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BARRIERS AND DRIVING FORCES FOR INDUSTRIAL ENERGY EFFICIENCY IMPROVEMENTS IN KENYA

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DECLARATION

I, Gachuri Amon Kevin Kirathe, declare this as my original work and to the best of my knowledge, no part of this report has been presented elsewhere for the Master's Degree award.

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ABSTRACT

Kenya having a Vision 2030 of transforming into an industrialized, middle income country has plans of increasing its power generation to meet the growing demand by the industries. However, this has to be done in a sustainable way to avoid any externalities. Since the introduction of Vision 2030 in 2008, Kenya has significantly expanded its renewable energy in order to generate a reliable and affordable energy while producing little or no greenhouse gases emissions. The Kenyan Government through sensitization, has ensured that high energy consumers take up energy management measures by adopting more efficient energy technologies and introduction of conservation measures within their organizations. Over the years, the government of Kenya has made tremendous progress towards energy management. This commitment has been seen with the introduction of the Energy Management Regulation of 2012. This regulation calls for the integration of energy management measures including the mandatory energy audits and drafting of energy management measures of which should be implemented within three (3) years, after the audit. This explorative and qualitative research was conducted to study the barriers and driving forces manufacturing industries have been facing in implementing the energy management recommendations drawn after the mandatory energy audit.

In order to get a clear picture of the barriers and driving forces, interviews were done using questioners and where possible face to face interviews of energy managers and others that are directly responsible for the conversion and consumption of energy within the manufacturing companies. A quantification method of the questions and results was used, 0 being least important to 10 being most important, so as to make it simpler for the respondents to rank their barriers and driving forces. This study was however limited to the manufacturing industries in Machakos and Nairobi Counties. Out of 15 requests, a total of seven (7) industries agreed to participate in the research. They were from the food processing, paper processing, food, soap and detergent manufacturing, petrochemicals and chemical and plastic product industries. All of the interviewed companies had complied with the energy management regulation of 2012; out of the seven (7) industries, four (4) companies had received their Energy Compliance certificate from the Kenyan Energy Regulatory Commission and the other three (3) were still being assessed or processed by the energy regulator.

The main barriers were found to be economic barriers and organizational barriers including but not limited to lack of funds and lack of time or other priorities by top management. The main driving forces were found to be market and policy related including but not limited to the adoption of energy

efficient technologies in order to reduce operation costs, thereby leading to increased profit margins and the introduction of the Energy Management Regulation of 2012. A number of recommendations were drawn from the study that ranged from policy to organizational related including the introduction of incentives by Kenyan Government to companies that complied with directives, and the improvement of energy sizing of equipments within the organization.

RÉSUMÉ

Le Kenya ayant une Vision 2030 de transformer en un pays industriel à revenu intermédiaire a l'intention d'augmenter sa production d'électricité pour répondre à la demande croissante des industries. Cependant, cela doit être fait de manière durable pour éviter toute externalité. Depuis l'introduction de Vision 2030 en 2008, le Kenya a considérablement élargi ses énergies renouvelables afin de générer une énergie fiable et abordable tout en produisant peu ou pas d'émissions de gaz à effet de serre. Le gouvernement Kényan, par la sensibilisation, a veillé à ce que les consommateurs d'énergie élevée adoptent des mesures de gestion de l'énergie en adoptant des technologies énergétiques plus efficaces et en introduisant des mesures de conservation au sein de leurs organisations. Au fil des ans, le gouvernement du Kenya a fait d'énormes progrès en matière de gestion de l'énergie. Cet engagement a été observé avec l'introduction du Règlement sur la gestion de l'énergie de 2012. Ce règlement prévoit l'intégration de mesures de gestion de l'énergie, y compris les audits énergétiques obligatoires et la rédaction de mesures de gestion de l'énergie qui devraient être mises en œuvre dans les trois (3) ans après l'audit. Cette recherche exploratoire et qualitative a été menée pour étudier les obstacles et les industries de fabrication des forces motrices ont été confrontées dans la mise en œuvre des recommandations de gestion de l'énergie élaborées après l'audit énergétique obligatoire.

Afin d'avoir une image claire des obstacles et des forces motrices, des entrevues ont été réalisées à l'aide de personnes interrogées et, si possible, des entrevues en face à face avec les gestionnaires de l'énergie et d'autres personnes directement responsables de la conversion et de la consommation d'énergie au sein des entreprises manufacturières. Une méthode de quantification des questions et des résultats a été utilisée, 0 étant le moins important pour 10 étant le plus important, de manière à rendre plus simple pour les répondants de classer leurs barrières et leurs forces motrices. Cette étude était cependant limitée aux industries manufacturières dans les comtés de Machakos et de Nairobi. Sur 15 demandes, un total de sept (7) industries ont accepté de participer à la recherche. Ils proviennent de la fabrication de produits alimentaires, de traitement du papier, de produits alimentaires, de savon et de détergents, de produits pétrochimiques et de produits chimiques et plastiques. Toutes les entreprises interrogées se sont conformées au règlement de gestion de l'énergie de 2012; Parmi les sept (7) industries, quatre (4) entreprises avaient reçu leur certificat de conformité énergétique de la Commission de réglementation de l'énergie du Kenya et les trois autres (3) étaient encore évaluées ou traitées par le régulateur de l'énergie.

Les principales barrières ont été des barrières économiques et des obstacles organisationnels, y compris, mais sans s'y limiter, le manque de fonds et le manque de temps ou d'autres priorités par la haute direction. Les principales forces motrices se sont révélées être liées au marché et à la politique, y compris, mais sans s'y limiter, l'adoption de technologies éconergétiques afin de réduire les coûts d'exploitation, ce qui a entraîné une augmentation des marges bénéficiaires et l'introduction du Règlement sur la gestion de l'énergie en 2012. Un certain nombre Des recommandations ont été tirées de l'étude allant de la politique aux relations organisationnelles, y compris l'introduction d'incitations du gouvernement Kényan aux entreprises qui ont respecté les directives et l'amélioration du dimensionnement énergétique des équipements au sein de l'organisation.

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ABBREVIATIONS

COP	Conference of Parties
EMA	Energy Management Act
GDP	Domestic Product
HFO	Heavy Furnace Oil
IDO	Industrial Diesel Oil
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization of Standardization
HVAC	Heating Ventilation and Air Conditioning
KenGen	Kenya Generating Company
KAM	Kenya Association of Manufacturers
LEDs	Light Emitting Diodes
PRVs	Pressure Reducing Valves
REN 21	Renewable Energy Network for the 21st Century
TPH	Tones per Hour
UN	United Nations
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Conversion on Climate Change
USD	United States Dollars
SDG	Sustainable Development Goal

CHAPTER ONE

1.0 INTRODUCTION

International bodies like the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC) in collaboration with professionals across various fields have for the past decades been assessing the causes, impacts and possible response strategies to climate change (IPCC, 2007). One of the main causes was found to be a rise in global temperatures due greenhouse gases emissions. The greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and water vapor of which are mostly emitted due to anthropogenic activities like farming and manufacturing. These emissions have caused the gradual rise in global temperature causing catastrophic weather patterns like floods and droughts (EPA, 2017).

In IPCC report (2007), one of the proposed response strategies, with regards to energy, was the utilization of renewable energy like solar, hydro and wind that emit little or no greenhouse gases as compared to the utilization of hydrocarbons. The other suggested strategy was the rolling out of energy efficiency programs in an effort to reduce the emissions per energy unit used (IPCC, 2007). According to REN 21 (2016), the two options of using renewable energy and energy efficiency are viable for the achievement of sustainable development goal (SDG 7) of ensuring access to affordable, reliable, sustainable and modern energy for all (REN21, 2016).

Majority of the countries got committed to scaling up energy efficiency programs and renewable energy through Intended Nationally Determined Contributions (INDCs) in Paris 2015, in a bid to limit global warming to below 2 degrees Celsius. A total of 167 countries were committed to energy efficiency, while 147 nations were committed to renewable energy and others to policy reforms in non-renewable energy (REN21, 2016). Kenya is one of the states that ratified the Paris agreement on Climate Change during COP 22 gathering in Marrakech, Morocco. Even though Kenya's total global emissions contribution was less than 0.1%, the President (President Uhuru Kenyatta) assured Kenya's commitment to ratify the agreement through the submitted INDCs through energy efficiency programs (Kenya Ministry of Environment & Natural Resources, 2017).

Prior to 2015, Kenya's commitment to energy management dates back to 2012 where all industrial, commercial and institutional users of energy, that are consuming more than 180,001 KWh per year (equivalent to 648,004 MJ per year) had to comply with the Energy Management Regulation, 2012

of Legal notice 102 dated 28th September 2012. This regulation came about from the Energy Act 2006 Section 105 of which the Energy Regulatory Commission (ERC), published in the Kenya Gazette notice 12928 dated 13th September 2013 that the medium to high energy consuming facilities shall comply with the regulation. Failure to do so, the institution's top management shall be subjected to either or both a fine of 1,000,000 Kenya Shillings or one year imprisonment for neglect or misrepresentation. A fine of 30,000 Kenyan Shilling per day for non-compliance on submission of documentation including an audit and implementation plan within six months of the end of the financial year after the audit and an implementation report 12 and 24 months after (ERC, 2017).

According to the Energy Management Regulation of 2012, institutions should comply by conducting an Energy Audit once every 3 years in order to identify real implementable projects and it has to be done by a licensed ERC Auditor. The institution must set up an Energy Management Committee, designate an energy officer and develop an internal energy policy. In the energy policy there must be a developed energy investment plan for next 3 years. Submission of annual implementation reports is mandatory to show progress against plan containing measurement and verification. Institutions within 3 years must implement at least half of the savings identified in the audit and a record of at least 5 years must be maintained for all water and fuel bills (ERC, 2017).

