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MINISTRY OF ENERGY

Assessment of Skills and Knowledge Gaps in Energy Efficiency in Manufacturing and Commercial Sectors in Kenya

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This report was prepared by Dr Keren Keberere and her team. Therefore, last but not the least we are thankful to Dr Keren Keberere, who, along with her team interviewed a host of professionals working on energy efficiency in the manufacturing and commercial sectors, and reviewed various audit report for these sectors that were provided by EPRA. She also reviewed curriculums taught in selected Kenyan universities and training institutes to identify the skills and knowledge gaps on energy efficiency in these sectors.

UNEP Copenhagen Climate Centre

Foreword

In line with Kenya's commitment to climate issues, Kenya's Ministry of Energy strives to promote the efficient use of energy resources in all sectors. There is a strong recognition that energy is an enabler for Kenya's Vision 2030, which aims to transform Kenya into a newly industrialised middle-income country that offers its citizens a high quality of life. In addition, the government's "Big 4 Agenda" depends on providing sufficient and affordable energy.

Energy efficiency and energy conservation policies in Kenya aim to promote energy use in the production of goods and services without compromising quality and quantity, using technology that requires less energy to perform the same function. The Ministry of Energy, the Kenyan Manufacturers Association, Kenya Energy and Petroleum Regulatory Authority and other stakeholders have been campaigning to improve Kenya's energy efficiency since the early 2000s. However, the benefits are insufficient, and the limited availability of skills and knowledge in the sector is considered one of the critical barriers to Kenya's path to achieving its energy efficiency targets. In the same sense, this will require the generation of capacities for responsible and efficient use of energy. It will also require the development of content that promotes pedagogical approaches to the rational use of energy and the adoption of sustainable habits and consumption, primarily to support the current and future policies to make manufacturing and the commercial sector in Kenya more energy efficient.

In this context, technical cooperation between the Ministry of Energy, Energy and Petroleum Regulatory Authority and the Copenhagen Center on Energy Efficiency has made it possible to develop the project "Assessment of Skills and Knowledge Gap in Commercial and Manufacturing Sector in Kenya", together with the consultant Dr Keren Keberere. The study was carried out through a review of relevant documents and interviews. Various stakeholders were identified, including designated facilities, energy auditors, energy management promoters and government agencies. The study identifies the gaps and how these skills and knowledge gaps need to be filled. It concludes that the culture of energy conservation needs to be taught among the populace from an early age. This can be achieved by integrating EE from the early stages of formal education to the college level. Kenya is in the process of changing to a new education system, which affords an excellent opportunity for the integration of energy management.

Key priorities of this goal of Kenya include sustainable consumption and production patterns in addition to renewable energy. It is therefore imperative to take a measure that bridge the knowledge and skill barriers that are key to implementing national energy efficiency and conservation strategy

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Acronyms

ACES	Air Conditioning Energy Savers
AEPEA	Association of Energy Professionals Eastern Africa
BEP	Business Energy Professional
BMS	Building management systems
C2E2	Copenhagen Centre on Energy Efficiency
CBK	Central Bank of Kenya
CEA	Certified Energy Auditor
CEEC	Centre for Energy Efficiency and Conservation
CEM	Certified Energy Manager
CHP	Combined heat & power
CIEP	Certified Industrial Energy Professional
COP	Coefficient of performance
CRM	Carbon Reduction Manager
CVMP	Certified Measurement and Verification Professional
CWEP	Certified Water Efficiency Professional
EACREEE	East African Centre for Renewable Energy and Energy Efficiency
ECM	Energy Conservation Measure
EE	Energy Efficiency
EER	Energy efficiency ratio
EMA	Energy Management Awards
EMS	Energy management system
EPI	Energy performance index
EPRA	Energy and Petroleum Regulatory Authority
ESCO	Energy Service Company
GEF	Global Environmental Facility
GDP	Gross domestic product
GEA	General energy audit
GIZ	German Agency for International Cooperation

HFO	Heavy Fuel Oil
HND	Higher national diploma
HVAC	Heating, Ventilation, and Air Conditioning
IEPA	Institute of Energy Professionals Africa
IDO	Industrial Diesel Oil
IGA	Investment grade audit
IGBT	Insulated-gate bipolar transistor
IRR	Internal rate of return
ISO	International Organization for Standardization
JKUAT	Jomo Kenyatta University of Agriculture & Technology
KAM	Kenya Association of Manufacturers
KEBS	Kenya Bureau of Standards
KEPSA	Kenya Private Sector Alliance
KIRDI	Kenya Industrial Research and Development Institute
KNBS	Kenya National Bureau of Statistics
KPI	Key performance index
KPLC	Kenya Power & Lighting Company
KU	Kenyatta University
kVA	kilo volt-ampere
kWh	kilo watthour
LED	Light emitting diode
LPG	Liquified petroleum gas
MEPS	Minimum energy performance standards
MoE	Ministry of Energy
MOU	Memorandum of Understanding
MU	Moi University
M&V	Measurement and verification
MW	Megawatt
NEECS	National Energy Efficiency and Conservation Strategy
NGO	Non-Governmental Organisation
NITA	National Industrial Training Authority
NPV	Net present value
O&M	Operation and maintenance

O&R	Offices & retail
PCF	Certified Performance Contracting and Funding Professional
PEM	Professional Energy Manager
pf	Power factor
PFC	Power factor correction
PLC	Programmable Logic Control
PV	Photovoltaic
RE&EE	Renewable Energy and Energy Efficiency
REP	Renewable Energy Professional
RIA	Regulation Impact Assessment
ROI	Return on investment
SCADA	Supervisory Control and Data Acquisition
SCR	Silicon-controlled rectifier
SDG	Sustainable Development Goal
SERC	Strathmore Energy Research Centre
SME	Small and medium enterprise
SUNREF	Sustainable Use of Natural Resources and Energy Finance
ToRs	Terms of Reference
UK	United Kingdom
UNIDO	United Nations Industrial Development Organisation
UoN	University of Nairobi
UPS	Uninterruptible power supply
USA	United States of America
VFD	Variable frequency drive
WASCO	Water service companies

Photo: Daniel Smyth on Unsplash

Executive Summary

The Copenhagen Centre on Energy Efficiency (C2E2), which is part of UNEP Copenhagen Climate Centre (UNEP CCC), initiated a program to help developing countries improve energy efficiency (EE) skills. C2E2 in consultation with the Ministry of Energy identified Kenya as one of the countries to benefit from the program. The project aims to create or strengthen local vocational skills in the area of energy efficiency (EE).

The study on the Assessment of Skills and Knowledge Gap in Energy Efficiency Professionals in Kenya was commissioned by UNEP CCC in August 2020. The study was carried out through review of relevant documents and interviews. Various stakeholders were identified that included designated facilities, energy auditors, energy management promoters and government agencies. Currently, the EE professionals in the country are the licensed energy auditors as the Energy (Energy Management) Regulations, 2012 only require every designated facility to appoint an energy officer. However, there are no academic or professional qualifications prescribed for the energy officers. This situation may change in future if the draft Energy (Energy Management) Regulations, 2021 are adopted which will bring assigned energy managers on board. Thus, the study mainly focused on assessing the skills and knowledge of the energy auditors and to a lesser extent, the energy officers.

The facilities were categorised into commercial, industrial, and institutional. The commercial facilities that participated in the study operate in the horticultural, hospitality, office & retail buildings, supermarkets, and water supply & sewerage sectors, among others. Further, the industrial facilities include agricultural produce, food & beverage, chemical, plastics, metal, and textile & apparels sectors, among others. The institutional facilities included hospitals, schools, learning/research, and recreational/charitable institutions. The participating facilities were spread across the country: Nairobi and its environs, Coast, Western, Central, and Rift Valley regions.

The roles of energy auditors were recognised as identifying opportunities to improve the operation, maintenance, or energy efficiency of buildings and process systems, data collection through measurements, analysing the technical and economic feasibility of energy conservation measures, and preparing audit reports. An energy manager monitors and manages the energy efficiency of a facility or organization. They coordinate implementation of energy conservation measures, monitor energy consumption, verify improvements in energy consumption, and coordinate all activities related to energy conservation. Thus, to perform their roles effectively, the study established that the EE professionals require to have technical and energy management knowledge as well as analytical, and financial and accounting skills. They also need to know the relevant regulations, standards, and best practices.

The licensed energy auditors who participated in the survey have been in the sector for a reasonable period with 71% of them having conducted energy audits for over 5 years and 29% for between 1-5 years. Additionally, the study established that 88%, 69%, 71%, and 59% of the energy auditors interviewed had audited industrial, commercial (hotels), commercial (office buildings, horticultural), and institutional facilities, respectively. The wide experience in auditing industrial facilities is attributable to the fact that the energy efficiency drive in Kenya initially focused on industries before it was opened to other types of facilities. The energy audit reports that were reviewed had been conducted between 2012 and 2020.

Further, 61% of the audits were general energy audits (GEA) whereas the remaining 39% were investment grade audits (IGA).

Lighting was found to be the most occurring main energy consuming system across the three types of facilities that was documented in the energy audit reports at 100%, 95%, and 93% for the institutional, commercial, and industrial facilities, respectively. However, it may not be accurate to list these systems as major energy consumers in most industrial facilities which often have heavy equipment that are relatively heavier energy consumers than lighting. The review of audit reports for industrial facilities revealed that motors & drives and air compressors & compressed air systems were identified as the next main energy consuming systems at 84% and 81% of the reviewed reports, respectively. In commercial and institutional facilities, pumping systems were identified as main energy consumers in 64% and 89% of the reviewed reports, respectively. The third most occurring main energy consumers in the reports for commercial and institutional facilities were HVAC and refrigeration systems at 58% and 68%, respectively.

The energy auditors had recommended implementation of energy conservation measures (ECMs) in various areas including lighting, compressed air systems, HVAC systems, motors and drives, boilers and steam systems, and water supply systems, among others. The study found that there were few ECMs for pumping systems even though pumps were documented as main energy consumers in most facilities. In addition, most of the ECMs related to motors and drives were for motor-load matching, motor efficiency and application of variable frequency drives (VFDs). Further, the ECMs for lighting systems were limited to light emitting diodes (LED) retrofits, and occupancy sensors in a few cases. Most of the reports did not focus on motor systems, process improvement, heating systems, heat exchangers, pumping and fluid delivery mechanisms, compressed air system design, and optimization of lighting. The coverage of EE in buildings was also found to be weak.

