARS	UNIT COST OF ENERGY	BUDGETARY ALLOCATION UNITS	% OF BUDGETARY ALLOCATION PAID OUT IN ENERGY BILLS
1	2010/11	3.750	50.393	7.4 %
2	2011/12	3.919	57.757	6.7 %
3	2012/13	4.689	70.040	6.7 %
4	2013/14	5.289	74.577	7.0%
5	2014/15	6.343	78.781	8.9%
	TOTAL	**23.991**	**281.155**	**7.34%**

Table 4; Unit and percentages cost of energy procured yearly in relation to annual budgetary allocation. Source; Author (2019)

The politics of climate security remain obscure as many militaries remain numb on disclosing how much they spent on climate change but still connote their military missions into implying that they are committed to averting climate change, Pemberton (2016).She further explains that accounting for what the US Army spends on traditional instruments or military force is straight forward, national security is the first major category in the federal budget and constitutes 95%of the total allocation unlike spending on climate security. However, she doesn't go on to define how much of the 95% goes into energy, Pemberton (2016). In "combat vs Climate change" gives the following breakdown of how the US Army budgetary allocation is spent as follows.

MILITARY EXPENDITURES	FY 2015	FY 2016	FY 2017
Military Personnel	134962	135,330	135,269
Operation and Maintenance	195,364	197,469	205,860
Procurement	93,587	110,737	102,567
R and D	63,500	68,778	71,392
Revolving mgmt. trust funds	2,134	1,176	1,372
Military Construction	5,431	6,910	6,124
Family Housing	1.127	1,261	1,320
Overseas Contingency ops	64,334	58,638	58,798
International security assistance	8,419	8,831	8,106
ADJUSTMENTS for programmes included in the climate change expenditure	-2,436	-2,436	-2500
Total	**566,425**	**586,692**	**588,308**

Table 5; US Army Military expenditure. Source; Pemberton (2016)

Still then the climate change budget is not clear and as she explained, it is subdued or immersed in other projects and a tangible figure is not obtainable.

4.4 Environmental Implications in Terms of CO_2 Emissions.

Nuttall (2017) reviewed the leading role of The United Nations (UN) in attempting to mitigate harmful climate change caused by human activities. In Rio de Janeiro Brazil in 1992, the UN created the Framework Convention on Climate Change, which was followed in 1997 in the Japanese city of Kyoto by The Kyoto Protocol. The intention of the Convention (UNFCCC, 1992) was that major developed industrial countries would lead the way in emissions reduction.

Rodriguez (2012) states that climatic change and global warming are facts and any steps taking towards their mitigation should be considered as positives. Having studied the U.S. military forces and their domestic oil use as well as their consumption in war situations, he says that despite the number of initiatives that there are, it is not only important that these initiatives are implemented but also that military forces become aware of the importance of good use of energy and renewable

energies to decrease the number of casualties in war situations. He reiterates that the investment on research that many military forces are making is positive since it is not only useful in war theaters to win wars, but also to improve a countries' energy use and general environmental situation.

According to NEMA SNC report to UNFCC (2010) as captured in Chapter 2, Kenya's total GHG emissions were in 2002 was 54,955 Gg CO2 equivalent (approximately 55 million tons of CO2 eq.) The total amount of CO2, CH4, N2O and HFCs emitted were 28,499 Gg, 15,726 Gg, 10,611 Gg and 118 Gg respectively, totalling to 54,955 Gg CO2 equivalent. The largest contributing to GHG was carbon dioxide followed by methane. This study also focused on CO2 emissions only for analysis. Previous research on GHG emissions in KDF have been a challenge to come across. The figure 5 below illustrates the carbon emission of electricity, petroleum, and bulk gas in the study sites from 2011 to 2015. The overall trend of carbon emissions is seen to rise.