Energy efficient technologies offer considerable promise in reducing financial costs and environmental damages associated with energy use, but these technologies appear not to be adopted by industries and business to the degree that would apparently be justified (Gerarden et al., 2015). This may be associated with the different engineering and economic approaches to energy efficiency. Hence, technology analysts must link both the empirical findings to a well-articulated theoretical framework while economists must recognize that theoretical assertions are meaningful only when they stand up to empirical scrutiny (Sanstad & Howarth). In view of these, this research aimed at outlining the barriers and driving forces of energy efficiency by linking both the theoretical assertions and empirical findings.

1.1 Overview of Energy and Industrial Sector in Kenya

1.1.1 Energy Sector

The Government of Kenya has set forth its vision 2030 program that aims to turn Kenya into a newly industrialized, middle-income country. The energy and industrial sectors have been recognized as one of the major foundations that needed to be developed so as to achieve this goal (Deloitte, 2016). According to the Energy Regulatory Commission of Kenya, energy needs of the country are derived primarily from three main sources namely wood fuel, petroleum and electricity that account for 66%, 22% and 9% of the total energy, respectively (ERC, 2017).

Demand for wood fuel in Kenya is approximately 3.5 million tons per year while supply is at 1.5 million tons per year (Deloitte, 2016). This has led to deforestation, destruction of animal habitats and climate change, thus bringing about a negative effect on other key economic sectors like the tourism sector (Deloitte, 2016). In a bid to reduce these consequences, the government has attempted to expand its power supply via electricity grid with the aim of increasing its capacity from 1,515 MW in 2011 to a projected 20,000 MW by 2031 with much priority given to renewable energy sources i.e. geothermal, wind and solar (ERC, 2011). Between 2014 and 2015, the total installed capacity was 2,299 MW. The main energy sources were Hydro, Geothermal and Thermal having respective share of 35.7%, 26.0% and 31.4% (Table 1). Within these periods, Kenya Power (the national electricity distribution company) recorded the highest sales in the commercial and industrial sector with 57% as shown in (Figure 1.1) and (Table 1.1) (ERC, 2015).

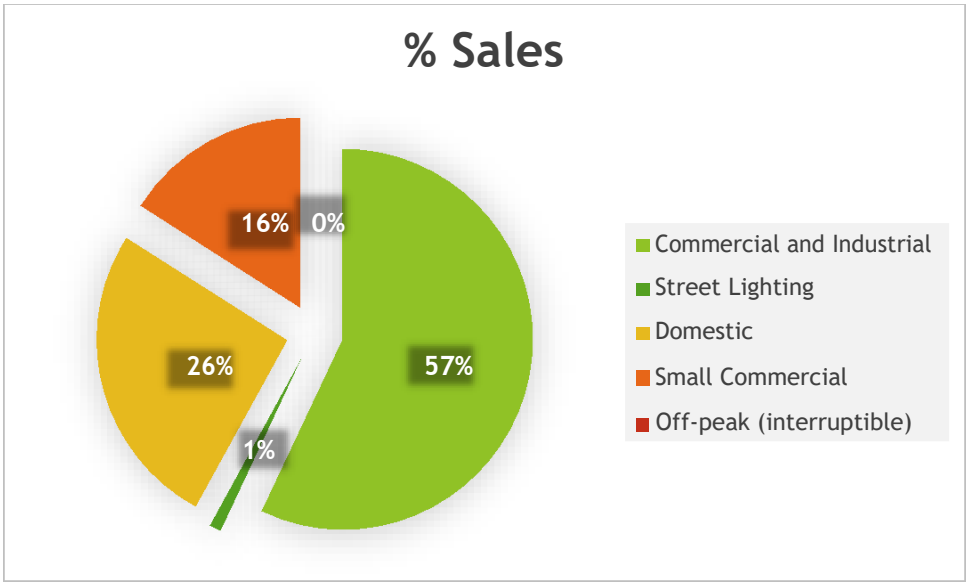

Figure 1.1: Kenya Power Sales by Customer Category (Source: ERC, 2015)

Table 1.1: Kenya Power Sales in GWh by Customer Category

Tariff	Types of Customers Covered by this Tariff	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
DC	Domestic	1,290	1,424	1,531	1,670	1,777	1,866
SC	Small Commercial	823	904	993	998	1,107	1,143
CI	Commercial and Industrial	3,153	3,401	3,440	3,440	3,819	4,030
IT	Off-peak (interruptible)	36	38	31	18	28	15
SL	Street Lighting	16	18	16	18	20	35
	Total	5,318	5,785	5,990	6,144	6,751	7,090
	% Increase P.A.	3.2	8.8	3.5	2.6	9.9	5

Source: ERC, 2015

1.1.2 Industrial Sector

Kenya is considered the most industrially developed country in East Africa with agricultural and manufacturing being the leading forms of industry. According to Deloitte (2016), the agricultural industry is by far the most prominent, important and dominant industry, contributing about 25% (approximately 15.85 Billion USD) of the country's GDP, 20% of employment, 75% of the labor force and over 50% of revenue from exports in 2015. This is mainly due to the excellent climatic conditions of the country, thus making it ideal place for growing crops, and with tea, coffee and mangoes being the major exports (Deloitte, 2016). The low levels of mechanization and technology involved makes farming slow and inexact with a lot of post-harvest losses, requiring a lot of manual labor thereby causing many children to end up working in farms most of their lives. The Kenyan government has therefore embarked on financially assisting farmers as well as helping them implement technological trainings which includes the use of modern energy efficient technologies and utilization of available renewable energy sources (Deloitte, 2016).

According to the World Bank Group (2016), the manufacturing industry accounts for about 11.8% (7.48 Billion USD) of the GDP. The manufacturing presence is in textiles, food and grain milling, cement production, milk processing and oil refining with a large portion coming from informal sector locally referred to as "Jua Kali" (Deloitte, 2016). Over the years, there has been a slow but gradual rise in manufacturing companies in Kenya; in October 2014, two major manufacturing companies namely Eveready East Africa and Mondelez (Formally Cadbury) relocated their production facility to Arab Republic of Egypt in an effort to lower production costs (land, labor, electricity and transport) and increase profits (World Bank Group, 2016).

With the vision 2030 of turning Kenya to a "newly industrialized, middle income country" the Government of Kenya has plans to establish three special economic zones (SEZ) which will help

to boost industrial manufacturing by allowing for lower tax levels and fewer regulatory hurdles. According to Oxford Business Group (2016), the SEZ's will boost manufacturing and eventually create as many as 1.5 million jobs in a year and 10 million in the next 30 years. Textile production will be the primary industry to benefit from it (Oxford Business Group, 2016). Nairobi hosts a mix of industries across the city, and mostly located in the Industrial Area at the southeast end of the central business district, sandwiched by the city center and the railway station to the west. The industries found in the area include: food processing, oil processing, cable manufacturing, motor vehicle assembly, chemical processing, engineering works and mass printing; all of these are energy intensive (Studio, n.d.). According to the Kenyan Machakos County Government (2015), industries that include the Export Processing Zone (EPZ) which is designed to facilitate the activities of licensed export oriented companies, holding the EPZ enterprise license (Manufacturing, commercial or services) are found in their Strategic Growth Plan. With this plan, the EPZ hosts three (3) cement factories, the Kenya Meat Commission, Athi River Mining, Alpharama Tannery, Athi River Steel Plant and a host of cottage based industrial concerns (Kenyan Machakos County Government, 2015).

1.2 Problem Statement

With the rising concerns of climate change and global warming due to anthropogenic activities, the lack of efficient use of energy can cause more damage to the environment. This is due to the continual emission of greenhouse gases during the generation of energy (especially energy generated using non-renewable, convectional energy sources like oil and gas). Kenya is the most industrialized country in East Africa; with its ambition of a Vision 2030 of transforming into an industrialized, middle income country, there has been plans on increasing its power generation to meet the growing demand by the industries. This necessitated, (i) the need for the construction of new power plants that require large amounts of capital by the government, (ii) the utilization of non-renewable energy sources which if not utilized in a sustainable way may cause a non-reversible disaster to the environment. This growing demand can however be controlled by implementing energy efficiency projects. The implementation of this energy efficiency projects by through either the adoption of energy efficient technologies or by integrating renewable energy sources, protect the environment and cuts down total operational costs of companies, thereby increasing profit margins of the companies. However, like in any other project, implementation of energy efficiency projects undergo driving forces and also face several barriers. These are to be considered in this project for manufacturing industries in Kenya.

1.3 Justification

This study aimed at to look for barriers and driving forces of implementing the Energy Management Act as well as ways in which the Act can be improved at a company level so as to increase the energy management drive in the manufacturing sector of the country. This will bring about the reduction in construction of new power plants by the government, and also the reduction in operation costs without compromising on quality thereby increasing the profit margin at a company level. The increased in profit margins will have positive effect on the economy, and employment growth rates due to availability of capital to support companies' expansion.

1.4 Aim and Objectives

The research work aims at providing a comprehensive overview of the present energy management strategies in Nairobi and the Machackos Industrial Area of Kenya. The objectives of the study are therefore to:

i. study the on-going energy efficiency and management strategies/measures undertaken by industries in Nairobi and Machackos Industrial Area;
ii. study major and prevailing energy efficiency driving forces in Nairobi and Machackos Industrial Area;
iii. study major and prevailing energy efficiency barriers in Nairobi and Machackos Industrial Area; and to,
iv. identify measures that can help improve energy management to bridge the present energy efficiency gaps.

1.5 Research Questions

In order to achieve the aims of the research, the under listed research questions will be addressed:

i. What are the adopted industrial energy management strategies in Kenya?
ii. How effective are these strategies/measures?

The use of written sources of information was the primary data collection methods. The use of survey forms mainly Google forms were used in data collection from respondents and where possible, face to face interviews were initiated and conducted.