Most of the auditors (88%) had certified energy manager (CEM) certification, which is one of the recognised qualifications for licensing by the licensing authority; the remaining 12% had either certified energy auditor (CEA) or professional energy manager (PEM) qualification. Most (60%) of the energy auditors had attained the qualification between 2011-2015. Only about 30% of the auditors held a master's degree in Energy Management/Technology, which is recognised as an alternative to certification by the licensing authority. In addition, only about 41% of the auditors had certified measurement and verification professional (CMVP) certification which is key for determination of the energy consumption improvement after ECM implementation. The CEM and CMVP courses and examination are offered locally through the Kenya Association of Manufacturers (KAM) and the Association of Energy Professionals Eastern Africa (AEPEA), which is the local chapter of the Association of Energy Engineers (AEE).

KAM was the most active energy efficiency (EE) training institution locally offering short courses. The Association has been working closely with the Ministry of Energy (MoE) since the 2000s in human capacity development and promotion of EE through undertaking energy audits, public education and awareness activities, and administration of the annual energy management award (EMA). Further, 80% of the energy auditors had their master's degree qualification from the University of Nairobi and the remaining 20% had theirs from Jomo Kenyatta University of Agriculture & Technology.

Five Kenyan universities that offer energy related postgraduate programs that can be acceptable qualifications for energy auditor licensing were identified; each university offered one 24-month master's course. Two of the five programs focus on energy management whereas the other three focus on energy technologies. In all the five programs, research methodology is a core course. In addition, Energy Measurement Techniques and Process Energy Management are both taught in only one of the two energy management programs whereas Processes in Energy Management and Project Management are taught in the other program. None of the universities had an active postgraduate diploma course at the time of the survey. There are numerous short courses that are offered by various training institutions that last between 2 days and 1 month. The courses range from the simple creation of awareness to the more complex certification courses targeting specialised audiences that seek to be energy efficiency professionals.

The gaps in knowledge and skills of the EE professionals include inadequacies in understanding of the energy consumption/accounting, establishing the energy consumption baseline, taking measurements, data analysis, financial analysis, and report writing. In addition, the M&V process to be used after ECM implementation for assessment of the energy consumption improvement was not clear in 83% of the audit reports that were reviewed. Further, most of the energy auditors were found to have skills/knowledge gaps in evaluation of EE performance of the following systems: motors, fans, HVAC, pumping, steam distribution, and compressed air systems.

The draft Energy (Energy Management) Regulations, 2021 propose that prospective energy manager license applicants should have attended trainings in financial engineering, energy management, project management, measurement & verification, appliances energy efficiency, and report writing. Most of the currently designated energy officers do not possess these skills and therefore, they will need to be trained.

To close the practicing EE professionals' knowledge and skills gaps, the following short courses are recommended:

Energy auditors

- Energy systems optimisation
- Energy measurement techniques and monitoring
- Energy accounting & metering
- Financial analysis of energy savings including sensitivity analysis
- Energy efficiency project financing
- Risk assessment and management for EE projects
- Energy economics, financing energy projects, and performance contracting
- Introduction to measurement and verification
- Energy management regulations and standards
- Energy audit report writing

Energy managers

- Introduction to energy efficiency and energy management
- Energy efficiency program implementation, reporting, and evaluation
- Contract development and project management
- Financial engineering
- Appliances' energy efficiency
- Operations & maintenance practices and requirements
- Metering, monitoring, and targeting techniques
- Energy performance measurement indicators
- Introduction to measurement & verification
- Energy accounting & metering
- Financing EE projects and performance contracting
- Energy management regulations and standards
- Report writing
- Mounting an effective staff awareness campaign
- Effective communication

In addition, the following areas or topics are recommended to be included in the postgraduate programs that can be recognised for licensing energy auditors.

- Energy management and auditing
- Process energy management
- Energy conservation and waste heat recovery
- Instrumentation and control for energy systems
- Energy modelling and optimization
- Energy use and resource management
- Energy measurement techniques
- Material and energy balance
- Energy, climate change, and carbon trade
- Solar thermal energy
- Energy efficiency in buildings

- Energy and water efficiency
- Energy management and transport
- Codes and standards
- Measurement and verification
- Energy economics and planning
- Financial and project management
- Project economics and evaluation

It is prudent that candidates who have a leaning towards enhancing their practical skills are afforded the opportunity through a postgraduate diploma program which is shorter and more practical oriented than a master's program. Such a program can be offered in partnership with designated facilities through KAM. The partnership can be extended to the lecturers teaching the energy management courses to bridge the gap between industry and academia.

Other recommendations include:

The Kenya National Energy Efficiency and Conservation Strategy identified five thematic sectors targeted for improvement of energy efficiency and conservation. The households and buildings sectors are among the five. These two sectors previously were not the focus of EE and thus, it will be necessary to introduce training programs that specifically address their needs.

Develop curricula for energy management, audit, and M&V training that matches the Kenyan needs for EE professionals (energy auditors and energy managers) to boost the numbers of those working in various sectors of the economy.

Develop and offer specialised sectoral training in manufacturing processes to the energy auditors to enhance their understanding of operations and issues that may be unique to specific sectors of the economy. For example, agricultural produce, cement, and dairy, among others.

Develop courses for prospective energy managers in the areas prescribed in the draft regulations and others as may be deemed necessary.

It is the business of everyone to conserve energy, but more specifically the technical people. Thus, in the long term, it may be prudent to integrate energy management into engineering and technical courses at tertiary institutions and universities at undergraduate level. This will entail introducing some topics on energy management in the already existing courses.

The culture of energy conservation needs to be inculcated among the populace from an early age. This can be achieved by integrating EE right from the early stages of formal education all the way to college level. Kenya is in the process of changing to a new education system and this affords a very good opportunity for the integration of energy management.

Photo: Riccardo Annandale on unsplash

1. Introduction

This chapter is the introduction section. The background to the study is drawn, highlighting the importance and the need for this study leading to the objectives of this study, this is followed by discussion on the status of energy efficiency in Kenya, highlighting the key opportunities, issues, and barriers. The third section in this chapter introduces the education system in Kenya. This chapter ends with describing the objectives of this study, scope of work and by describing how rest of the report is organised.

1.1. Background

Energy efficiency can position businesses more competitively in global markets and can have a significant impact on their bottom line by lowering energy bills, reducing equipment maintenance and replacement costs, and increasing the asset value of buildings. In addition, the money saved through energy efficiency can be reinvested, which can help grow the business, create new jobs and strengthen a country's economy. Further, improving energy efficiency is widely recognised as one of the strategies for addressing climate change and contributing to sustainable development. The Sustainable Development Goal (SDG) 7 is to ensure access to affordable, reliable, sustainable, and modern energy for all. One of the targets under this goal is to double the global rate of improvement in energy efficiency (EE) by 2030 (Target 7.3). In Kenya, the cost of both thermal and electrical energy is relatively high, which drives up business's production cost, affecting the country's competitiveness. Kenya's gross domestic product (GDP) expanded by 5.4% in 2019 (KNBS, 2020). For this growth level to be sustained, it is important that industrial, commercial and institutional facilities be competitive in their activities. One of the pathways for competitiveness is adopting energy-efficient practices.

It is necessary to have the right mix of people and skills to achieve Target 7.3 of doubling the rate of energy efficiency and accelerate the development and implementation of public-private energy efficiency projects. Therefore, there is a need for initiatives that provide energy efficiency skills and knowledge, among both the in-service professionals working in the energy efficiency sector and professionals coming out from the educational system. The appropriate initiatives can only be known if the knowledge and skills gap is established. Thus, there is a need to review the EE training programmes available to in-service professionals in Kenya and relevant programs that provide EE knowledge in universities and elsewhere. This will ensure that the training institutions provide market-responsive education and training for individuals taking on new responsibilities in energy management and those seeking entry into energy management occupations.

Previous studies (EPRA, 2020) have found that organisations continue to pursue energy efficiency goals, and they are looking to EE initiatives mainly to reduce their operating costs and environmental impacts. The development and availability of qualified EE professionals will enable the organisations to pursue those goals and help ensure that they are competitive.

Copenhagen Centre on Energy Efficiency (C2E2), which is part of UNEP Copenhagen Climate Centre (UNEP CCC) initiated a program to help developing countries improve EE skills. C2E2 in consultation with the Ministry of Energy identified Kenya as one of the countries to benefit from the program. The project aims to create or strengthen local vocational skills in the area of energy efficiency. Within this program in Kenya, the following needs were identified:

1. Upgrade of knowledge and skills of the energy efficiency technicians/ professionals to support Kenya's initiatives to make the production and service sectors more energy efficient.
2. Identification of energy efficiency knowledge and skills requirement vis-à-vis the available programs offered by the universities and other training centres in Kenya.

To meet these needs, one requires an understanding of:

1. The relevant areas/applications or processes within the industrial, institutional, and commercial sectors where EE projects can potentially be implemented, and the skills required for that.
2. The skill sets currently possessed by the professionals working in EE in the industrial, institutional, and commercial sectors.

3. How, when, and where the professionals acquired the skills.
4. The gap between the requirement of skills and knowledge of the EE professionals and the current availability of these skills for future EE projects.
5. Whether the gap can be closed through short term training courses like *in-service professional training programmes*.
6. Whether the available training/academic programs in EE can provide the required skills and knowledge.
7. What needs can be met by longer-term degree courses at the universities.
8. What changes/modifications need to be made to the current programs so that they can provide the needed skills and knowledge.

1.2. Status of energy efficiency in Kenya

Kenya has championed energy efficiency since the early 2000s. In particular, the country has two regulatory instruments geared towards energy efficiency: The Energy (Appliances Energy Performance and Labelling) Regulations, 2016 and The Energy (Energy Management) Regulations, 2012. The Appliances Energy Performance and Labelling Regulations require that specified appliances (self-ballasted lamps, double capped fluorescent lamps, ballasts for fluorescent lamps, refrigerating appliances, non-ducted air conditioners, and three-phase cage induction motors) manufactured or imported in Kenya shall be tested in an accredited laboratory and should meet the set Minimum Energy Performance Standards (MEPS), get registered with the Energy and Petroleum Regulatory Authority (EPRA) and be affixed with an appropriate energy star label.

The main objective of the Energy Management Regulations is to improve energy efficiency and conservation among the medium and high energy consumers in Kenya. These Regulations target industrial, commercial, and institutional facilities consuming more than 180,000 kWh (640,000 MJ) equivalent of thermal and electrical energy per year. The Regulations have been in enforcement by EPRA since 2013. The designated facilities are required to carry out the following activities:

1. Develop an energy management policy
2. Designate an energy officer
3. Conduct an energy audit once every three years
4. Develop an energy management implementation plan
5. Implement energy audit recommendations to achieve at least fifty (50) percent of the recommended energy savings
6. Carry out monitoring of the performance of energy efficiency projects, prepare implementation reports and send them to the Authority
7. Keep a record of production and energy consumption data.