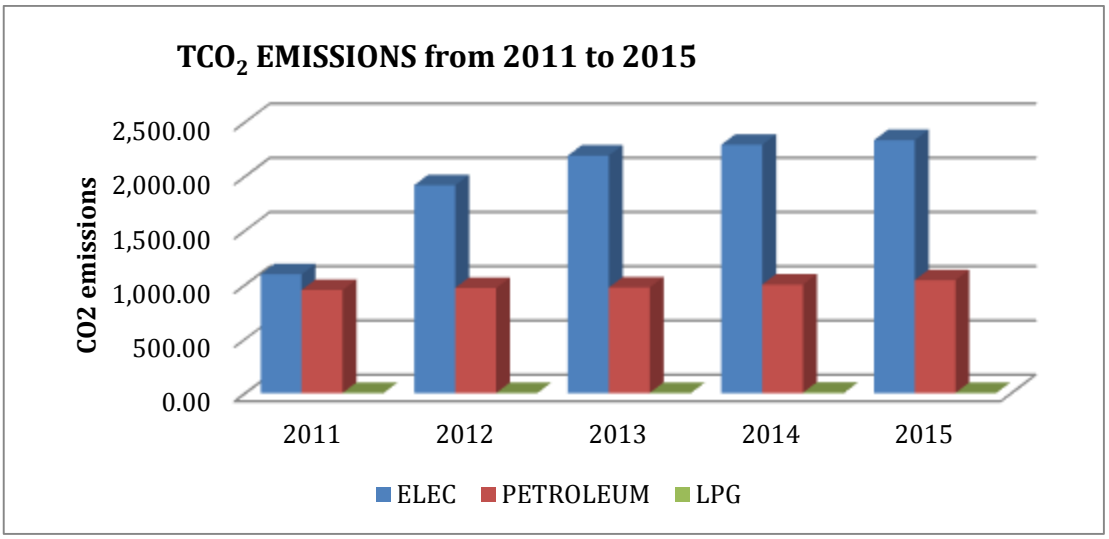

Figure 8: Total Co2 Emissions In Site A, B And C From 2011 To 2015. Source; Author (2019).

The highest levels of carbon emissions are from electricity followed by petroleum. The researcher termed the level of emissions captured above as insignificant by virtue of the fact that Kenya has little historical or responsibility for global climate change and its emissions are insignificant in relation to global emission, However the country is highly vulnerable to Climate change impacts. Being a developing country with its major population highly dependent on climate sensitive sectors like agriculture, the country has a low adaptive capacity to withstand the impacts of climate change

bearing in mind its weak institutional mechanisms, poor infrastructure and restricted budgets. With this in mind it is important for the country to invest in adaptation mechanisms to climate change.

Militaries are the most capable dynamic institutions most governments have and history has shown that military commitment to research and development can lead to breakthroughs in technology, because of the formidable budgets and research and development resources allocated to defence. For example, in the US Army, Cameron (2015) suggests existence of a Memorandum of Understanding between the Department of Energy and Department of Defence that places a strong focus on the potential benefits of a transition to RE to the United States military. In doing so, the military may "improve energy security and operational effectiveness, reduce GHG emissions in support. The country's climate change initiatives and energy price fluctuations. Security, environment, and economics can be analysed as follows;

1. **Security;** A domestic transition to RE sources contributes to long-term security of military interests installation electricity generation to renewable sources and moving away from fossil fuel sources will lessen the dependence on foreign supplies of these resource extractive fuels. Tommey (2015) further argues that moving away from reliance on petroleum will also ultimately address the long-standing irony" of sourcing our military energy needs from conflict regions.

2. **Environmental;** Since research indicates that climate change could have significant geopolitical impacts around the world, contributing to poverty, environmental degradation, and the further weakening of fragile governments. Climate change alone may not cause conflict, but it may act as an accelerant of instability or conflict, placing a burden to respond on civilian institutions and militaries around the world. Hence by Militaries to "help to reduce greenhouse gas emissions and protect our natural resources in order to slow, stabilize, or reverse climate change effects, (Tommey 2015).

3. **Economic;** Across the board, federal agency budgets have steadily declined while energy costs of all forms continue to fluctuate. At the same time, the costs associated with various renewable energy technologies decrease as innovation and development drive market competition. For example, "the average price of a completed [solar photovoltaic] system has declined by more than 40%" in the last three years. Similar trends have occurred

in other renewable energy generation fields. The ability of the military to sign long-term contracts for these developing technologies allows it to hedge against volatile energy costs.