1.6 Scope of the Study

This research was conducted in the Kenyan Counties of Machakos and Nairobi. It was limited to the research of manufacturing industrial plants. It involved the study of present energy management strategies of the interviewed companies, their driving forces and barriers they face in implementing energy efficiency projects.

CHAPTER TWO

2.0 Literature Review

According to update report of the International Energy Agency (IEA), there are substantial opportunities to improve industrial energy efficiency (IEA, 2011). It is estimated that the overall potential energy saving in the sector in 2010 was at least 26 EJ per year by 2030 (IEA, 2011). Much of it was captured through policies for promoting use and optimization of energy efficient industrial equipment and systems and improving overall efficiency through energy management. They recommend the government should support industry adoption of energy management protocols, mandate MEPS for electric performance, implement a package of measures to promote energy efficiency in a small and medium sized enterprises (SMEs) and put in place complementary financial policies that promote energy efficient investment (IEA, 2011).

2.1 Energy Management Strategies in African Industries

In order for countries globally to achieve energy supply security, economic competitiveness, livelihood improvements and environmental sustainability, industrial energy efficiency measures must be adopted. The adoption of these measures will bring about more economic output with little energy input (Taylor, Govindarajalu, Levin, Meyer, & Ward, 2008). In 2008, it was estimated that an investment of 90 billion USD up to 2020 could have annual energy savings totaling 600 billion USD. The investment of 90 billion USD would only have been half of what would have been required to keep up with the growing energy demand without energy efficiency interventions (UNIDO, 2011). A review by UNIDO (2011) proved that energy efficiency technologies and solutions for industries already exist. They only needed to be diffused into industrial processes, although some customization and modifications are required to fit into the process, through capacity building especially in developing countries (UNIDO, 2011).

In a study conducted in Nigeria and Kenya on the adoption of energy efficiency measures by firms in Africa (a case study of cassava processing in Nigeria and maize milling in Kenya), it was found that a number of companies adopted energy efficiency measures. This measures of which were ranked per country included good housekeeping in the various plants, better process controls, acquisition of new equipment and equipment modification as shown in Figure 2.1 (Kemp, Adeoti, Obayelu, Ndichu, & Blohmke, 2015).

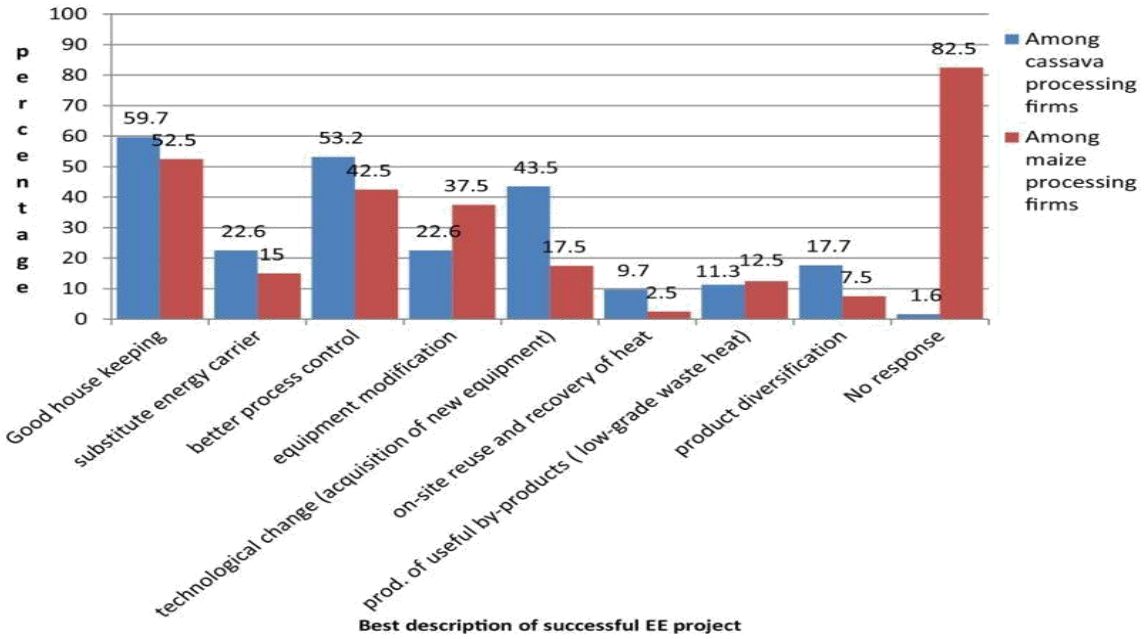

Figure 2.1: Overview of energy efficiency measures adopted. Sources of technologies. Source: (Kemp, Adeoti, Obayelu, Ndichu, & Blohmke, 2015)

In a study done in Ghana, it was found that companies in the industrial area had taken up a number of energy efficient measures. The energy efficiency measures adopted in various operations included, the metering of electricity either at site and building level or at equipment level giving a proper baseline for the assessment of energy data. Some of the companies had gone further to have monitoring and targeted schemes in the use of their electricity. The other measure the companies had taken up was doing energy audits that gave them proper analysis of the use of their energy in the plants (Apeaning & Thollander, 2013). Some of the Ghanaian companies had subscribed to ISO standards including ISO (22000, 9001 and 14001). The presence of standards enabled them to have a standard energy policy especially the firms that had adopted ISO 14001(Apeaning & Thollander, 2013).

Energy efficiency technology measures were highly reliant on electricity use. They included power factor correction. One of the respondents explained that the adoption of this measure helped the firm to reduce their annual electricity bill by 5-10%. Energy conservation measures like avoidance of idle running of electrical machinery e.g. pumps and fans (through employee sensitization using posters and labels), helped in cost reduction. The use of appropriate and efficient motors was done as a way of reducing energy costs. In other firms the rigorous inspection and sealing of compressed air leaks was taken up but not so seriously due to the lack of a proper maintenance culture

(Apeaning & Thollander, 2013). Furthermore, lighting energy efficiency measures taken up by industrial plants in Ghana to reduce their lighting costs included the replacement of tungsten lamps with compact fluorescent lamps (CFLs). In other firms, the maximization of daylight through retrofitting of the buildings was taken up to reduce lighting electricity costs (Apeaning & Thollander, 2013). Other energy efficiency measures done were in thermal applications. These measures included regulating the boiler temperature, pressure, and air-fuel ratio. The use of boiler refractory, to reduce on thermal heat loss, helped in reducing fuel consumption. Heat recovery systems and complete sealing of steam leaks were also put in place to reduce boiler fuel consumption and reduce loss of steam in distribution, thereby improving on the overall steam system efficiency (Apeaning & Thollander, 2013).

Other energy management strategies include the integration of renewable energy and waste recovery strategies into processes. A case example is the use of bagasse, which is the residue left after the extraction of juice from sugar cane, in power generation or in direct heating of sugar processes. One of the main sugar manufacturing companies in Kenya i.e. the Mumias Sugar Company Limited, has taken up this practice. They have set up a 35 MW bagasse based cogeneration plant. Out of the 35 MW generated only 10 MW is consumed by the company and the rest is injected into the national grid at a feed-in-tariff negotiated by the company with the national utility company Kenya Power through a Power Purchase Agreement. The electricity is generated by turning turbines using steam generated by a 150 TPH high pressure (87 Bar) boiler. Studies that were done on this project showed a projection of GHG emission reduction of 955,215.68 tCO_2e over the period of 10 years. This is due to the fact that bagasse when combusted using efficient methods and technologies produces less CO_2 emissions as compared to the combustion of HFO and diesel during power generation (UNFCCC-Clean Development Mechanism, 2006)

2.2 Driving Forces of Industrial Energy Efficiency

A driving force is seen as a factor that can reduce or overcome a barrier. With reference to energy efficiency a driver is referred to as a factor that can promote the adoption of cost effective energy efficient investment (Thollander & Ottosson, Exploring energy management in the Swedish pulp and paper industry, 2009). Driving forces to energy efficiency are divided into, market related,

energy policy related, organizational and behavioral factors (Thollander & Ottosson, Exploring energy management in the Swedish pulp and paper industry, 2009).

Market related driving forces is when a firm has to stay competitive by reducing their energy use thereby reducing the energy costs internally. This cost reduction can also be as a way of securing a firms position in energy use as a way of dealing with the rising cost of energy prices (Apeaning & Thollander, 2013). In Ghana, the cost reduction by reduction in energy use and the treats of rising cost of energy were the main market related driving forces forcing companies into promoting energy efficiency measures internally (Apeaning & Thollander, 2013). In a study that was done in Nigeria and Kenya, the desire to save cost was one of the leading driving forces in the adoption of energy efficiency measures in cassava and maize milling plants in Nigeria and Kenya respectively (Kemp, Adeoti, Obayelu, Ndichu, & Blohmke, 2015). According to UNIDO, the adoption of energy efficiency Measures are driving forces for firms due to the fact the firms benefit directly by lowering of production costs due to lowered energy costs. The reductions in operation costs ensure that their products remain economically competitive of which is a benefit to the firm as well as at a national level due to the fact products remain affordable to the citizens (UNIDO, 2011).