The energy audits are supposed to be conducted by energy auditors who are licensed by EPRA. Currently, there are about eighty-seven (87) licensed energy auditors in Kenya. A person is qualified to be licensed as an energy auditor if (s)he has a minimum academic qualification of a higher national diploma (HND), bachelors or postgraduate degree. Further, energy auditors are required to have passed an energy management certification examination offered by a body recognized by the Authority or have a Postgraduate Diploma in Energy Management or a Master of Science degree in Energy Management from a recognised University. About 81% of the licensed auditors have Certified Energy Manager (CEM) certification (EPRA, 2020). Other qualifications held by the auditors include Certified Measurement and Verification Professionals (CMVP), Masters in Renewable Energy, MSc Chemical Engineering, MSc Energy Technology, and Professional Energy Management (PEM). As part of the qualification process, the licence applicants are examined by

EPRA to ascertain their ability to undertake, engage in or perform energy audit work. In addition, the licence applicants are required to have conducted at least five energy audits.
In the past, CEM trainings have been offered by the Kenya Association of Manufacturers (KAM) and the Association of Energy Professionals Eastern Africa (AEPEA). However, a few of the licensees undertook the CEM course outside the country. The local universities that offer master's degree courses in fields relevant to energy efficiency/management include Jomo Kenyatta University of Agriculture & Technology (JKUAT), Kenyatta University (KU), Moi University (MU), University of Nairobi (UoN), and Multimedia University of Kenya (MMU). Other institutions accredited by the National Industrial Training Authority (NITA) to offer EE related courses include Centurion Systems Ltd, Davis & Shirtliff Knowledge Centre, Eenovators Ltd, KAD Controls Ltd, and Kenya National Cleaner Production Centre Trust.

Recently, EPRA carried out an impact assessment study of the Energy Management Regulations (EPRA, 2020). It was found that whereas the facilities rated the quality of most energy audit reports as good or very good, some stakeholders were of the view that some of the recommended energy conservation measures (ECMs) were not realistic and not well costed, the investment indicators were not correctly computed, monitoring and verification process was not comprehensively outlined in most audit reports, and some ECMs may be clear but not necessarily creative. The study culminated in the Draft Energy (Energy Management) Regulations, 2021 that were published in The Kenya Gazette Vol. CXXII - No. 169, for public comments.

An energy manager in a facility constitutes a critically important role. Without a champion to lead the cause of EE, it becomes much more difficult to accomplish energy conservation goals. Thus, the Energy Act 2019 requires designated facilities to designate an energy manager. This requirement is included in the draft regulations. The energy manager shall be responsible for the co-ordination and promotion of energy efficiency and conservation programmes within the facility. Usually, the roles of the energy manager include:

1. Spearheading identification and implementation of energy efficiency and conservation measures.
2. Sensitization of other staff members on the need to conserve energy by using energy efficient equipment.
3. Advice management on Energy Regulations and energy management issues and ensuring compliance with Regulations when it comes to implementation of ECMs.
4. Collect data, analyse, develop, implement, and coordinate energy efficiency projects and identify gaps that could lead to energy wastage or high energy costs.
5. Recommending procurement of efficient equipment.
6. Constituting energy committee and conducting its meetings and coordinating activities of the energy management team.
7. Overseeing energy audit and implementation of audit recommendations.
8. Decision making on matters energy efficiency.
9. Developing targets for energy efficiency and monitoring energy consumption versus target.
10. Training staff on energy efficiency.
11. Ensuring that the organisation has a well charted strategic plan, an efficient monitoring system and adequate technical ability for analysing and implementing energy saving measures.
12. Reporting on energy use performance and coming up with a clear roadmap for managing energy consumption.
13. Preparing an annual activity plan and presenting it to management covering financially attractive investments to reduce energy costs.

However, there may be variations in responsibilities and requirements among organisations depending on the unique organizational structures, production systems, and operational features of each organisation. In addition, the roles and expectations of energy managers can vary depending on the importance attached to energy efficiency by the corporate leadership, including whether EE is viewed as a primary or secondary goal. The energy managers need technical skills and experience, along with leadership and communication skills essential to draw together a team of people with varying skills and lead them in activities focused on the common goal of improving EE at the facility.

In September 2020, the Kenya National Energy Efficiency and Conservation Strategy (NEECS) was launched (MoE, 2020). This strategy established targets in five thematic sectors (households, buildings, agriculture and industry, transport, and power utilities) to be accomplished within a five-year timeline up to 2025. Further, the strategy acknowledges that training and capacity-building in energy efficiency and conservation is central to meeting the set targets.

1.3. Education system in Kenya

Kenya is currently transitioning from the 8-4-4 system of education which has served the country for thirty-two years to the Competency Based Curriculum (CBC) under the 2-6-3-3 system of education. The structure of the new system is as shown in Figure 1.1

As can be seen from Figure 1.1Error! Reference source not found., in this new education system, l earners take 2 years in pre-primary schooling, 6 years in primary and another 6 years in secondary schooling divided into 3 years at junior secondary school and another 3 years at senior secondary school. Higher education either in a tertiary institution or university will take at least 3 years.

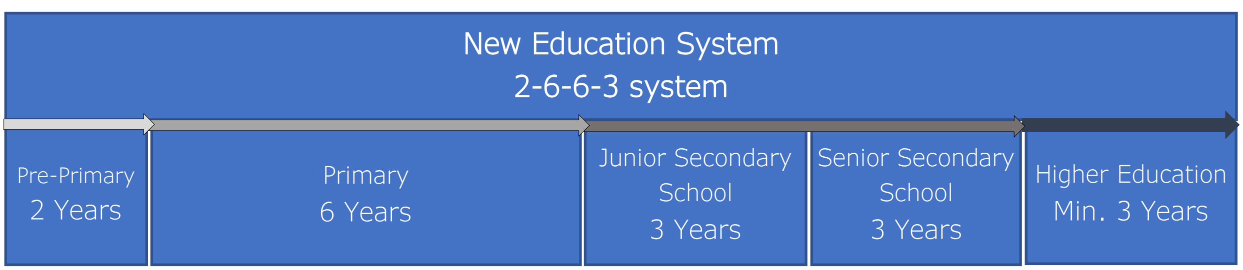

Figure 1.1: Structure of the new CBC education system

1.4. Project objectives

The project aims to create or strengthen local vocational skills in energy efficiency. The steps that led to achievement of the project goal included:

1. Identification of the relevant applications or processes within the industrial, institutional, and commercial facilities where EE projects can potentially be implemented, and the skills required.
2. Establishment of the skill-sets of the professionals who are currently working in the EE sector.
3. Establishment of how, when, and where the professionals acquired the EE skills.
4. Identification of gaps in knowledge and skills of the professionals required for future EE projects in the industrial, commercial, and institutional facilities.

5. Assessment of the content of courses at university and training programs run by different institutions in Kenya and identify skills and knowledge gaps.
6. Review of the short-term training and university programs in other jurisdictions with a view to understanding how the EE programmes in Kenya can be improved.
7. Establishment of the skills and knowledge gaps which can be closed through short courses and which ones can be met through longer-term degree courses.
8. Deduction of the short courses and the core courses to be included in university degree programs so that they can provide the needed skills and knowledge.

1.5. Scope of the project

The study focused on licenced energy auditors who conduct audits in facilities and energy officers working in designated facilities, as the energy efficiency professionals who are currently working in the EE sector in Kenya. The demand for the EE skills and knowledge was established through review of the audit reports submitted to EPRA by medium and high energy consuming facilities. Additional data was collected from sampled facilities by way of interviews. Further, EE professionals training institutions, government and non-governmental agencies that have interests in energy management, and financial institutions that finance energy management projects also participated in the study.

1.6. Organization of the report

This report comprises of six chapters. The background information, study objectives, and scope are presented in Chapter 1. The methodology employed to execute the study is outlined in Chapter 2 whereas the roles of EE professionals in energy management, the knowledge and skills that they require, and the training programs for EE professionals in other jurisdictions are presented in Chapter 3. The demand for EE skills in Kenya, competences of the EE professionals currently working in Kenya, and the EE training programs offered by various training institutions in the country are discussed in Chapter 4. In Chapter 5, the gaps identified in the knowledge and skills of the EE professionals and in the EE training programs offered in Kenya are presented. Finally, the recommendations on the short courses that can be offered to the in-service EE professionals to bridge the identified skills and knowledge gaps are presented in Chapter 6. In addition, the courses that should be included in postgraduate courses that can be recognised by the Authority for licensing of energy auditors are also presented in this chapter.

Photo by Debby Hudson on Unsplash

2. Study Methodology

This chapter is a description of the methods used in the study. The first section of the chapter describes the overall approach, which is followed by description of data methods that have been used in this study. The data section discussion the approach used to select stakeholders and other data and information gathering tools that are used in the study. This chapter ends by discussing the analytical tools use and how reporting of analysis is done.

2.1. The overall approach

The relevant applications and processes within the industrial, commercial, and institutional facilities where EE projects can potentially be implemented and the skills required for their implementation were identified. This was done through review of sampled audit reports submitted to EPRA. The quality of the reports was assessed in terms of the clarity in communication and wholesome coverage of the main energy consuming equipment and processes in the audit. In addition, a few facilities in the three categories were visited to verify and gather more information on the EE opportunities and energy officers' skills and knowledge of EE.

A representative sample size was selected based on the total number of facilities that had been audited and submitted audit reports to EPRA. Data collection tools were developed and collected from various stakeholders in the EE sector. The collected data were analysed, and gaps and weaknesses in the EE professionals' skills and knowledge were identified. The content of courses at university and training programs run by different institutions in Kenya were benchmarked against those in other jurisdictions.

Based on the study findings, recommendations have been made on the skills and knowledge gaps that can be closed through short courses and the ones that can be met through longer-term degree courses.

Further, customised program modules for training in-service EE professionals and the core courses to be taught at university level so that they can provide the needed skills and knowledge were identified. Finally, recommendations have been made for policymaking on how to update educational profiles according to local needs and state-of-the-art international best practices.

2.2. Approach for data collection

2.2.1. The basis

a) The key stakeholders in EE sector were first identified and a sample size was selected that was used for evaluation to meet the study objectives.
b) Data collection tools were developed that were validated by UNEP CCC.
c) Data that were relevant to meeting the study objectives were collected and analysed.
d) The project findings were documented. After the project draft report was prepared, a stakeholders' workshop was held. Different experts and focus groups in energy efficiency were invited to give their views on the report, which were incorporated in this final report as was found to be necessary.