4.5 An Evaluation of the Existing Frameworks Governing Energy Use in KDF.

4.5.1 The Kenyan Constitution (2010) and Energy Regulation.

The promulgation of the Constitution of Kenya 2010 marked an important chapter in Kenya's environmental policy development in the context of climate change. Hailed as a 'Green Constitution', it includes elaborate provisions with considerable implications for sustainable development. These range from environmental principles and implications of Multilateral Environmental Agreements (MEAs), to the right to a clean and healthy environment as enshrined in the Bill of Rights. Chapter V of the Constitution is entirely dedicated to land and the environment. It also incorporates a host of social and economic rights which are of environmental character such as the right to water, food, and shelter, among others.

Following sessional paper no.4 of 2004, the government enacted Energy Act (2006), which converted then Energy Regulatory Board (ERB) to Energy Regulatory Commission, ERC (2007) which was mandated by the Act to offer regulatory stewardship to electricity, petroleum and renewable sub sectors.

In March 2019 the Energy Act (2019) was enacted which converted the ERC (2007) to the Energy and Petroleum Regulatory Authority EPRA (2019) and it has an expanded mandated with the following roles;

a. To Regulate;

   i. Generation, importation, exportation, transmission, distribution, supply and use of electrical energy with the exception of licensing of nuclear facilities;

   ii. Importation, refining, exportation, transportation, storage and sale of petroleum and petroleum products with the exception of crude oil;

iii. Production, conversion, distribution, supply, marketing and use of renewable energy;

iv. Exploration, extraction, production, processing, transportation, storage exportation, importation and sale of coal bed methane gas and other energy forms;

b. Regulate, monitor and supervise upstream petroleum operations in Kenya in accordance with the law relating to petroleum, the regulations made there under and the relevant petroleum agreement;

c. Provide such information and statistics in relation to upstream petroleum operations in Kenya to the Cabinet Secretary responsible for matters relating to petroleum as may be required from time to time;

d. Collect, maintain and manage upstream petroleum data;

e. Receive, review and grant an application for a nonexclusive exploration;

Other institutional frameworks enforced by this act include;

a. Rural Electrification Authority (REA)

b. Energy Tribunal

c. Geothermal Development Company (GDC)

d. Kenya Electricity Transmission Company (KETRACO)

With all these institutions in place, the future of energy sector in Kenya is bright. Green Electricity is the future energy. Government efforts to increase power generation are in Geothermal and wind sources of electricity. The GDC has a programme to increase the number of wells in Olkaria, KPLC has signed an PPA with Lake Turkana Power Company to supply 300MW of electricity. Increased

activities in exploration of Hydrocarbons in the Northern and Coastal parts of Kenya began. (Ngamia one) lastly, future government policies are geared towards improvement of the working modalities with Public Private Partnerships (PPPs) all these are geared towards achieving Vision 2030,KIPPRA (2019).

The Kenya National Climate Change Action plan (2013 -2017) emphasises on the Government of Kenya's commitment to mitigating Climate Change and its impacts on development by enforcing low carbon climate resilient environment, Enabling policy and regulatory framework, adaptation and mitigation.

4.5.2 The Defence White Paper (2017)

KDF (2017) in "Defence White Paper" is The National Defence Policy, and it guarantees protection against internal and external threats to Kenya's sovereignty and territorial integrity. It is Kenya's defence policy and provides a broad guideline from which KDF draws the way to carry out its obligation. In part, the following objectives are highlighted;

a. Quick response to varying degrees of threat without risking escalation of the level of conflict.

b. In peacetime, a balance of power that does not encourage an arms race and defence capability that is convincing enough to deter coercion or aggression.

c. In time of crisis, readiness for effective defence that is easily and immediately demonstrated in order to solve crises without resorting to use of lethal force.

Part II para 2.1 under the threats and opportunities, The KDF acknowledges that prevailing strategic security environment is characterised by social, economic and environmental concerns; that the world is faced with a population explosion estimated to rise to 10 billion by 2050 and the implication will be increased competition over diminishing resources resulting in increased conflicts. That MDGs have failed to meet their goals and the international community introduced Sustainable Development Goals expected to end poverty and improve global security, KDF (2017 p8).