Energy policy related is done by the government using energy policy instruments which include but are not limited to voluntary agreements, energy saving certificates, energy emission taxes, information dissemination, tax exemptions and investment subsidies. This is done as a way of promoting the responsible use of energy in a company or institution externally by the government (Apeaning & Thollander, 2013). In a study done in Nigeria and Kenya found support given by the government and donor countries was a major driving force in the fast adoption of energy efficiency measures. The government incentives of Energy Efficiency measures such as removal of taxes on all renewable energy technologies and support of government institutions like ERC, development partners, and campaigns by environmental NGO's in Kenya and Nigeria played the policy support for the interviewed companies' fast adoption of energy efficiency measures. The presence of local technical expertise from the local institutions e.g. universities and technical colleges in both countries played a major role in the fast adoption of energy efficiency technologies (Kemp, Adeoti, Obayelu, Ndichu, & Blohmke, 2015). In Ghana, the presence of Government efficiency requirements through the introduction of standards and labeling of air conditioners, refrigerators and lamps was a promoter of the fast adoption of energy efficiency measures by the industries

(Apeaning & Thollander, 2013). According to UNIDO, the government supports the energy efficiency drive due to the fact that it directly and indirectly benefits from the measures. It benefits in that there is more economic output without requiring additional , constrained energy supply, jobs of technical local human resources increase due to the installation, repair and maintenance of the energy efficiency technologies, there are improvements of livelihoods of people through reduction in poverty due to increased jobs, there is a reduction in import bills of energy imports like oil and gas, there is a reduction in energy insecurity due to over dependence of import of energy like oil and gas and finally there is environmental sustainability due to less contamination of environment while in transportation, generation and utilization of the energy especially in conventional energy such as Oil (UNIDO, 2011).

Organizational and behavioral factors are considered internal factors that include the way energy is viewed or taken up within a company. It involves a wholesome commitment of approaching the way energy is used and finding ways in which it can be conserved by the help of employees as a way of boosting the company's cooperate image. This is however driven by people with real ambition or managers who have an internal self-drive towards environmental conservation and implementing energy management systems (Thollander & Rohdin, 2006). In studies done in Nigeria and Kenya, it was found it was a requirement by many parent companies to adopt energy efficiency measures as a way of saving energy. The parent companies ensured their commitment through the commitment of top managers and so as to ensure the energy efficiency drive cuts across the organization, they ensured in-house sensitization about energy efficiency through trainings and putting up of posters and labels in the company premises (Kemp, Adeoti, Obayelu, Ndichu, & Blohmke, 2015). In Ghana, though the researcher acknowledges the importance of top management commitment, the research found that the information dissemination geared towards energy efficiency was low among top management. The research also found that the public campaigns towards energy efficiency were mostly done whenever there was an energy crisis in the country (Apeaning & Thollander, 2013).

2.3 Barriers to Energy Efficiency

A barrier is considered a postulated mechanism that inhibits investment in technologies that are both energy efficient and economically efficient (Sorrell, O'Malley, Schleich, & Scott, 2004). A barrier can be considered an explanation for the reluctance to adopt cost effective energy efficiency

measures derived from mainstream economics, organizational economics, and organizational and behavioral theories (Thollander, Palm, & Rohdin, Categorizing Barriers to Energy Efficiency: An Interdisciplinary Perspective).

Barriers are divided into three main categories: Economic, Organizational and Behavioral (Thollander, Palm, & Rohdin, Categorizing Barriers to Energy Efficiency: An Interdisciplinary Perspective). Based on extensive research, Sorrell Et al. (2000) compiled a barrier framework (See Table 2.1). Additional barrier of policy or political was derived from (UNIDO, 2011).

Table 2.1: Classification of barriers to energy efficiency

Economic **Non Market Failure**	• Heterogeneity • Hidden costs • Access to capital • Risk • Imperfect information
Economic **Market Failure**	• Split incentives • Adverse selection • Principle-agent relationships
Behavioral	• Bounded rationality • Form of information • Credibility and trust • Inertia • Values
Organizational	• Power • Culture
Policy/ Political	• Political instability • Weak contracting institutions • Absence of a national energy efficiency policy • In appropriate energy pricing and cross subsidies • Skill-short government • Government without adequate training facilities • Government without access to necessary hardware and software

Source: (Thollander & Rohdin, 2006) and (UNIDO, 2011)

Economic barriers are caused by market failures or by non-market failures. Market failures are considered to be the sources of potential market failure that may affect energy conservation technology adoption rates (Thollander & Rohdin, 2006). Market failures may come as a result of

lack of information leading to cost effective energy efficiency opportunities being missed, lack of split incentives leading to less interest in adopting the efficient technologies, adverse selection of goods by consumers due to other factors like price and not efficiency and lack of strict monitoring of the principle like the government may create a loop hole for agents to ignore efficient technologies (Jaffe & Stavins, 1994). Non-market failures include heterogeneity of which a technology or measure may be cost efficient in general but not in all cases, they may be hidden costs like the cost of collecting and analyzing data, limited access to capital, and risk aversion being one of the reasons why energy efficiency measures are constrained by short payback criteria (Jaffe & Stavins, 1994). In a research conducted in Nigeria's cassava and Kenya's maize milling industries, found that the high cost of financing, the lack of technical capability, uncertainty about energy efficiency projects and lack of information on appropriate energy efficiency measures were the main economic barriers towards energy efficiency in the researched countries (Kemp, Adeoti, Obayelu, Ndichu, & Blohmke, 2015). According to UNIDO, economic barriers include lack of available funds or the absence of credit, technological barriers due to unavailability of efficient technologies and lack of local technical staff to undertake the implementation of the projects, limited energy resources leading to limited fuel options, the discrepancies in discount rates due to uncertainty of future energy prices, high user discount rates, slow rate of capital turnover, perceived risks of implementing project, and high transaction costs are among the barriers (UNIDO, 2011).

Behavioral barriers are considered barriers that limit the adoption of energy efficiency due to bounded rationality, form of information, credibility and trust, inertia and values as explained below (Thollander & Rohdin, 2006). Bounded rationality is when decisions are based on rule of thumb rather than perfect information. The form of information has also to be vivid, specific, simple and personally relating to the consumers for it to be adopted by the customers. The information has to come from a credible and trust worthy source for consumers to adopt it faster. Inertia being individuals who are opposed to energy efficiency within an organization and tend to overlook efficient technologies has been an issue in the adoption of the technologies. And finally values of people with real ambition in energy efficiency lacking within an organization (Thollander & Rohdin, 2006).

Organizational barriers include power and culture. In most cases, low status of energy management may lead to lower priority of energy issues within an organization. Culture of an organization may encourage energy efficiency investments by developing a culture characterized by environmental values (Thollander & Rohdin, 2006). According to UNIDO, there is an additional barrier in policy/ political barriers. The political uncertainty/ instability make investors skeptical in investing heavily due to the risk of not paying back their investment within the required period. Weak contracting institutions of which should ensure that the consumers are well protected from exploiters either through forming or enforcing standards and labeling create a large barrier for promotion of energy efficiency within a country. The absence of effective energy efficiency policy at national level doesn't create a common objective in companies of reducing energy efficiency. The fact that energy efficiency is beneficial at company and national level the lack of a common aim creates no common framework, focus and roadmap towards efficient sustainable generation and utilization of energy. The inappropriate energy pricing and cross subsidies do not provide a conducive environment for the fast adoption of energy efficiency measures. In areas where energy is highly subsidized by the government creates an environment for companies to misuse energy due to the fact they are not paying the true price of the generation, distribution and after effects of externalities including environmental damage by fossil fuel use. Another barrier is when governments lack enough technically skilled labor to oversee energy efficiency drive in the country. This labor includes well trained government personnel i.e. policy makers and engineers. The lack of local training institutions to ensure that the supply of well qualified, trained personnel at any given time meets market demand is another major barrier. At any given time for energy efficiency drive to be successful there has to be technicians and engineers to install, repair and maintain the technologies as well as managers to oversee that the projects are done in a timely way (UNIDO, 2011).

There are studies done in Africa relating to barriers to industrial energy efficiency in Ghana in Tema industrial area. It was found that energy is poorly managed with low implementation to cost effective energy efficient technologies due to market barriers linked to the lack of government framework externally and internally lack of a standardized energy policy nor an energy management system (Apeaning & Thollander, 2013). Additionally limited access to funds internally and externally played a role in poor implementation and adoption of energy efficiency. Lack of internal access to funds was limited by the low awareness of top management to energy efficiency resulting to it being a low priority compared to operations and production.

External access was limited by the high interests rates associated with loans from banks and financial institutes. The facts underscore the importance of finding means, such as energy policy instruments for providing financial support or incentives to overcome these barriers in Ghanaian industries (Apeaning & Thollander, 2013).

2.4 Possible UNIDO Policy Solutions to Barriers to Adoption of Energy Efficiency Measures

UNIDO adopted a chart from UNDP on possible policies to overcome some barriers. This policies have been outlined in the Table 2.2 below.

Table 2.2: Possible Policy Solutions

Barriers	Policy Solutions
Lack of knowledge and market transparency	• On the spot consulting, training, motivation of top management • Energy labeling for electric appliances • Voluntary agreement of mass producers • Energy service companies service, contracting • Joint research and development projects in small and medium sized firms
Financial bottlenecks and investment priorities	• Energy service companies service, contracting • Financial incentives by governments and utilities
Disparity of profitable expectations	• Voluntary agreement of mass producers • Financial incentives by governments and utilities • Changes of tariff structures
Investor/ user dilemma	• Voluntary agreement of mass producers • Energy service companies service, contracting
Legal and administrative obstacles	• Changes of law, standards and regulations
Utility and auto producers relationship	• Energy service companies service, contracting • Changes of law, standards and regulations
Actual electricity and gas tariffs	• Voluntary agreement of mass producers • Changes of tariff structures
Lacking of externalization of external costs	• Financial incentives by governments and utilities • Changes of law, standards and regulations
	• Emissions or energy levies or taxes

Source: (UNIDO, 2011)

CHAPTER THREE

3.0 Methods

This study was carried out as a case study using semi structured interviews due to its explorative nature of study and multiple sites investigated. The companies that were targeted included the manufacturing companies in Nairobi and Machakos County that had done energy audits with regards to the Energy Management Act (EMA), 2012. The choosing of the industries was done based on contacts from my previous industry experience as well as referrals from my contacts. The main industries that were targeted were beverage and food processing, steel and aluminum, plastic products, petrochemical and chemical and energy auditors.