2.2.2. Identification of stakeholders

A recent study (EPRA, 2020) found that there are about 3,383 medium and high energy consuming facilities in Kenya that are obligated to cause energy audits of their facilities to be conducted. However, only about 1,987 energy audit reports had been submitted to the Authority as per the Energy (Energy Management) Regulations, 2012 between 2014 and August 2020, with some facilities having submitted more than one report. Table 2.1 gives the categories of the designated facilities whose audit reports were reviewed, and their respective sub-sectors.

Other stakeholders who were targeted in the study included licensed energy auditors, EE professionals' training institutions, government and non-governmental agencies that have interests in energy management, and financial institutions that finance energy management projects. The selected agencies are involved in: capacity building initiatives including training and development of awareness materials and content on energy efficiency; financing solar PV and EE projects, solar water heating, and air conditioning; promoting the use of renewable energy and energy efficiency (RE&EE) in the region through development and harmonization of policies, strategies, and roadmaps, among others at regional scale with specific support to national processes, capacity building, investment promotion, knowledge management, and research & development; offering sustainable use of natural resources and energy financing programmes that are aimed at assisting small to medium size entities adopt sustainable green solutions through provision of technical assistance and concessional finance; developing energy efficiency related standards.
Details on the sampling techniques used in the study are given in Appendix A.

Table 2.1: Categories of participating facilities

Type of facility	Sector
Commercial	Hospitality Horticultural Water & sewerage companies (WASCO) Offices & retail (O&R) buildings Supermarkets Others
Industrial	Food & beverage Pharmaceutical Metals & allied Agricultural produce Cement Plastics Textile & apparels Others
Institutional	Universities/research Hospitals Schools Recreational amenities Others

2.2.3. Development of data and information gathering tools

Tools were developed for the purposes of collecting relevant data (see Appendix B) that would meet the project objectives. The questionnaires were administered to sample designated facilities, licensed energy auditors, and EE professionals training institutions. Other stakeholders were interviewed using interview guides. The interview sought information about the skills and knowledge of the EE professionals working in Kenya. The tools were used during the study for the following:

1. To identify the relevant applications or processes within the industrial, institutional and commercial facilities where EE projects can potentially be implemented.
2. To establish the skill-sets of the professionals who are currently working in the EE sector.
3. To establish how, when, and where the professionals acquired the EE skills.
4. To identify gaps in knowledge and skills of the professionals required for future EE projects in the industrial, commercial, and institutional facilities.
5. To establish the content of courses at university and training programs run by different institutions in Kenya.

2.2.4. Data collection

Desktop study

Published literature was reviewed to establish the roles of EE professionals in energy management and the knowledge and skills that they require to perform the roles. Further, sample energy audit reports submitted to the Authority as per the Energy (Energy Management) Regulations, 2012 were reviewed to establish the EE projects that can be implemented in future, as well as to assess the quality of the energy conservation measures (ECMs) documentation. This partly informed the demand for EE professionals' skills and knowledge.

The content of EE training programs and short courses offered in Kenya and other jurisdictions where EE is well established were also reviewed. This was with a view to making recommendations for enhancement of the local EE programs.

Using information gathering tools

An introduction letter from the Ministry of Energy was obtained. The letter together with the information gathering tool were sent out through email to the selected stakeholders prior to a face-to-face interview. This was then followed by a visit by a team member who verified, validated, and where necessary sought clarification on the information provided.

2.3. Data analysis and reporting

After collecting the data using the information gathering tools and through interviews, a detailed review and analysis of the responses from the various stakeholders was undertaken. Based on the responses from the various stakeholders and the information gathered from the review of audit reports, conclusions were drawn on (i) the relevant applications or processes within the industrial, institutional, and commercial facilities where EE projects can potentially be implemented and the skills required, (ii) the skill-sets of the professionals who are currently working in the EE sector, (iii) how, when, and where the professionals acquired the EE skills, (iv) the gaps in knowledge and skills of the professionals required for future EE projects in the industrial, commercial, and institutional facilities. Recommendations on which skills and knowledge gaps can be closed through short courses and which ones can be met through longer-term degree courses were made.

The content of courses offered by universities and training programs run by different institutions in Kenya were also assessed and skills and knowledge gaps identified. In addition, suitable jurisdictions were identified and a review of similar courses in such jurisdictions undertaken. Thereafter, recommendations were made on the core courses for the training of in-service professionals and programs to be taught at university level so that they can provide the needed skills and knowledge.

Finally, recommendations were made for policymaking on how to update educational profiles according to local needs and state-of-the-art international practices on this matter. The project findings were disseminated through a stakeholders' workshop. The stakeholders' feedbacks were considered and where necessary, incorporated in this final report.

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3. Requisite Knowledge and Skills For EE-Professionals

This chapter presents the findings of the study from information and data collected from the literature. The chapter starts with presentation of the roles of EE professionals in energy management. This is followed by a presentation of the knowledge and skills that these professionals should have to effectively deliver on their roles. Finally, the training programs for EE professionals offered in other jurisdictions are presented.

3.1. Roles of EE professionals in energy management

As highlighted earlier in this report, the key EE professionals currently working in Kenya are energy auditors. However, in future, every designated facility may be required to designate an energy manager. Thus, the study only explored the roles of these two categories of EE professionals in energy management as follows.

Energy auditor

- Plan the energy audit scope, resources and time required to carry out the exercise
- Identify the major energy uses in a facility
- Primary data collection through measurements, observations, and interviews
- Secondary data collection
- Analysis of field data related to energy usage
- Review of processes and operating data
- Plant production logs and maintenance records review
- Identification of ECMs
- Technical evaluation of the identified ECMs - calculate the expected energy and cost savings
- Financial evaluation of the ECMs
- Make judicious recommendations of the viable ECMs
- Write energy audit report
- Present the energy audit findings to the facility operator and incorporate any feedback.

Energy manager

- Build support for energy management initiatives and goals at all levels of the facility
- Coordinate energy committee and energy champions
- Develop and track energy goals, plans, and proposals
- Oversee site inspections and energy surveys
- Monitor energy consumption
- Analyse energy bills
- Coordinate energy audits
- Develop energy efficiency targets
- Develop a programme of energy efficiency projects and prepare an annual activity plan and budget
- Oversee implementation of ECMs
- Verify improvements in energy consumption
- Keep accurate records on energy consumption and other measurable variables which affect energy consumption e.g., occupancy, production, weather data etc.
- Regularly analyse the energy data
- Lead energy conservation awareness programs
- Ensure compliance with the energy policy
- Champion energy management
- Advise management on relevant legislation, regulations, and carbon trading schemes
- Develop and manage EE training programmes at operating levels
- Prepare periodic reports for presentation to stakeholders.

To effectively perform their respective roles, the EE professionals need to have the knowledge and skills presented in the following section.

3.2. Knowledge and skills required by EE professionals

Generally, energy management requires knowledge and skills in different areas as reported in various publications (Pugh & Hardcastle, 2014), (Global Superior Energy Performance Partnership Energy Management Working Group, 2013), (Australian Government Department of Resources, Energy and Tourism, 2010). These reports highlight that energy auditors require the knowledge and skills in the areas presented in Table 3.1.

Table 3.1: Requisite skills and knowledge for energy auditors

Knowledge/ skills	Area/ topic
Energy management knowledge	• Energy fundamentals • Energy metrics • Energy and other data collection • Energy accounting and analysis • Tariffs and tariff structures • Establishing energy performance indicators • Energy mass balance diagrams and models • Factors influencing energy use or waste
Technical knowledge	• New/emerging and existing technologies for EE improvement • Operations and maintenance practices • Systems optimization • Metering, monitoring, measurement, and verification techniques and protocols • Electrical power systems analysis • Thermodynamics and heat transfer • Commissioning principles • Combined heat and power • Technical understanding of processes
Analytical skills	• Energy and production data statistical analysis including regression analysis • Whole-system analysis • Problem-solving abilities
Financial and accounting skills	• Economics of energy management • Life cycle cost analysis • Financial decision-making processes • Economic assessment indicators • Financing options • Cost control and budgeting • Risk management
Regulations, standards, and best practices knowledge	• National and county laws, rules, regulations, standards, policies • Global and sector best practices
Other knowledge and skill areas	• Organizational and leadership skills • Project planning and management • Communication and interpersonal skills • Performance contracting • Judgment and decision making; considering the relative costs and benefits of potential actions to choose the most appropriate one • Report writing skills

The energy managers require to acquire the skills and knowledge in the areas presented in Table 3.2 for them to play their roles effectively.

Table 3.2: Requisite skills and knowledge for energy managers

Knowledge/ skills	Area/ topic
Management skills	• Organizational and leadership skills • Project planning and management • Cultural and behavioural change management
Analytical skills	• Energy data collection and analysis
Technical knowledge	• Energy-using systems • Selection and use of metering and monitoring equipment • Ability to develop and implement effective data management, tracking and reporting systems
Regulations, standards, and best practices	• National and county laws, rules, regulations, policies and standards • Global and sector best practices
Other knowledge and skill areas	• Ability to manage integration of EE projects and goals into cross-business operational plans, procedures and key performance indicators • Communication skills • Personnel motivation methods • Development of business cases for EE projects • Energy procurement • Cost implications of wasting energy • Information management • Communicating effectively in writing
Soft skills	• Time management • Positive attitude • Strong work ethic • Problem-solving skills • Team Player • Flexible & adaptable • Passion for the energy industry

3.3. Training programs for EE Professionals in other jurisdictions

The training of EE professionals in other jurisdictions was reviewed and the findings are presented in the following sub-sections.