In Part III, Environmental degradation is recognised to have distinct connection to resource based conflicts, erratic climate patterns resulting in scarcity of resources such as water and pasture which escalate internal conflict. Hence military activities should aim minimizing the destruction of environment and degradation of the habitat for both wildlife and human habitation.

4.4.2 The Energy Management and Environmental Conservation Policies

The Kenya Defence Forces has an Energy programme here in referred to as the Energy Management and Energy Conservation Programme (EMECP) that has been in use as an Energy policy guideline since (2011); Sourcing and optimally utilizing energy cost effectively, Promoting the use of sustainable energy sources and achieving and maintaining a carbon neutral (green) status and participating fully in the Government Energy and Environmental Campaign in line with Kenya Vision 2030.

a. Strengths of EMECP

i. Establishment of EMECP committees and responsibilities
ii. Establishment cost centres, coordinators and auditors.
iii. Monitoring and Reporting mechanisms
iv. Promotes Environmental awareness,
v. Acknowledges significance of energy efficiency and environmental conservation,
vi. Recognises RE as key to creating sustainable and independent future energy supply
vii. Defined Green/ Carbon Neutral status and how it shall be achieved.
viii. Proposes funding for the Energy projects.

b. **Weaknesses of EMECP**

i. Absence of an Implementation strategy
ii. Does not promote introduction of Energy Management Systems ISO EMS 50001:2018
iii. Absence of Regulatory Framework.

c. **Challenges faced by KDF in Energy Use.** The following areas pose a challenge in the KDF when it comes to energy and its utilization;

i. Establishing effective energy and environment management systems.
ii. Utilizing energy efficiently.
iii. Encouraging behaviour change towards efficient energy use and environment conservation.
iv. Incorporating energy efficiency into existing equipment and facilities, and in selection and purchase of new equipment.
v. Increasing use of renewable energy.
vi. Minimizing greenhouse gas emissions.
vii. Continuously striving to achieve a green status.

Despite there being an energy policy in place in the Kenya Defence Forces, the lack of comprehensive studies on RE is greatly evident. Limited previous studies in this area poses a great challenge to researcher interested in venturing the RE path, notwithstanding the fact that access to data is also a challenge for various security reasons.

4.5 Possible Sustainable Interventions

Three recommendations to answer objective 5 were recommended in favour of reviewing and strengthening the current policy, measures to enhance efficient utilization and measures involving introduction of alternative sources.

4.5.1 Policy Review and Formulation of Implementation Strategy

This should be done with immediate effect in order to strengthen the existing EMECP (2011). To achieve a Carbon Neutral Status, the researcher proposes that it should be clearly stated in the policy that; The Kenya Defence Forces should strive should strive to achieve carbon neutral status through reduced energy emissions as follows.

a. Create a monitoring system for all emissions and their impact on the environment (Green Audit) and continuously quantify energy use.

b. Continuously research into new energy efficiency and renewable energy technologies and adopt them whenever technically and economically feasible.

c. Continually reducing net emissions to a minimum by bench marking allowable running conditions for motor vehicles, aircrafts, ships and boilers among others.

d. Recycling waste materials as opposed to burning as a better option.

4.5.2 Measures to Enhance Efficient Utilization. EMS 50001:2018

Energy efficiency and environmental conservation involves identifying a scope, establishing objectives, significant risks and opportunities, identifying external providers, documenting, root cause analysis, auditing and certification for the Kenya Defence Forces. EMS will also go a long way in to reducing energy consumption and carbon dioxide emissions through energy efficiency. Setting requirements for running equipment and facilities, ensuring the procurement and installation of new equipment and facilities meet the minimum set standards for energy efficiency and environmental concern and to carry out energy performance assessment of major energy utilities at the end of set life spans to establish energy economic viability. This has been discussed in relation to two (2) energy forms currently in use as follows;

a. **Grid Electricity**

1) Automation of switching system.
2) Adoption of LED vs. normal tungsten bulb.
3) Training of personnel to manage and spearhead energy systems.
4) Awareness campaigns through seminars, barazas and other aids.
5) Sensitization of all military personnel on the KAIZEN productivity improvement programme.
6) Appointment of energy management wardens.
7) Purchase of ECO friendly appliances.

b. **Bulk Gas**

1) Use of enclosed burners.
2) Reduction on leakages.
3) Use of cookers/ burners with different burner sizes.