Contacts of the scheduled interviews were initiated by phone and through letter of requests. A total of 15 companies from across the industries were contacted and 7 accepted to participate in the study. Eight (8) did not respond. Out of the respondents who agreed, 42.9% were from food processing, 14.3% paper processing, 14.3% food, soap and detergent manufacturing, 14.3% petrochemicals and chemicals, 14.3% plastic products industries as shown in Figure 3.1. 57% of the companies that accepted to participate were from Machakos region and the remaining 43% from Nairobi region. 57% of the respondents were in senior level management and the remaining 43% were middle level management in their various companies. All the respondents were directly accountable to energy matters within the company and departments they manage.

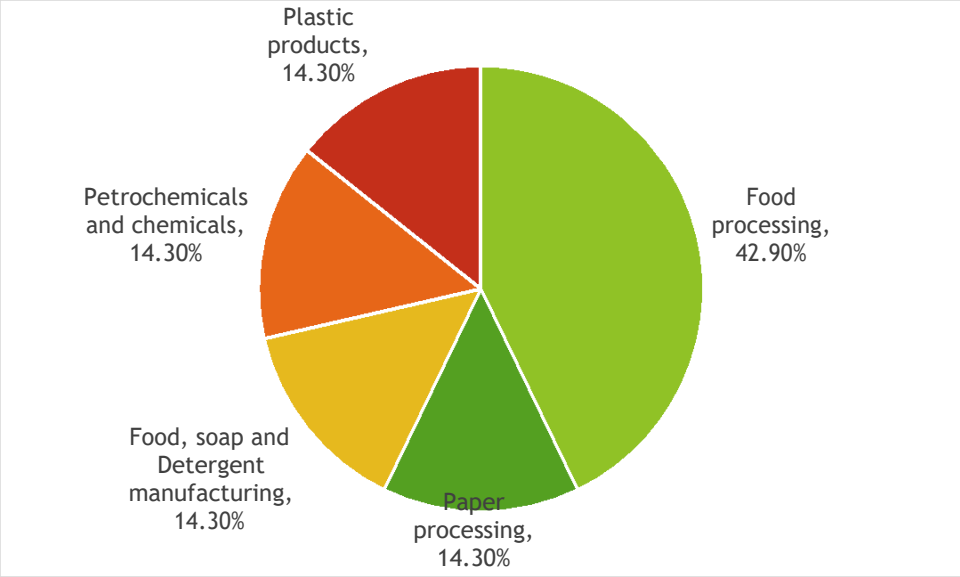

Figure 3.1: Participating Industries

Initially the interviews were to be done in two stages: (i) face to face where the respondent were asked to describe their views of the barriers and driving forces towards energy efficiency in their organization, (ii) respondents were asked to fill out Google questioners drawn from the various possible barriers and driving forces from previous studies and covering various aspects thereafter discussions and conclusions were drawn. However all of the contacted respondents suggested due to time constrain, it is best that all questions were put in the survey and for them to just fill in the questionnaire.

Questions asked were drawn from previous groupings of barriers and driving forces studies carried out in Europe and Africa. The questions were developed through a literature review of related articles in the work of Jaffe & Stavins, (1994), Gerarden, Newell, & Stavins (2015), Sorrell, O'Malley, Schleich, & Scott (2004), Thollander & Rohdin (2006), Thollander, Palm, & Rohdin (n.d), Apeaning & Thollander (2013). A quantification process of scoring 0-10, 0 being least important 10 being most important, was preferred so as to make it simpler for the respondents to rate their barriers and driving forces. Using recommendations previous studies, it was kept in mind that the respondents' answers might be biased to some degree (Apeaning & Thollander, 2013).

CHAPTER FOUR

4.0 Results and Discussion

4.1 On-going Industrial Energy Efficiency and Management Strategies/Measures

The first research question sought clarification to whether the firms had undertaken an energy audit in regards to the Kenyan regulation of EMA (2012). All of the respondents had undertaken an energy audit. Majority of the companies requested that they remain anonymous and so as to oblige to their request, the research referred them as Company 1 to Company 7.

The second research question was for all the respondents to list the top 5 main energy applications for the year 2016/2017. For consistency they were classified as Electricity (lighting and running of machine motors), thermal (heating using steam and in direct heating using Industrial Diesel Oil, heavy fuel oil or electrical heaters), cooling(use of Air conditioning, chillers and cooling towers), and compressed air. Different companies had different applications as shown in Table 4.1.

Table 3.1: Energy Applications for 2016-2017

Application	Company 1	Company 2	Company 3
Electricity	• 15,085,334 KWh	• 2,928,539Kwh	• 1,400,000 KWh
Thermal	• 36,393 MT of wood	• IDO 1,922.280 L • Steam 6206 MT	• Steam 60,000 MT

Application	Company 4	Company 5	Company 6
Electricity	• 1,380,468 KWh	• 178,495 KWh	• 460,000 KWh
Thermal	• HFO 720,000 L	-	• HFO 576,000 L
Cooling	-	• 46,945 KWh	-
Compressed air	-	• 27, 073 KWh	-

Application	Company 7
Electricity	• 152100000MJ
Thermal	• 407633000MJ Heating • 23551228 MJ Boiler Ignition and forklift LPG.
Cooling	-
Compressed air	-

As part of the study the respondents were requested to list the energy efficiency measures, initiatives or projects the company undertook after the energy audit. They were to give a brief of the savings they have seen after implementation of the projects. The results are shown in Table 4.2.

Table 4.2: Energy Efficiency Measures

Application	Company 1	Company 2	Company 3
Electricity	• Use of LED lighting • Installation of energy management system to monitor steam and power consumption per department	• Centralization of Air compressors to optimize loading based on air demand	-
Thermal	• Replacement of steam traps and valves with more energy efficient ones • Improvement on boiler house to ensure complete combustion of coal and eventually running on biomass	• Installation of steam traps and PRV's • Heat recovery system redesign from the sulphonation plant to the detergent plant • Installation of a more efficient 20 TPH boiler to replace 6-4TPH boilers	• Installation of a fluidized bed boiler to improve on combustion efficiency
Savings	• Approximately 3,000,000-4,000,000 USD annually	• Steam consumption reduced from 6206 tons in 2015 to 3617 tons in 2016 • IDO consumption reduced by 45,557 liters in 2016 as compared to 2015 • Centralization of the compressors was under testing	• 30,000 USD per month on fuel

Application	Company 4	Company 5	Company 6
Electricity	• Use of LED lighting	• Use of LED lighting	• Use of LED lighting
Thermal	• Boiler conversion from HFO to biomass • Sealing of steam leakages	• Insulation of chiller water pipes	• Redesign of condensate recovery • Installation of solar water heaters • Lagging of steam pipes
Trainings	-	• Energy Management Trainings	• -
Savings	• Sealing leakages 15000 KWh per month • Use of LED 1200 KWh per month	• 2,000 USD Annually	• Approximately 623550.62 KWH

Application	Company 7
Electricity	• Use of LED lighting • Installation of solar tubes • Embracing brewing recipes that save energy
Thermal	• Lagging of all hot and cold water pipes • Running of machines on the recommended temperatures • Thermal heat recovery system in the brew house
Trainings	-
Savings	• Approximately 2,000,000 USD annually

4.2 Driving Forces for Industrial Energy Efficiency

As a way to understand further why the companies undertook the projects, the respondents were questioned on common driving forces for the adoption of energy efficiency measures in their company. The questions were developed through a literature review of related articles as indicated in Chapter 3. In order to get to know how important the developed questions were, the respondents were asked to rank them from 0-10. 0, being least important and 10 being most important. In order to find the most to least important the points were added up and averaged. The rankings are shown in Table 4.3.

Table 4.3: List of Driving Forces

No	Proposed driving force	Category	Average score
1	Energy efficiency adoption so as to cost cut and increase profit margin.	Market related	9.7
2	The Energy Management Regulation of 2012.	Policy related	8.4
3	Investor interest in energy efficiency	Market related	8.3
4	Sector organizations such as K.A.M	Policy related	8
5	Energy auditors support	Policy related	7.6
6	Information from energy companies or consultancies	Policy related	7
7	Colleagues within the group or company	Organizational and behavioral factors	7
8	Conferences and seminars	Organizational and behavioral factors	6.6
9	Product information from suppliers	Market related	6.3
10	Colleagues within the sector	Organizational and behavioral factors	6
11	Interest in International Standard Organization (ISO) certification like ISO 50001 of Energy Management	Organizational and behavioral factors	5.9
12	Written sources of information	Organizational and behavioral factors	5.9
13	Support form Energy Regulatory Commission	Policy related	5.4

Using a scale of 0 (least important) and 10 (most important) of 13 driving forces, the highest ranking driving force was the adoption of the energy efficiency measures so as to increase their profit margin by reducing their operation costs. This is considered a market related driving force. The second ranking driving force was policy related where the passing of the Energy Management Regulation of 2012 saw a push of the companies by the government to adopt the energy efficiency drive within industries. Investor interest in energy efficiency was ranked third. This is a market related driving force where the investors feel the drive towards energy efficiency is in line to their visions of reducing operation cost so as to ensure their products are price competitive within the market and ensuring sustainable energy consumption within their companies.

Sector organizations such as KAM came in fourth and Energy auditors support came in fifth. The two are inter dependent and are policy related. Sector organizations have been established to unite industrialists so as to offer a common voice for business. They offer convenient support services to their members including sourcing of registered energy auditors. Information from energy companies or consultancies come in sixth. The energy companies include the national utility company Kenya Power in charge of distribution of energy and ERC in charge of regulation of energy sector and are both policy related. The information regarding the law they have to covey to the customers include the consumption of energy in a periodical time i.e. monthly, quarterly or annually. The companies have the responsibility to advise the consumers on energy issues including their consumption and help in any energy disputes.