3.3.1. Postgraduate courses

Table 3.3: Postgraduate Courses

University, Country Degree programme	Modules/ Courses
Centre for Alternative Technology, UK Master of Science, Sustainability in Energy Provision and Demand Management	*Core modules* • Introduction to sustainability in energy provision and demand management • Energy flows in buildings – Part B • Energy generation from wind • Energy generation from solar *Optional modules* • Energy flows in buildings – Part A • Environmental politics and economics • Energy generation, supply and demand in cities • Hydroelectric and marine energy generation
Tezpur University, India Master of Technology in Energy Technology	*Core courses* • Foundation for energy technology: • Fuel and combustion • Heat transfer • Solar energy engineering and application • Biomass energy and application • Wind and hydro energy • Energy laboratory • Energy management and auditing • Energy economics and planning • Energy systems and simulation laboratory • Energy study with community engagement *Optional courses* *Cluster 1* • Advanced bio-energy • Advanced solar thermal energy • Advanced solar photovoltaic energy • Hydrogen energy and fuel cell • Alternative fuels for IC engines • Petroleum exploration, production and refining • Nuclear energy *Cluster 2* • Thermal power plant engineering • Energy efficient buildings • Renewable energy grid integration • Decentralized energy systems • Energy, climate change and carbon trade • Instrumentation and control for energy systems • Numerical heat transfer and fluid flow • Energy conservation and waste heat recovery

University, Country Degree programme	Modules/ Courses
	• Energy storage systems • Energy modelling and optimization • Energy-environment interaction • Materials and devices for energy applications • Power generation and system planning • Hybrid renewable energy systems design
Heriot-Watt University, UK Master of Science in Energy	*Core courses* • Foundations of energy • Technology futures and business strategy • Critical analysis and research preparation *Optional courses (select five)* • Renewable energy technologies • Economics of renewable energy • Environmental impact assessment • Demand management and energy storage • Energy technology • Ventilation & air conditioning • Computational fluid dynamics with heat transfer • Heat transfer and heat exchangers • Process intensification • Sustainable processing • Oil & gas field appraisal • Oil & gas field development • Electrical power systems • High voltage *Maximum 3 business courses* • Environmental and energy economics • Competitive strategy • Strategic project management • Financial analysis • Project economics and evaluation • Business economics
Al Akhawayn University, Morocco Master of Science in Sustainable Energy Management	• Introduction to renewable energy • Energy and the environment • Energy management • Energy economics and finance • Conventional energy technologies • Energy distribution systems • Renewable energy technologies • Special topics in sustainable energy management

3.3.2. Short-term courses

Table 3.4: Short term courses

Institution, Country	Courses offered
National Cleaner Production Centre, South Africa	• Resource efficiency and cleaner production • Energy management system implementation • Energy performance measurement indicators • Energy management 101 • Power quality principles • Energy systems optimisation; biogas, compressed air, motor, pump, fan, steam, large scale cooling and industrial refrigeration systems
Terra Firma Academy, South Africa	• Energy Management Fundamentals • Energy Efficiency Management • M&V Professional
Centre for Research in Energy and Energy Conservation, Makerere University, Uganda	(5-day EE course) • Introduction to energy efficiency and energy management • Energy audit methodologies • Energy audit instruments • Energy monitoring • Lighting • Electrical motors and drives • Refrigeration and cooling • Compressors, boilers, etc. • Energy audit reporting
American Public Power Association, USA	• Electric utility industry overview: strategic challenges & trends • Energy efficiency: concepts and strategies • Designing efficiency programs to serve your customers • Energy efficiency program implementation, reporting and evaluation • Emerging trends and opportunities in energy efficiency and distributed energy resources
Indian Institute of Social Welfare and Business Management, Kolkata, India	• General aspects of energy management and energy audit • Energy efficiency in thermal utilities • Efficiency in electrical utilities • Energy performance assessment for equipment and utility systems
Canadian Institute for Energy Training, Canada	• Advanced management of compressed air systems • Advanced Measurement and Verification (M&V) • Dollars to $ense energy management workshops • Energy efficiency financing: understanding the mechanisms & resources to fund EE projects • Heat integration of industrial processes • Introduction to combined heat & power (CHP) • Introduction to measurement and verification (M&V) • Energy efficiency program evaluation • Motors, variable speed drives and energy efficiency • Finding savings opportunities motors and flow inducing equipment (fans, pumps, blowers, etc)

Institution, Country	Courses offered
	• Financial analysis of energy savings
Energy Institute, UK	• Energy auditing in practice • Energy auditing: Report writing • Energy management solutions • Energy management: Project development • Metering and buying • Metering, monitoring, and targeting techniques • Mounting an effective staff awareness campaign • Regulations and standards • Building management systems (BMS) • Building physics and thermal comfort • Data testing and analysis • Energy and water efficiency • Energy management and transport • Finance, procurement, and risk assessment • Heating and ventilation • Measurement and verification • Motors and drives • Project implementation • The UK energy industry and energy costs
	European Energy Manager • Energy basics • Project management • Profitability calculation • Energy management/ Load management • Energy and emissions trading • Building energy demand/ Energy efficient buildings • Heating technology • Process heat, steam, heat recovery • Combined heat and power • Ventilation and air conditioning technology • Refrigeration • Electrical engineering, electrical drives • Lighting • Compressed air • Solar technology • Energy from biomass • Green IT
Association of Energy Engineers, Global	Certified Energy Manager (CEM) • Codes and standards • Energy accounting and economics • Energy audits and instrumentation • Electrical power systems and motors • HVAC systems • Industrial systems • Building envelope • CHP systems and renewable energy • Fuel supply and pricing

Institution, Country	Courses offered
	• Building automation and control systems thermal energy storage systems • Lighting systems • Boiler and steam systems • Maintenance and commissioning • Energy savings performance contracting and measurement & verification
Association of Energy Engineers, Global	Business Energy Professional (BEP) • Codes & standards; and green buildings • Energy fundamentals • Utility rates • Electric and gas procurement • Energy accounting & metering • Energy audits and instrumentation • Energy economics, financing energy projects, and performance contracting • Commissioning; measurement and verification • Building systems • Industrial systems • Energy efficient equipment & applications
Association of Energy Engineers, Global	Certified Energy Auditors (CEA) • Developing an energy audit strategy & plan • Energy use analysis • Data collection & analysis • Economic analysis • Lighting systems • HVAC systems • Domestic hot water systems • Motors and drives & compressed air systems • Building envelope • Building automation systems, process automation systems, & energy management and control systems • Alternative generation & storage • Transport
Association of Energy Engineers, Global	Certified Industrial Energy Professional (CIEP) • Fundamentals to industrial energy audits and energy • Management systems • Instrumentation and controls • Energy investigation support tools • Fuels, furnaces, and fired equipment basics • Plant water systems • Heat exchange systems • Boiler and steam systems • Electric motors & drives • Pump systems • Fan systems • Compressed air systems

Institution, Country	Courses offered
Association of Energy Engineers, Global	Certified Measurement & Verification Professional (CMVP) • Basis for adjustments • M&V plans • IPMVP options • Option A: Retrofit isolation • Option B: Retrofit isolation • Option C: Whole facility • Option D: Calibrated simulation • Savings reports • Adherence • Metering and considerations • Modelling, sampling, and uncertainty • Foundational principles

Photo by Sharon McCutcheon on Unsplash

4. Demand for EE Skills, EE Competences and EE Training Programs in Kenya

This chapter presents the findings on the current situation of the EE sector in Kenya. The chapter starts with a presentation of the applications and processes in various types of facilities where energy efficiency (EE) projects can be implemented. Thereafter, the skill sets of the professionals currently working in the EE sector are presented; an analysis of how, when, and where the skills were acquired. An analysis of the level of competence of the professionals is then presented, and the chapter closes with presentation of the energy efficiency related postgraduate programs and short courses that are offered in Kenya.

4.1. Applications and processes requiring EE intervention

4.1.1. Type and size of facilities audited

Designated facilities are categorised according to their total (electrical and thermal) annual energy consumption as high, medium, or low consumers. The facilities that are categorised as high consumers consume more than 1,200,000 kWh equivalent annually, medium consumers between 180,001 and 1,200,000 kWh, and low consumers between 102,500 and 180,000 kWh. The facilities that consume less than 102,500 kWh equivalent annually are not designated. Further, only the facilities categorised as either high or medium consumers are obliged to carry out energy audits as per the Energy (Energy Management) Regulations, 2012. However, some of the low consumers opt to have their facilities audited. The study sought to find out the type of facilities that the energy auditors who participated in the study had audited and their energy consumption categorisation. The results are as shown in Table 4.1.

It can be observed from Table 4.1 that most energy auditors had experience auditing industrial and commercial (horticultural) facilities that are high and medium energy consumers, respectively each at 94% of the respondents. In addition, 88% of the auditors had audited industrial facilities categorised as medium consumers. Most of the auditors had not audited high energy consumption institutional facilities, with only 41% having had this experience. Overall, for all three energy consumption classifications, 88% of the auditors had audited industrial facilities whereas 71% had audited commercial office buildings and a similar percentage had audited commercial horticultural facilities. The wide experience in auditing industrial facilities is attributable to the fact that the energy efficiency drive in Kenya initially focused on industries before it was opened up to other types of facilities. It is worth noting that institutional (hospitals, learning, research, religious) facilities were the least audited according to the survey, with 59% of the energy auditors having this experience. One factor that may have contributed to the low uptake of energy audits by this type of facilities is the fact that the institutional facilities in the country that meet the threshold (annual energy consumption above 180,000 kWh equivalent) for carrying out an energy audit are not many. Further, some of the institutional facilities are either owned or operated by government agencies that often do not have budgetary allocations for EE projects and activities.

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Table 4.1: Types and energy consumption categorisation of audited facilities

Type of facility	Energy consumption category	Percentage of energy auditors who have conducted energy audit (%)	
		Individual category	Average
Industrial	High	94	88
	Medium	88	
	Low	82	
Commercial (Hotels)	High	59	69
	Medium	82	
	Low	65	
Commercial (Office buildings)	High	65	71
	Medium	82	
	Low	65	
Commercial (Horticultural)	High	59	71
	Medium	94	
	Low	59	
Institutional (Hospitals, learning, research, religious)	High	41	59
	Medium	82	
	Low	53	

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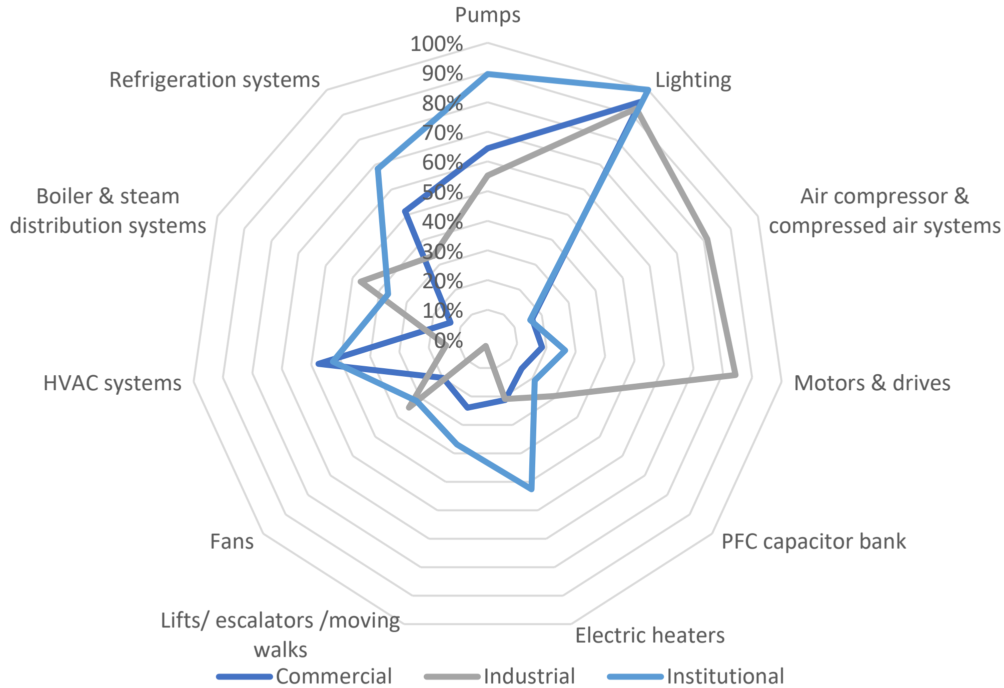
4.1.2. Equipment and systems used