4.5.3 Measures Involving Introduction of Alternative Sources

The Renewable energy strategy recognizes that renewable energy is key to creating a sustainable and independent energy supply for the future. While choosing the various alternatives it is important to consider their initial cost, accessibility and suitability for given environment.

a. **Solar Energy**

This form of energy is abundant and can be used in the following applications that are technically and economically viable.

1) Replace the use of electrical water heaters with solar water heaters.
2) Integrate the use of solar hybrid systems for powering electronic equipment, especially those which are primarily used during the day.
3) Maximise the use of portable solar generation technology (including hybrid systems) to reduce dependence on fossil fuels for electric power generation in operation areas.
4) Replace and install technically and economically viable solar street lighting.

b. **Wind Energy**

Wind is universally available in all parts of the country. In some areas wind speeds are much higher and can be harnessed as a source to generate electricity. Therefore, the following can be considered:

1) Carrying out wind energy surveys in areas of high potential, like SITE B

2) Integrating wind turbines to supplement energy used for pumping water.

3) Integrating wind turbines to hybrid energy systems which have storage capability.

c. **Biogas**

Biomass, when used sustainably, is an appropriate source of renewable energy. Organic waste generated from animals and plants can be converted in digesters into biogas, which is a reliable and renewable source of energy. This can be achieved by:

1) Assessing the feasibility of using biogas at all the stations with a high concentration of personnel or animal life
2) Where technically and economically feasible, build bio-digesters to produce biogas in stations with a high concentration of personnel or animals for example at the Site B.
3) Adopting the use of efficient cook stoves to reduce the rate of fuel wood consumption.
4) Enhancing the tree planting program to ensure that the total amount of new trees planted and sustained exceeds the total wood fuel used.

d. **Waste Resources**

Most of the solid waste generated can be salvaged and turned into an energy resource, thereby reducing the pressure on the environment while maximizing on resource efficiency. This shall be done by:

1) Categorizing and segregating waste so as to isolate wastes which can be salvaged into useful energy.

2) Where technically and economically feasible, installing appropriate technologies which can convert waste materials into energy for cooking and reduce the dependence on firewood.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

The study aimed at establishing an analysis of energy consumption patterns and carbon footprints of selected units of the Kenya Defence Forces and establishing lessons and policy implications. This section includes the implications of the findings from theoretical and practical considerations, the research limitations, suggestions for further research and the policy implications.

5.1 Conclusions

At the end of the study clear statistics and explanations on the modes of implementation of the study were outlined and explicit explanations offered to defend them. The study outcomes are convincing that there was an increasing trend of energy consumption in the period 2011 to 2015 and that the trends were related to the cost of energy either directly through energy demand and increased energy needs or indirectly through inflation, poor policies and their lack of implementation. High peaks were achieved between 2011 and 2015 which directly reflected on unclear policies and the absent implementation strategy.

In investigating the cost of energy (Electricity, LPG and Petroleum) compared to total budget allocation between 2011 and 2015, 7.34% of the total budget was used in procurement of the analysed sources. However, this percentage is exclusive of other forms of fuel like Jet fuel used by the Kenya Air force amongst other energy expenditures not captured. So the question of whether the expenditure is sustainable can be recommended for future studies.

On CO_2 emissions, the levels discovered were regarded insignificant owing to the fact that Kenya in itself has not hit the headlines on being a serious polluter. So a small amount of emission from KDF may not meet the threshold of analysis. However, the importance of the military in driving the country into achieving great research and innovation on how Kenya can achieve and establish adaptive features to climate change were greatly discussed.

The existing energy policing policies in the KDF are inadequate and thus require to be strengthened by a review and formulation of a comprehensive implementation strategy in order to achieve their set goals of low carbon emissions as well as investment into RE sources to achieve energy efficiency. The importance of considering introduction of the Energy Management Systems EMS;

50001:2018 into the KDF seems far from being achieved but if approached with serious commitment it will go a long way in achieving a "*Green military"*

The KDF has good future prospects in its quest to engage measures to embrace RE and achieve low status carbon emissions. In as much as this study may not have established the extent to which other sub-Saharan armies' energy consumption patterns and their perception on climate change, it is assumed that the KDF is on the track towards achieving a green status ahead of other African militaries.