Colleagues within the group or company and conferences and seminars came in seventh and eighth respectively. These are both organizational and behavioral factors where the company promotes energy efficiency by allowing free flow of information between colleagues and departments as well as promoting employees to attending energy efficiency conferences and seminars. Product information from suppliers came in ninth and is considered a market related driving force. According to the respondents suppliers had a role in driving energy efficiency where different suppliers with different brands of technologies approached the company in a way to promote their products ended up selling or giving energy efficiency services and technologies.

Colleagues within the sector came in tenth. It is considered an organizational and behavioral factor and according to the respondents this was ranked lower was due to the fact due to the nature of their time consuming day to day operations; they rarely get an opportunity to interact with other employees within the sector. Interest in ISO 50001 Energy Management certification came in eleventh. It is considered an organizational and behavioral factor and even tough this is a prestigious certification they were considering subscribing to, the plans were still underway and it played a low role in them adopting energy efficiency measures. Written sources of information came in twelfth. This are organizational and behavioral factors and the respondents acknowledged they are an important factor driving energy efficiency but raked it low due to the fact their limited research in application of energy efficiency measures in application to Kenyan industries. Majority of the information and research is limited to a group of companies and is most cases kept secret to

ensure other companies don't become more energy efficient leading to their products being more market competitive.

Support by ERC came in thirteenth and last. The support is considered a policy related driving force. The respondents acknowledged ERC played a big responsibility in enforcing the Energy Management Regulation of 2012. They however felt the support of ERC to the companies was needed. The ERC drive, in total enforcement of the regulation was not as strong as they expected it to be. There had been no publication by ERC of recognizing complied companies and showing the penalizing of non-complying companies to companies. A respondent felt their services including feedback response on submitted reports was slow and needed to be improved for companies to be motivated from a policy point of view.

4.3 Barriers to Industrial Energy Efficiency

Further questions were asked to the respondents so as to understand the barriers they have faced in the implementation of the recommended energy efficiency projects. Just like in the driving forces, the questions were developed through a literature review of related articles as indicated in Chapter 3. Scoring was done so as to get to know how important the developed questions were, the respondents were asked to rank them from 0-10. 0 being least important 10 being most important. In order to find the most important to least recognized, the points were added up and averaged. The rankings are shown in Table 4.4.

Table 4.4: List of Barriers

No	Proposed barriers	Category	Average score
1	Lack of budget funding	Economic Non Market Failure	6.7
2	Other priorities for capital investment	Economic Non Market Failure	6.7
3	Lack of time or other priorities	Economic Non Market Failure	6.4
4	Access to capital to project	Economic Non Market Failure	6.3
5	Possible poor performance of the machines	Economic Market Failure	6
6	Technical risks such as risk of disruption of production	Economic Non Market Failure	6
7	Lack of employee awareness	Behavioral barrier	4.6
8	Cost of identifying opportunities, analyzing cost effectiveness and Tendering	Economic Non Market Failure	4.4
9	Lack of sub metering	Economic Non Market Failure	4.3

10	Department and workers not accountable to the energy costs	Organizational barrier	4.3
11	Low priority given to energy management	Behavioral barrier	4.3
12	Energy objectives not incorporated in the company's operations, maintenance and purchasing procedures	Organizational barrier	4.1
13	Poor information quality regarding energy efficiency opportunities	Economic Non Market Failure	3.9
14	Lack of technical skills	Organizational barrier	3.7
15	Long decision chains	Organizational barrier	3.6
16	Difficulties in obtaining information about energy consumption of purchased technology	Economic Market Failure	3.6
17	Energy manager lacks influence	Organizational barrier	3.3
18	Conflict of interest with the company	Economic Market Failure	2.7
19	Technology is inappropriate in the site	Economic Non Market Failure	2.2
20	Small size of organization	Organizational barrier	2.1
21	Uncertainty regarding the company's future	Economic Market Failure	1.6

The respondents ranked barriers from 0 (least important) to 10 (most important). They ranked the lack of budget funding, other priorities for capital investment, lack of time or other priorities and the lack of access to capital to project came in first, second, third and fourth respectively. They are all classified as economic and non-market failures and the respondents acknowledged the lack of budget or capital made it nearly impossible for them to undertake energy efficient projects. They acknowledged even though their companies had the capacity to undertake such projects, some top managers considered energy efficiency not as important as other priorities for capital investment like increasing production by buying second hand machinery. The lack of time or other priorities was another reason their companies did not undertake projects. Both other priorities for capital investment and lack of time or other priorities according to (Thollander & Rohdin, 2006) are considered hidden costs.

The possible poor performance of the machines was ranked fifth and is considered an economic market failure. One of the respondents acknowledged that in the past couple of years there has been growing demand of production forcing the management to buy second hand refurbished machinery. These purchased second hand machinery are less efficient as compared to the up to date modern machinery. A technical risk such as risk of disruption of production was ranked sixth. This are considered Economic non market failure due to the fact they are hidden costs.

The lack of employee awareness was ranked seventh. This is classified as a behavioral barrier. Two of the respondents mentioned energy efficiency awareness had been done in their companies

through posters, trainings but acknowledged due to the large number of employees they had not been able to reach all their staff. The cost of identifying opportunities, analyzing cost effectiveness and tendering as well as lack of sub metering were ranked eighth and ninth respectively. They are both considered economic non market failures. One of the respondents mentioned the company lacks sub meters for each department. This made it hard for the departments to tackle energy matters due to the fact electric bills come for the whole company and one cannot know what department consumes what. Due to this lack of sub meters department and workers not accountable to energy costs was ranked tenth. This was considered an organizational barrier.

The respondents ranked eleventh the low priority given to energy management. This is considered a behavioral barrier by the top management. According to two respondents the lack of support by top management towards energy efficiency was a barrier towards energy management. The lack of energy objectives not incorporated in the company's operation, maintenance and purchasing procedures was considered an organizational barrier. Two of the respondents mentioned that the company's purchasing of spares and machinery was mainly cost focused. The lower the sale prices of a machine, the higher the chances of it being bought. One respondent mentioned that the maintenance procedure especially preventive maintenance was basic. Some of the technicians considered the changing of oil and filters alone as the preventive maintenance instead of proper machine diagnosis to ensure all functions and parameters are working efficiently.

The lack of technical skills and long decision chains came in fourteenth and fifteenth respectively. They were both considered organizational barriers. Only one of the respondents mentioned the company lacked enough skilled manpower to undertake projects. The skilled manpower included technicians and qualified local engineers. In one companies, long decision chains were considered a barrier in implementing energy efficiency projects in a timely way. All and any of the projects had to be proposed and then passed on to senior level management for approval.

A difficulty in obtaining information about energy consumption of purchased technology was ranked sixteenth. This was categorized as an economic market failure. One of the respondents acknowledged that things have greatly improved in Kenya as compared to ten years ago. Many international machine companies have opened shop or made partnership with local firms in Kenya enabling easy access of technology information to companies. The energy manager lacking influence came in seventeenth. This was considered an organizational barrier. Four out of the seven

acknowledged the energy manager has influence but to some point his decision on energy maters could be overwritten by his fellow managers. This called for intervention by the business owners' on implementation of the proposed projects in a timely manner. This was however such a strong barrier due to the commitment of the business owners towards energy efficiency.

The conflict of interest with the company and technology is inappropriate in the site came in eighteenth and nineteenth respectively. They were both economic barriers but had little influence as a barrier since the family was committed to wards energy efficiency and the technologies they had the financial capability to purchase globally. The small size of the organization and uncertainty regarding the company's future came in the last two due to the fact all the seven companies were considered one of the leaders in their manufacturing sectors.

4.4 Measures that can help Improve Industrial Energy Management

The respondents were asked to further give suggestions of other measures that should be taken in promoting energy efficiency of industries in Kenya. They gave the following suggestions.

- A thorough scrutiny of equipment sizing internally in the industries should be done in terms of electricity consumption and pneumatic requirements.
- A targeted distribution of energy efficiency information especially via media should be initiated by the government or sector support organizations.
- The Energy Regulatory Commission to visit companies and encourage them to embrace energy efficiency programs.
- ERC to aggressively showcase companies that have complied with the regulation.
- Companies to encourage energy management practices in the company.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Presence of Industrial energy efficiency measures

5.1.1 Energy Management Regulation 2012

The Energy management regulation of 2012 brought about tremendous changes in the energy sector. This regulation was brought about to ensure energy is used efficiently by industrial, commercial and institutional facilities using any form of energy. As per the regulation, companies are to undertake an energy audit at least once every three years in their facilities by a licensed energy auditor. The auditors are to get their license from the ERC. An audit report is then to be submitted to the ERC within six (6) months to the end of the financial year, the audit has been undertaken. If the company owner fails to comply, there is likelihood of penalty charges of 30,000 shillings per day. After an audit, the companies are to come up with an energy investment plan so as to promote energy efficiency and energy conservation measures. These measures are to be reviewed every three years. About 50% of these measures have to be implemented within 3 years and the energy consumptions and savings data recorded over that period. An energy officer within the audited company has to be appointed to oversee the implementation of at least 50% of the audit recommendations. An annual implementation report has to be drawn and submitted to the ERC. Failure to do so will result to a penalty of not less than 30,000 shillings per day.

All the respondents companies had complied with the Energy Management Regulation of 2012. They had all undertaken the energy audit and submitted their energy reports to ERC. Out of the 7 companies, three (3) had received their compliance certificate from ERC. Concerning the other four (4), their reports were under review by the commission.