The study team obtained data on the main energy consuming equipment and systems used by the three types of designated facilities from audit reports and through interviewing the facility operators. The results are as shown in Figure 4.1.

a. Audit Reports



b. Interviews

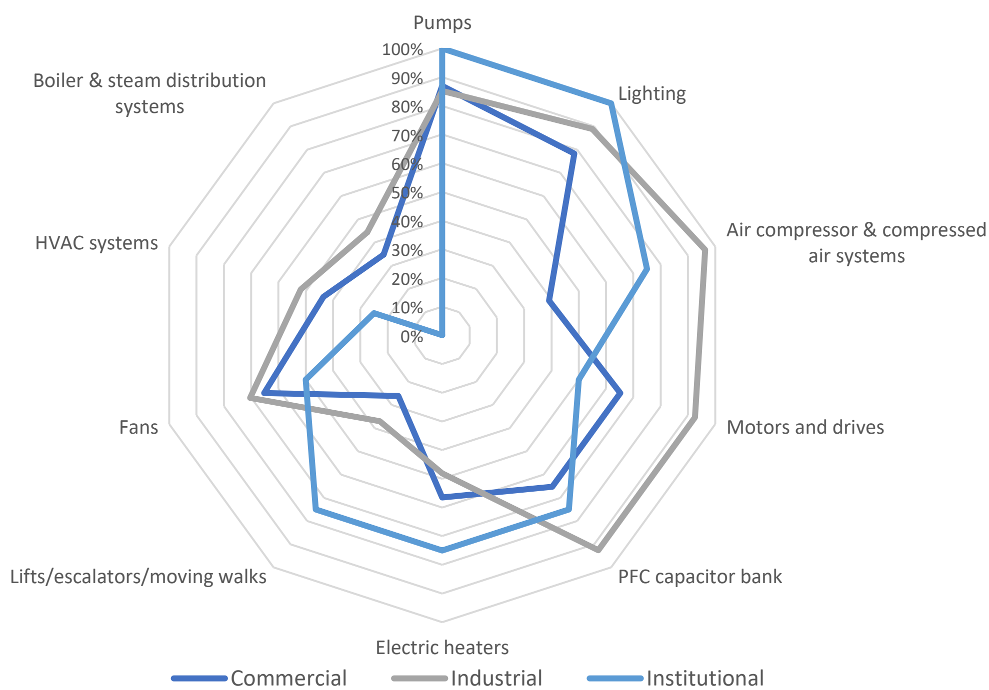


Figure 4.1: Main energy consuming equipment and systems used by designated facilities

From Figure 4.1(a), it is revealed that lighting was the most occurring main energy consuming equipment/system across the three types of facilities that was documented in the energy audit reports at 100%, 95%, and 93% for the institutional, commercial, and industrial facilities, respectively. As much as every facility has lighting systems, it may not be accurate to list these systems as major energy consumers in most industrial facilities which often have heavy equipment that are relatively heavier energy consumers than lighting. In the past, there have been concerns on the energy auditors concentrating on/forcing ECMs related to lighting systems even when the energy consumption of these systems is not significant compared to other systems. For industrial facilities, motors & drives at 84% and air compressors & compressed air systems at 81% took second and third place, respectively. For the commercial facilities, the second and third most common equipment/systems were pumps at 64% and HVAC systems at 58% whereas for the institutional facilities, pumps were second at 89% and refrigeration systems third at 68%. Lifts/escalators/ moving walks were the least documented energy consuming equipment/systems in the industrial facilities' energy audit reports at 2% as can be seen from Figure 4.1(a). This observation is expected since most industrial facilities are not housed in high multi-storeyed buildings that require lifts and their products and materials are moved using conveyor systems and/or forklifts. Further, boiler and steam distribution systems were the least occurring energy consumers documented in the audit reports for commercial facilities at 14%. These systems are mainly used in the hospitality sector; 26% of the audit reports that were reviewed were for facilities in this sector as can be seen from Figure C.1: Commercial facilities
Air compressors & compressed air systems were the least documented energy consuming equipment/systems in the institutional facilities' energy audit reports at 16%.

All the institutional facilities that participated in the interviews had pumps and lighting as main energy consuming equipment/systems as can be seen from Figure 4.1(b). The other main energy consumers in this type of facilities were given as lifts/ escalators/ moving walks, electric heaters, and air compressors & compressed air systems each at 75% occurrence rate. Further, for the industrial facilities, air compressors & compressed air systems were the most occurring equipment/systems as per the interview responses at 96% closely followed by motors and drives at 93%. For the commercial facilities, pumps were the most common equipment/systems at 87% of the interview respondents, followed by lighting at 78%; every facility has lighting systems but not all of them consider such systems to be major energy consumers. Hence, not all facilities affirmed that they have lighting systems.

It can be seen from Figure 4.1(b) that there were no boiler and steam distribution systems in all the institutional facilities that participated in the interviews. This may be due to the low number of facilities that participated in the interviews; 37% of audit reports reviewed for this type of facilities listed these systems as major energy consumers. Further, for both the industrial and commercial facilities, lifts/ escalators/ moving walks were the least common energy consuming equipment/systems as per the interview respondents at 37% and 26%, respectively.
Power factor (*pf*) correction does not significantly save energy but results in reduction in the maximum kVA demand which is also a chargeable component in the electricity bill, depending on

the applicable billing tariff. Electricity consumers in Kenya are classified into domestic, non-domestic small commercial, commercial and industrial, and public and county governments for street lighting.

All designated facilities (industrial, commercial, institutional) whose consumption exceeds 15,000 kWh per billing period (monthly) are charged using commercial and industrial tariffs (CI methods) whereas all the other facilities whose consumption does not exceeds this amount are charged using non-domestic small commercial tariffs (SC methods). The electricity tariffs for commercial and industrial consumers have a surcharge/penalty component if the *pf* falls below 0.9. It can be observed from Figure 4.1(b) that 93%, 75%, and 65% of the industrial, institutional, and commercial facilities had installed power factor correction (PFC) capacitor banks. The main motivation for the facilities to instal the banks is to avoid the penalty and hence, the high incidence of the banks in all types of facilities. In addition, industrial facilities have staff who are better versed with energy management; most of these facilities have higher power demand than those in the other two types of facilities. These factors may have contributed to the higher uptake of PFC capacitor banks by industrial facilities.

4.2. ECMs recommended for implementation

Most (77%) of the facilities that participated in the study had had an energy audit conducted in the recent past (1-3 years prior to the survey) whereas the remaining 23% had one done more than 3 years earlier. This is an indication that most facilities adhere to the regulations that oblige them to carry out an energy audit at least once every three years. However, the audit reports that were reviewed were randomly picked to meet the sample quotas for the three types of facilities as presented in Table A.6. The energy audits had been conducted between 2012 and 2020 as shown in Figure 4.2.

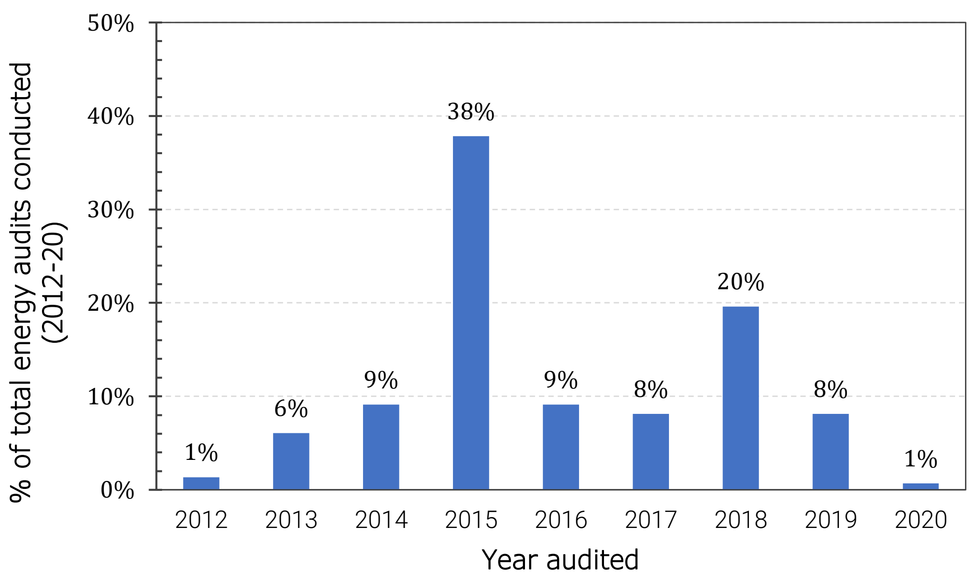


Figure 4.2: Years when the energy audits were conducted

It can be observed from Figure 4.2 that the mode year when the audits were conducted was 2015 at 38% and the next peak in 2018 at 20%. The Energy Management Regulations came into operation in 2013. It is worth noting that some of the energy audits were conducted in 2012 before the regulations became effective. Majority of the audit reports that were reviewed were for commercial facilities at 49% whereas 45% and 6% were for industrial and institutional facilities, respectively as presented in Table C.1. Further, 61% of the audits were general energy audits (GEA) whereas the remaining 39% were investment grade audits (IGA).

The energy auditors had made recommendations in various areas including lighting, compressed air systems, HVAC systems, motors and drives, boilers and steam systems, and water supply systems, among others. The detailed ECMs are given in Appendix D. The study found out that there were few ECMs for pumping systems despite the fact that pumps were documented as main energy consumers in 55%, 64%, and 89% of the industrial, commercial, and institutional facilities' audit reports, respectively as presented earlier in Figure 4.1: Main energy consuming equipment and systems used by designated facilities

In addition, most of the ECMs related to motors and drives were on motor-load matching, motor efficiency and application of VFDs. Further, the lighting systems ECMs are limited to LED retrofits, and occupancy sensors in a few cases. There does not seem to be much focus on the motor systems including power transmission systems. Process improvement also seems to be a neglected part in design of ECMs. Improvements of processes like heating systems, heat exchangers, cooling, pumping and fluid delivery mechanisms, compressed air system design, and optimization of lighting had not been considered in the audits reviewed, despite the fact that they offer potent savings. The coverage of EE in buildings is also weak. This could possibly be attributable to the auditors' minimal exposure in auditing this type of facilities.