5.2 Recommendations

Recommendations for further research in the following areas are proposed;

5.2.1. Liaison or collaboration on how militaries can best interact with civilian counterparts in energy, it was observed that there is an unhelpful separation, organizationally and socially, between experts involved in civilian energy policy and innovation and their colleagues concerned for military strategy and planning.

1.2.2. Comprehensive analysis of knowledge attitudes and practice of soldiers towards energy consumption and its effects on energy consumption.

Lastly it is of importance to state that this study was successful because the findings have perfectly fulfilled the specific objectives and will go a long way into solving the existing problems.

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6.0 STRUCTURED QUESTIONNAIRE TO POLICY MAKERS AND UNIT COMMANDING OFFICERS

ANALYSIS OF ENERGY CONSUMPTION PATTERNS AND CARBON FOOTPRINTS OF SELECTED UNITS OF THE KENYA DEFENCE FORCES: LESSONS AND POLICY IMPLICATIONS

Introduction:

My name is……..……., I am a Master of XXXX student at XXX School - University of Nairobi. The questionnaire is meant to assess cost effective energy management options for uptake by the Kenya Army. Kindly fill this questionnaire to enable me collect data for this study. Thank you for taking the time to complete this questionnaire for the above research on The Kenya Army.

Instructions:

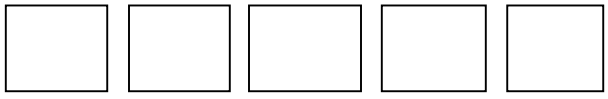
Request that you please give a verbal consent to be a participant in this study, before we begin. Kindly answer the questions by writing a brief statement or ticking in the boxes provided as applicable. The information provided will be treated as strictly confidential and at no instance will your name be mentioned in this research. This research is intended for an academic purpose only

Consideration:

The study is aimed at helping to make important decisions on the use of alternative energy sources and implementing measures for reducing energy consumption. Kindly note that this study has been cleared to be undertaken by the Kenya Army and so your opinion counts.

Section: Bio-Information

1.Age Group? 18-20 21-30 31-40 41-50 51-60



2. Gender? Male ☐ Female ☐

5. Education level?.....

6. Military unit?.....

7. Your specialization?.....

8. What are some of the energy sources currently available to the Kenya Defence Forces (KDF)?

Gas	Fuel	Electricity	Firewood	Others
☐	☐	☐	☐	☐

9. Ever heard of renewable energy? Yes ☐ No ☐

10. Which types of renewable energy are you familiar with?

Hydroelectric	Solar	Wind	Biomass	Geothermal	Nuclear
☐	☐	☐	☐	☐	☐

Section B: Cost effective energy management

Please rate (give scale) where necessary the following statements on cost effective energy management options for uptake and give your main justifications for the answer.

Where 1 = Very much; 2 = Moderate; 3 = A little; 4 = Not at all, 5 = Do not know; respectively.

11. To what extent do you believe that reducing energy consumption is a good idea?

Rate.....

Justification.....
.....
.....

12. To what extend do you believe that action needs to be taken immediately to reduce energy consumption?

Rate.....

Justification.....
.....

13. To what extend have you personally taken steps to reduce your consumption of energy?

Rate.....

Justification.....
.....

14. To what extent do you think the Kenya Army should invest money in reducing energy consumption?

Rate.....

Justification.....
.....

15. To what extent do you feel the Kenya Army should be more active in providing information on ways to reduce energy consumption?

Rate.....

Justification.....
.....

16. To what extend do you understand the Energy management and energy Conservation policy (EMECP)?

Rate.....

Justification.....
.....

- THANK YOU FOR PARTICIPATING

7.0 DATA EXTRACTION TOOL (MATRIX)

NAME OF SITE _____ DATE _____								
NO.	**YEARS**	**FIREWOOD**		**ELECTRICITY**		**BULK GAS**		**REMARKS**
	Averages	Tonnes	Kshs.	Kilowatts	Kshs.	litre	Kshs.	Others

Table 6; Data Collection Matrix. **Source** Author (2019)

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