5.1.2 On-going Energy Management Strategies in Manufacturing Companies in Nairobi and Machakos Region

The survey further showed that there was an energy management opportunity in the industrial sector. It was noted the companies are high energy consumers of energy as shown by their energy applications in Table 4.1. The first energy application that was noted was in electricity where the companies implemented a number of projects in lighting where there was a retrofit of use of older, energy intensive lighting technologies including incandescent lamps, florescent lighting and mercury vapor lamps to LEDs. According to Energy GOV website, LEDs use 75% less energy

and last 25 times longer than the older energy intensive lighting technologies (US-DoE, 2017). Due to this reason five out of the seven companies opted to retrofit their premises with the technologies. Second, the centralization of air compressors was done to reduce on the electricity consumption. This according to one the respondents was a move to reduce the number of compressors running in a given time from six to two. It was also a way of making the maintenance of the compressed air system more effective since the technicians could find it more convenient to service the centralized system as compared to six independent systems. Third, was the installation of an online energy management monitoring system. Such a system involved the installation of energy meters and steam flow meters. This equipment's would help in auditing and monitoring the energy system by helping in monitoring key parameters such as equipment efficiencies and energy saving costs. It would also help in the validation of data (Ershaid, Ruiz, Ruiz, Visuara, & Peritasami, 2014).

The second energy application that was noted was in thermal where the companies implemented a number of projects in waste heat recovery. The projects involved the lagging of naked steam pipes as well as chiller water pipes so as to reduce on the heat loss to the atmosphere and the formation of condensate in the steam pipes and heat gain of chiller water temperature. This lagging had a ripple effect on the burning of fuel so as to convert water to steam and the quantity dispersion of condensate was less as compared to when the pipes were naked. The recovery of condensate was another waste heat recovery project. It is well noted that condensate is relatively hot (50^0-60^0C) as compared to boiler room temperature water (25^0-28^0 C). The return of condensate to the boiler feed tank is a highly effective way to improve the efficiency of steam plant due to reduction of fuel to be used in raising the water temperature as well as the reduction of water required in the system (Spirax Sarco, 2014).

The installation of a new 20 TPH automatically fed fluidized bed boiler as replacement to eight

(8) TPH type manually fed boilers. This boiler was installed so as to ensure consistency in the feeding of fuel i.e. biomass thus improving the combustion efficiency and automatic regulation of steam supply to the demand of the various plants to improve steam supply and distribution efficiency. The replacement of older less efficient PRVs and steam traps was also done in one of the companies. This was a way to ensure leakages are minimized and the required pressure is utilized in a given process section. This improved on system efficiency as well.

The integration of renewable energy was done in some of the plants as a way of improving thermal application. It was noted in one of the plants the boilers were converted to use biomass, which is considered a renewable energy, rather than the use of HFO. This was a way of cost cutting in the plant due to the fact that biomass is relatively cheaper as compared to HFO in Kenya. In another plant the integration of solar water heaters instead of use of steam to heat process water was done. This reduced on the formation of condensate and fuel used by the boilers to do the heating. According to IRENA, synergies between renewable energy and energy efficiencies will be required so as to ensure that there is clean, sustainable and affordable energy supply in the future of companies and the continent as a whole (IRENA, 2015).

Due to the Energy Management Regulation of 2012, all the companies were required to develop an energy policy. All of the interviewed companies in our survey therefore had complied with this requirement and although there was no standard format, they all had relatively similar contents. The energy policy contained the structure of the energy management team, their roles, aims/ objectives and roadmap to achieve their set objectives. In all of the viewed policies, the energy management team composed of employees across the position ladder. A senior manager was part of the team, department heads or supervisors and a designated energy officer. The roles and responsibilities of the members were clearly outlined. Under objectives there were broad objectives and specific objectives. There were also action points/roadmaps on how the team was to achieve their objectives. And finally so as to show commitment of senior management, all of the policies were signed by the head of the organization.

Energy management trainings on staff were another strategy employed in the companies. According to one of the respondents, this training was necessary in making aware the employees on the importance of energy efficiency and energy conservation in the integration in their day to day operations. This involved the use of formal trainings where the staff sat in a training room and were taken through by a registered energy auditor on the importance of energy efficiency. The use of informal training was also done by the use of posters and running of films in the cafeteria. The companies were however yet to find a way of monitoring and quantifying the success of such trainings.

5.2 Driving Forces for Energy efficiency

All the three driving forces i.e. market related driving forces, the policy related driving forces and organizational and behavioral factors/ driving forces scored an average above 5 points.

5.2.1 Market Related Driving Forces

Market related driving forces is when a firm has to stay competitive by reducing their energy use thereby reducing the energy costs internally. This cost reduction can also be as a way of securing a firms position in energy use as a way of dealing with the rising cost of energy prices (Apeaning & Thollander, 2013) . The research found this was a major driving forces towards energy efficiency within the company. The investors and business owners found this as a good opportunity for them to reduce their operation costs of which would increase their profit margins. The reduction in operation costs would help their pricing of products to remain competitive in the market. According to Rekettye (2011), there is an increasing importance of pricing in the functioning of market economies by providing a link between supply and demand of products and services. According to his research it is best to consider customers' interest, value of the commodity, price, and cost then profit respectively in order for a product to remain competitive (Rekettye, 2011). For such a case of a middle level economy such as Kenya, forty two percent of the forty four million citizens live below the poverty line (UNICEF, 2017). This means so as to ensure that before one produces valuable products, price and costs have to be considered before profit. This is due to the fact that the lower the price of a valuable product the higher the chances of the product being consumed. The lower the cost the higher the chances of the profit margin remaining constant or increasing. The drive towards energy efficiency is considered a way of cost cutting.

The availability of technologies as well as information of them is considered a market related driving force. If the technologies are readily available in an economy, the industries would consider the integration of the technologies in their processes. Kenya over the years has tremendously improved in the availability of such energy efficient technologies. This has been brought about by the improvement in internet access leading to opportunities of online trade as well as the opening up of leading technology companies' distribution hubs and partnerships across the country. This opportunity has made it easier for companies to look for more energy efficient technologies.

5.2.2 Policy Related Driving Force

The presence of the Energy Management Regulation of 2012 has helped in the drive towards energy efficiency in Kenya. Most of the respondents acknowledged the main reason they did an energy audit and came up with energy efficiency measures and strategies was because they wanted to comply with the regulation and not face the penalties that are stated in the regulation. This external influence guided them in complying and also forces them to implement what their recommendations in their report. The support of sector organizations such as KAM and the support of other organizations such as energy auditors and consultancies have an external influence in energy efficiency within the company. These organizations were brought about by policy related influence and have tremendously helped the manufacturing companies in implementing their recommendations.

5.2.3 Organizational and behavioral factors

Organizational and behavioral factors are considered internal factors that include the way energy is viewed or taken up within a company. The interaction of the colleagues within the company played the driving force towards energy efficiency. According to a research done, it was found that social interactions had an influence on an individual's behavior pattern in a work environment. The constant interactions of workmates help in exchange of ideas and in smooth implementation of these ideas. (Chih-Wei , Aztiria, Allouch, & Aghajan, 2011) The attendance of seminars and workshops was also a driving force towards energy efficiency. It is during these seminars the colleagues from across the sectors came and shared ideas on how to improve their operations by integrating more energy efficient technologies.

5.3 Barriers to Industrial Energy Efficiency

Only economic barriers scored an average above 5 points. The rest i.e. behavioral and organizational factors scored below 5 points. This shows even though they are considered barriers the ones below 5 points are considered less important and have little influence on the adoption of energy efficient technologies.

5.3.1 Economic Barriers

The main barriers that scored above 5 average points were economic barriers. The top economic barrier was the lack of access to funds. As highlighted in the results this could be as a result of top management being reluctant to adopt energy efficiency technologies as opposed to using the same

funds to increase production. The other reason why top management is reluctant is as a result of high interest rates of loans. The top management was reluctant to undertake such projects due to the fact that there were afraid that the said energy savings were not assured and they project would end up being more expensive to the business. This is said to be as a result of lack of proper technical experience in banks or financial institutes to properly evaluate credit worthiness of companies and risks associated in funding such projects. The possibility of poor performance of machines was considered an economic barrier. It is closely linked to investors avoiding technical risks such as disruption of production. The respondents highlighted this is as a result of high demand of their products but not enough capital to buy new and efficient machines, forcing the business owner to purchase refurbished older machinery that are less efficient.

5.4 Measures that can help Improve Industrial Energy Management

It was clearly noted that even though major strides have been made in energy efficiency in the Kenya. It is however evident that there is still room for improvement internally at company level and externally at policy level.

5.4.1 Internal Improvements

The respondents although acknowledged the drive towards energy efficiency had been embraced positively within the company, there was still room for improvements especially in proper scrutiny of equipment sizing. This sizing would be important in making sure that the equipment's run in an efficient way. This would however only possible if there is dedicated manpower with proper technical skills as well as the right equipment's to do the analysis of the machines.

The second improvement that is important is employee awards in a way to acknowledge employees role in implementing energy efficiency projects. Top management should bring a rewarding culture to employee's ideas on how to reduce the energy consumption. They should as well have an open door policy to all employees' ideas regardless of position and have the initiative to follow up on the project ideas through research and development. This will in turn motivate the employees to ensure that the energy efficiency culture is maintained within the company.

5.4.2 External Improvements

It was noted that even though there has been a major support of energy efficiency by external factors like the government Energy Management Regulation of 2012, support organizations like KAM, ERC and registered energy auditors, there were still opportunities for improvement. One of

the opportunities is a targeted distribution of energy efficiency information through media. This should be initiated by the government institutions like Kenya Power, ERC and Ministry of energy and petroleum or the sector support organizations like KAM. Information that should be conveyed includes advantages of integrating the efficient technologies, the technologies available including renewable energy technologies and the funding opportunities available. Other ways it should support is by aggressively showcasing companies that have complied with the regulation via the media. This would in turn be a way of encouraging those companies that are yet to comply to pull up their efforts in ensuring they comply.