You cannot manage that which you cannot measure. Monitoring of energy use is important to identify problems early and to measure improvements. It is advisable that the facilities' install, monitor, and analyse the data recorded by energy sub-meters so that they can give useful information appertaining to the energy use at their facility. Thus, the study sought to find out if designated facilities had installed energy sub meters and the results are given in Figure 4.3.

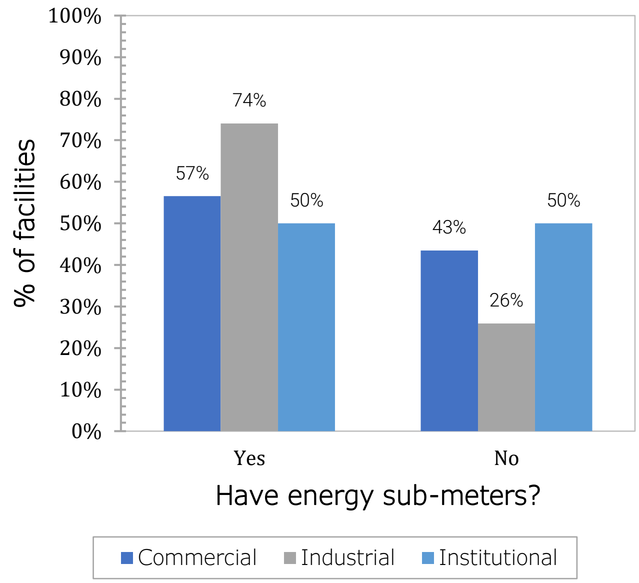


Figure 4.3: Energy sub meters installation in designated facilities

It is evident from Figure 4.3 that the industrial facilities led in installation of sub meters at 74% of the facilities that participated in the survey whereas the uptake by the commercial and institutional facilities was at 57% and 50%, respectively. The facilities should be encouraged to install sub-metres so that they can have a better understanding of where energy is consumed.
Some designated facilities alluded to having experienced technical challenges in implementing the recommended ECMs as presented in

Figure 4.4.

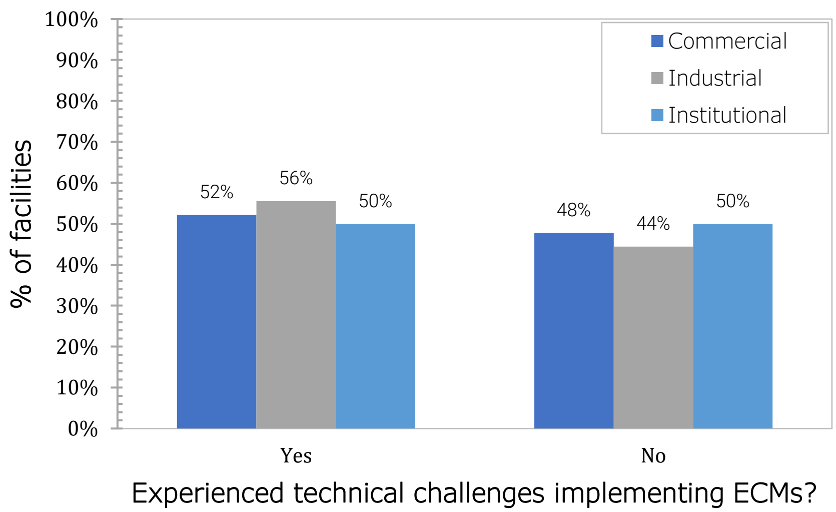
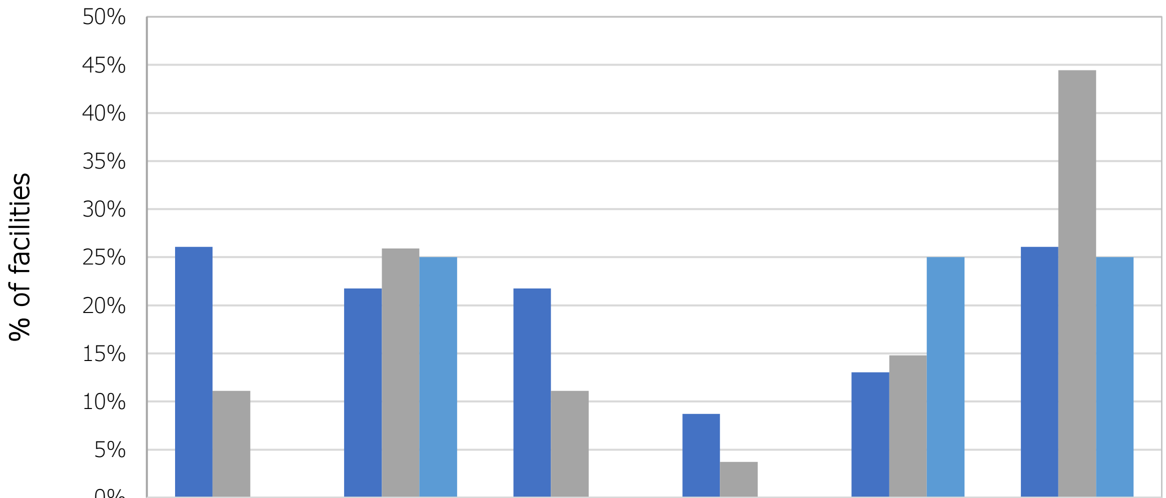


Figure 4.4: Whether or not designated facilities experienced technical challenges in implementing ECMs

It is clear from Figure 4.4 that across the three types of facilities, 50% and more of the facilities that participated in the survey experienced challenges in implementing the ECMs recommended during the energy audit. The frequency of occurrence of specific challenges faced by the facilities is as shown in Figure 4.5.



	Lack of skilled personnel	Energy efficient technologies are not readily available locally	Limited know-how on running new technology based-equipment	ECMs documented in the audit report were not well understood	The audit report lacked adequate/relevant information on the ECMs	Unrealistic ECMs implementation cost
Commercial	26%	22%	22%	9%	13%	26%
Industrial	11%	26%	11%	4%	15%	44%
Institutional	0%	25%	0%	0%	25%	25%

Figure 4.5: Challenges encountered by facilities in implementing ECMs

As seen from Figure 4.5, the leading challenge that was cited was unrealistic ECMs implementation cost experienced by 44% of the industrial facilities that participated in the survey. This is a significant percentage of facilities that experience challenges in implementing ECMs. According to the energy management regulations, the energy auditor should take the client through the audit report so that they understand the contents. It would appear that this is happening as corroborated by the fact that only 4% and 9% of the industrial and commercial facility operators, respectively and none of the institutional ones cited lack of understanding of the ECMs as a challenge to implementation. After being taken through the report, the client then makes a *Statement accepting the report and verifying that the audit report has considered the company's financial criteria for funding of projects*. Thus, by the time the facility operators accept the report, they ought to have understood and be comfortable and agreeable with the financial analysis of the ECMs including the cost of implementing the ECMs. To improve on the acceptability of the recommended ECMs, there is a need to improve training on energy auditors' project costing skills.

4.3. Skillsets of the professionals currently working in the EE sector in Kenya

In Kenya, energy auditors work as consultants except for a few facilities that have licensed energy auditors in their employment who may conduct an energy audit of their facility. In addition, every designated facility is obliged to designate an energy officer who shall be responsible for the development and implementation of energy efficiency and conservation projects. Further, the Energy Act, 2019 envisages that designated energy consumers may be directed to designate or appoint an energy manager or energy auditor in charge of activities for efficient use of energy and its conservation. Thus, for the future energy managers to play their roles effectively, they ought to have certain skills/knowledge of energy conservation. Therefore, the study focused on the energy auditors and energy officers since these are the professionals who are currently working in the EE sector in Kenya.

4.3.1. Energy auditors

The study found that 71% of the licensed energy auditors had conducted energy audits for over 5 years whereas the remaining 29% had conducted energy audits for between 1-5 years. This is an indication that most of the auditors have been in the sector for a reasonable period of time and are well familiar with the skills and knowledge requirements of the EE sector.

Professional qualifications

According to the Energy (Energy Management) Regulations, 2012, an energy auditor license applicant is required to have a relevant energy management certification from a body recognised by the Authority or Post Graduate Diploma in Energy Management or Master of Science degree in Energy Management from a recognised University. This is in addition to meeting the stipulated minimum academic qualifications. The energy auditors practising in Kenya have different energy management professional qualifications with some having multiple qualifications as shown in Table 4.2.

Table 4.2: Energy Auditors Qualifications

Qualification	Percentage of energy auditors (%)
Certified Energy Manager (CEM)	41.2
Certified Measurement & Verification Professional (CMVP), CEM	17.6
MSc. Energy Management/ Technology, CEM	5.9
MSc. Energy Management/ Technology, CEM, CMVP	11.8
MSc. Energy Management, CEM, CMVP, CWEP	5.9
MSc. Energy Management, CEM, CEA, CMVP, Certified Water Efficiency Professional (CWEP), Certified Performance Contracting and Funding Professional (PCF), Carbon Reduction Manager (CRM), Renewable Energy Professional (REP)	5.9
Certified Energy Auditor (CEA)	5.9
Professional Energy Manager (PEM)	5.9

Most (88%) of the energy auditors had CEM qualification as can be observed from Table 4.2. As expected, all the energy auditors who have CMVP qualification also have the CEM one. The CWEP, PFC, and CRM are not core energy management qualifications and they are not admissible for licensing of energy auditors. However, they complement the energy efficiency qualifications/skills.

Most (75%) of the licensed energy auditors had also attended other training courses relevant to energy efficiency or management, with only 25% who had not attended. These courses are presented later in this section.

When skills were acquired

As earlier discussed, CEM is the qualification possessed by most licensed energy auditors. The distribution of the years when the energy auditors qualified is as shown in Figure 4.6.