Second, the government should use their policy tools in a way to encourage the fast adoption of energy efficient technologies. The use of subsidies on energy efficient technologies could prove to be one of the many ways that will encourage companies' fast adoption of the said technologies. The subsidies include tax reliefs and tax exemptions of companies investing in energy efficient technologies. The possibilities of introduction of carbon credit system to companies that invest in energy efficient technologies have also a positive effect on the fast adoption of energy efficient technologies.

CHAPTER SIX

6.0 CONCLUSION

The results of the energy management research revealed that there has been a major stride towards energy efficiency by manufacturing companies. All of the companies interviewed are considered one of the leading manufacturing companies in their sectors and are considered high energy intensive companies in Kenya. They have all undertaken an energy audit as per the Energy Management Regulation of 2012 and have already begun implementing their energy audit report recommendations. More than half of the respondent companies have received their compliance certificates from ERC and the remaining have submitted their annual reports awaiting the approval and issuance of certificate by ERC. The total annual savings of all of the companies are achieving so far after implementing the projects have been over 2 million USD. This shows how effective the energy efficiency drive is to the companies and to Kenya.

Among the driving forces that have been noted include market related driving forces. This forces including the adoption of energy efficiency technologies as well as the integration of renewable energies, e.g. solar water heating and boiler conversions from HFO to biomass, have led to the operations cost cutting. This has enabled the respondent company's products to maintain their quality value while making the products be price competitive in the market. It is clear that this synergies of energy efficiency and renewable energy is the way forward in ensuring the development of sustainable, clean, reliable and affordable energy to industries. Many industries across Kenya are switching from the high priced conventional energy sources to readily affordable energy sources. There is however concern that if proper policies and enforcements are not put in place in protection of some renewable energy like biomass from trees, there will be a catastrophic effect on the environment. The market related driving forces have created an international business opportunity to energy efficiency companies. These include the energy efficient technology manufacturers as well as energy management consultancies. This opportunity has created employment opportunities to Kenyan locals due to the fact we have seen the setting up of international companies distribution hubs across the country. These hubs have made it more convenient for industries to gather information on the latest technology trends and even the spare parts of these technologies encouraging business owners to adopt the technologies.

Policy related driving forces have played a major role in promoting energy efficiency in Kenya. The introduction of the Energy Management Regulation of 2012 is the backbone of energy efficiency in Kenya. It has forced the industries to adopt energy efficiency as a way of helping the industries to lower energy consumption while developing quality goods. It has also helped the government regulate the energy consumption of the industries of which consume 57% of the total energy generated thereby regulating on the building of new power plants so as to meet the growing demand of energy. This has been in line with the countries vision 2030 of "Transforming Kenya into a newly industrializing, middle income country while providing a high quality of life to all her citizens by 2030 in a clean secure environment" (Kenyan Vision 2030, 2017) Generation and sustainable and efficient consumption of energy falls under infrastructure in the economic pillar of the vision 2030.

Organizational and behavioral driving forces have played a role in the fast adoption of energy efficient technologies. This has been mainly seen by the management's commitment towards energy efficiency. This commitment has enabled the employees to share energy efficiency ideas and solutions both internally and across the sector. The participation of employees in conferences and seminars has also created a forum for the suppliers and consumers to gather and give possible solutions to challenges the business owners face on a day to day basis. The opportunity to train the staff is also an organizational and behavioral driving force that has enabled employees to be sensitized on the importance of energy efficiency and conservation towards a sustainable future.

Among the barriers, in implementing energy efficient projects, which are currently being faced by companies are economic barriers, behavioral and organizational factors. However in this research we found the economic barriers were strongly faced as compared to the behavioral and organizational. Under the economic barriers there were two main classifications namely economic barriers caused due to market failure and economic factors caused due to non-market failure. Under the economic barriers due to non-market failure, it was found that the lack of budget funding, other priorities for capital investment, lack of time or other priorities, access to capital to projects and technical risks such as risk of disruption of production were the contributing factors. The possible poor performance of the machines was the main economic barrier due to market failure.

In order for the energy efficiency drives to be strengthened, it was found some improvements had to be done internally as well as externally. Internally, the proper and accurate sizing procedures of

process equipment had to be put in place. The encouragement of open door policy for conveying of energy efficiency ideas by employees had to be put in place. The management had to put in place a reward system for the employees who convey the best viable idea as a way of encouraging more and more employees to convey ideas. Externally, the government institutions should develop policy tools and instruments that encourage the adoption of energy efficient technologies and renewable energy technologies. This could be in form of tax exemptions or through subsidies. The other way the government could encourage this drive is by aggressively showcasing and awarding the complied manufacturing companies through the help of media. This way it will encourage more and more companies to comply with the regulation through implementation of their proposed projects.

This research represents a study showing the barriers of and driving forces of adoption of energy efficient technologies in Kenya. It clearly shows the current policy state in Kenya towards energy efficiency, the main energy applications in the industries, the implemented projects and the current annual energy savings realized through the project implementations. However recommended further studies should be carried out to the external stakeholders such as ERC, Kenya Power, researchers, equipment dealers, and financial institutions so as to have a holistic view of the possible energy policy improvements towards a more sustainable energy consumption economy.

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APPENDICES

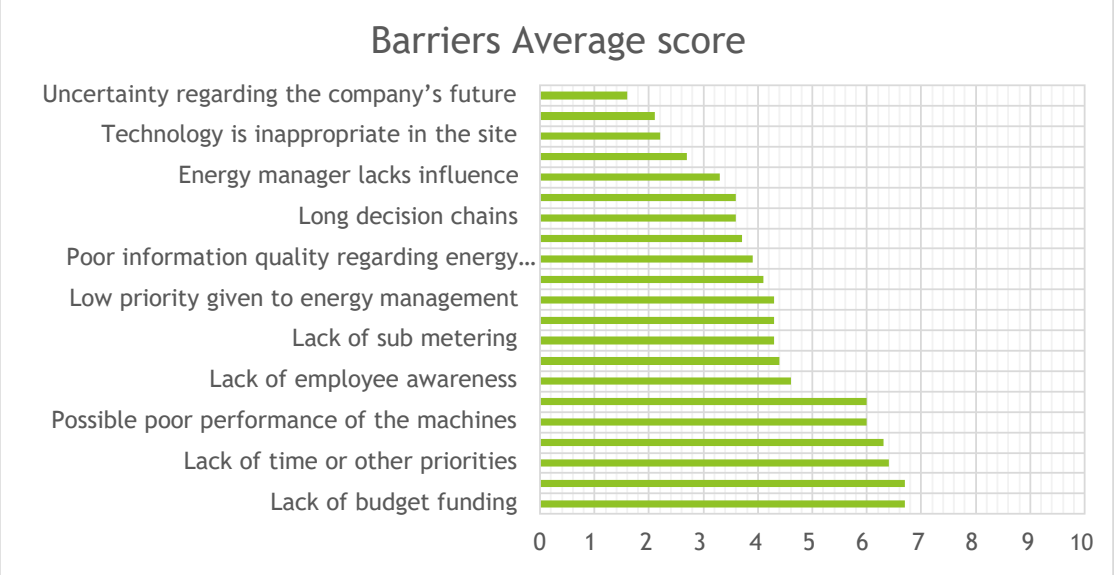

Figure 4: Barriers Average Score Ranking (Last to First)

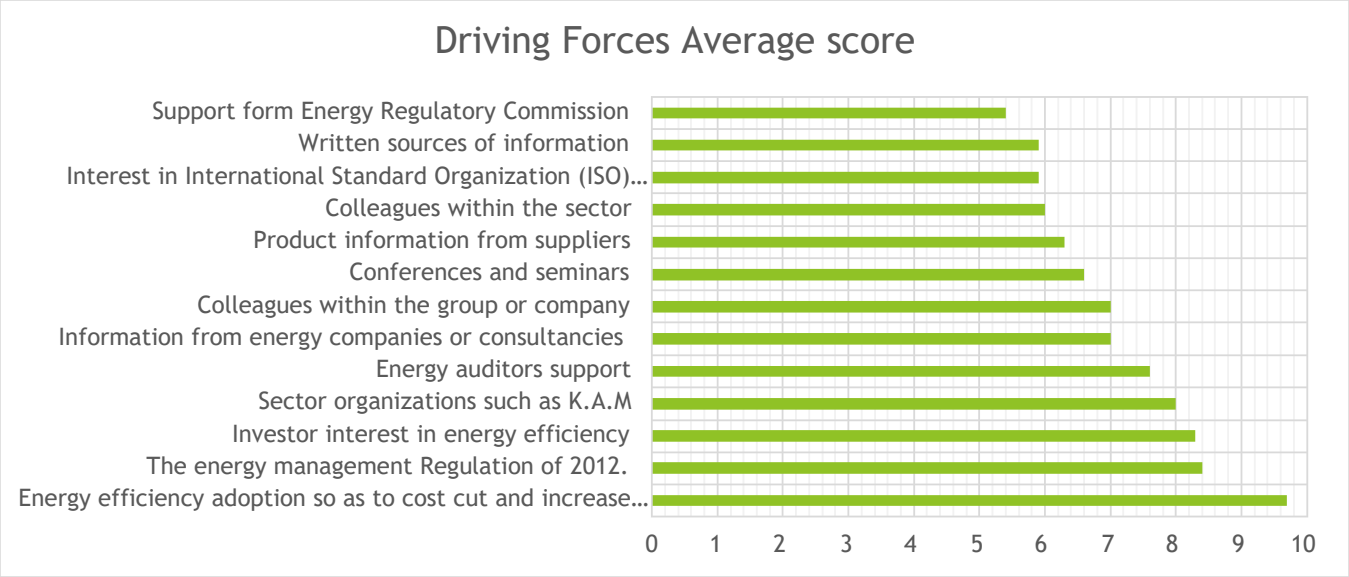

Figure 5: Driving Forces Average Ranking (Last to First)