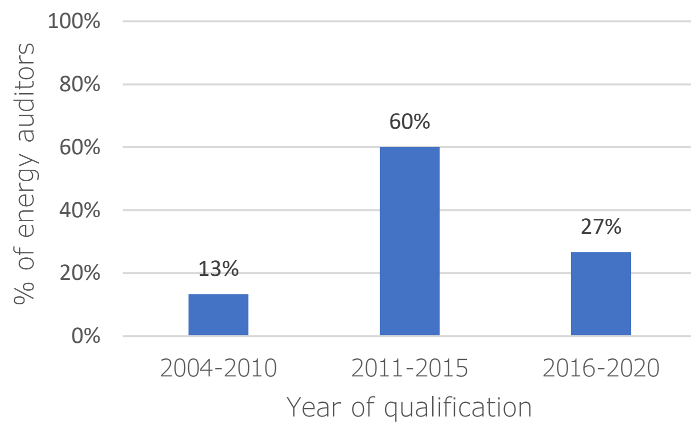


Figure 4.6: Year of CEM qualification by energy auditors

It can be observed from Figure 4.6 that about 87% of the energy auditors who participated in the survey acquired the CEM qualification after 2010 (between 2011-2020). Indeed, 60% of the qualifications were acquired between 2011-2015. It is worth noting that the energy management regulations that require energy audits to be conducted by licensed energy auditors became effective in January 2013. As expected, human capacity development had started in 2004 before the regulations were effected. The high number of energy auditors seeking certification between 2011 and 2015 may be attributable to the requirements stipulated in the regulations.

All CMVP qualifications were attained between 2013 to 2020. Further, the MSc qualification in an EE related field has recently gained popularity with 60% of the holders having attained it either in 2019 or 2020 whereas the remaining 40% qualified between 2011-2018.

Where skills were acquired

The CEM, CEA, and CMVP certifications are all offered by the Association of Energy Engineers (AEE). The CEM and CMVP courses and examination are offered locally through KAM and AEPEA, which is the local chapter of the AEE. Majority (94%) of the energy auditors with CEM qualification did the course locally and only a handful (6%) have taken the courses outside Kenya e.g., through Energy Training Foundation, South Africa. As for the MSc. courses, 80% of the respondents with this qualification undertook the Energy Management course offered at the University of Nairobi (UoN) and the remaining 20% did the Energy Technology course offered by Jomo Kenyatta University of Agriculture & Technology (JKUAT).

Most of the energy auditors had attended other short courses in addition to those that qualify them for licensing as energy auditors. The courses attended by the energy auditors and the institutions offering them are summarised in Table 4.3.

Table 4.3: Other short courses attended by energy auditors

Course name	Training Institution
Optimization of compressed air, motors, steam, and fan systems	Institute of Energy Professionals Africa (IEPA)/UNIDO
Compressed air and steam systems	KAM
Electrical and compressed air systems	GEF-KAM
Power Quality	Eenovators
Boilers and steam systems	GEF-KAM
ISO 50001 Energy Management System	IEPA and Bureau Veritas
Energy Efficiency in the Building Sector	German Delegation of Industry & Commerce in Kenya
Energy Auditing Training	KAM
Energy Management Training	Integrated Energy Solutions (IES) Ltd
Energy Management System	KAM
Energy Management	Eenovators
Lead Auditor course on ISO 9001:2000	SGS
Lead Auditor course on ISO 14001	BVQI
Resource efficiency and cleaner production	IEPA
Resource efficiency & circular production	International Trade Centre (ITC)
Energy Efficiency & Conservation	Indian Institute of Technology (IIT), Roorkee
Ultra-Low Head Micro-Hydro Power	UNIDO
Energy Management Training for the financial sector	KAM
Financial Engineering for Energy Efficiency	KAM
Financial Management for Renewable Energy	University of London
Financial Engineering	KAM
Addressing Climate change in Development Context	Danish Fellowship Centre
Prescribing Renewable Energy	KAM
Sustainable Energy Audit & Project assessment	IFC
Green Energy & Carbon Markets	DANIDA Fellowship Centre
Carbon Finance	IFC
Development and implementation of Energy Standards and Labels	KAM
International program on the management of sustainability	Sustainability challenge foundation (Zeist, the Netherlands)
Operation of energy service companies (ESCOs)	Econoler International, Canada

It can be observed from Table 4.3 that KAM is the most active training institution locally. In addition to policy advocacy, the association in collaboration with the government through the Ministry of Energy (MoE) and donor agencies has been involved in human capacity development and promotion of EE for a long period. Between 2001 and 2006, the Global Environmental Facility – Kenya Association of Manufacturers (GEF-KAM) partnership ran the project on *Removal of Barriers to Energy Conservation and Energy Efficiency in Small and Medium Scale Enterprises (SMEs).* In 2006, the MoE and KAM signed a Memorandum of Understanding (MOU) to establish a Centre for Energy Efficiency and Conservation (CEEC). The key activities of the Centre included undertaking energy audits on behalf of the MoE in mainstream industries, SMEs, and public institutions, provision of capacity-building in energy efficiency and conservation, public education and awareness activities, as well as administration of the annual Energy Management Awards (EMA).

4.3.2. Designated energy officers

Every designated facility is obliged by the energy management regulations to designate an energy officer. Thus, the study sought to establish the proportion of facilities that have a designated energy officer, and the results are presented in Figure 4.7.

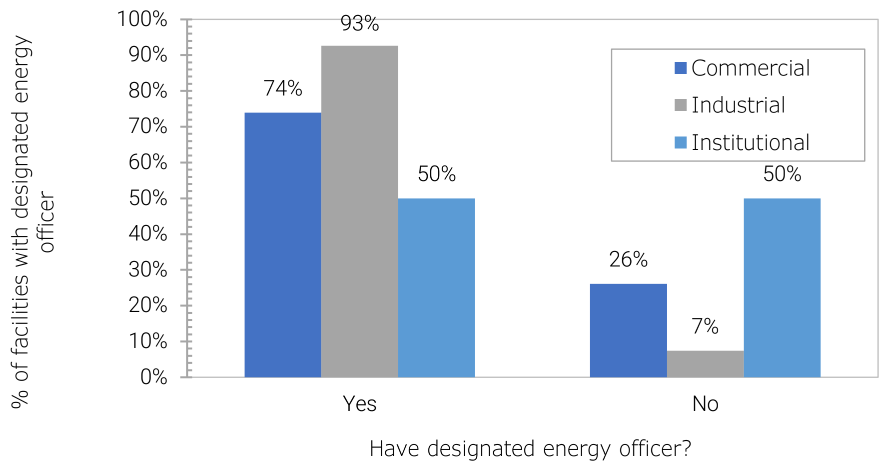


Figure 4.7: Designation of energy officer

It can be seen from Figure 4.7 that 93%, 74%, and 50% of the industrial, commercial, and institutional facilities, respectively that participated in the survey had designated an energy officer and thus, had complied with the regulations. A previous study (EPRA, 2020) found that most of the facilities that had not designated an energy manager were not aware that they were required to do so.

According to the regulations, the designated energy officer should be responsible for the development and implementation of energy efficiency and conservation. However, there is no prescribed minimum academic and professional qualifications for the designated energy officer. The highest academic qualifications of the designated energy officers at the three types of facilities that participated in the survey are as shown in Figure 4.8.

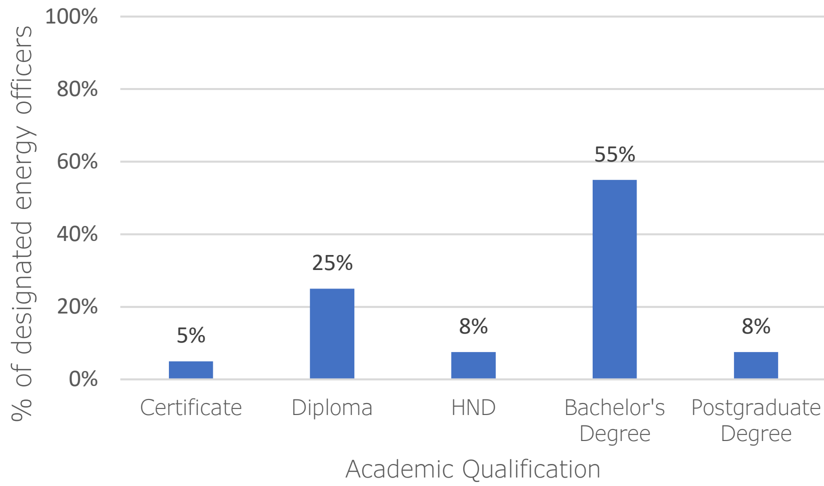


Figure 4.8: Highest academic qualification[1] of energy officers in the 3 types of facilities

It can be seen from Figure 4.8 that only 5% of the designated energy officers were certificate holders; the other 95% were holders of diploma certificate and above. It can also be seen that the majority (55%) of the energy officers were bachelor's degree holders. In addition, it was established that 97% of the energy officers were trained in engineering/ technology whereas the remaining 3% were trained in finance/ business studies. The Draft Energy (Energy Management) Regulations, 2021 (EPRA, 2021) propose that every designated facility shall designate a licenced energy manager. The regulations further propose the minimum academic qualification for accreditation of an energy manager to be a Bachelor's degree or Higher National Diploma or Diploma in Engineering, Physical Sciences or any related field. Thus, it is clear that if this requirement is adopted, majority of the designated energy officers would be admissible for accreditation as energy managers. The energy officers had also undertaken several energy management related courses as presented in Table 4.4.

It is evident from Table 4.4 that energy management courses were the most popular (64%) among the energy officers followed by energy auditing (33%). The popularity of the energy management courses may be attributed to the fact that most of these courses are usually broad and they cover energy efficiency of most energy consuming equipment and systems. The uptake of the measurement and verification courses was low at 21% of the respondents; this skill is necessary for evaluating the improvement/ energy savings that accrue after implementation of ECMs. Further, a significant proportion of the officers had also attended courses in financial analysis (12%), project management (19%), and report writing (21%). These courses are important since the energy officer ought to understand the financial viability of the proposed ECMs, implement the EE projects, monitor the accrued energy savings after ECMs implementation and report on the same. All the other courses are specific to given systems and their uptake

[1] HND - higher national diploma

largely depends on the systems' contribution to a specific facility's energy consumption. The draft regulations further propose that in addition to meeting the minimum academic qualifications, prospective energy managers should have attended trainings in financial engineering, energy management, project management, measurement & verification, appliances energy efficiency, and report writing. It can be seen from Table 4.4 that less than 25% of the energy officers had attended each of these courses except energy management. It is worth noting that only 12% of the energy officers had not participated in any energy management related course; the other 88% had attended various courses which is commendable. However, if the draft regulations are adopted, there will be need to train the people who are currently designated energy officers who meet the minimum academic qualifications so that they qualify for accreditation as energy managers as per the regulations.

Table 4.4: EE related courses undertaken by energy officers in the 3 types of facilities

Energy management course	Percentage of designated energy officers (%)
Energy management	64
Energy auditing	33
Measurement and verification	21
Electrical and compressed air systems	26
Boilers and steam systems	14
Motors, PLCs, VFDs	31
Refrigeration and air conditioning/ HVAC systems	14
Pumping systems and fans	14
Report writing	21
Financial analysis	12
Project management	19
None	12

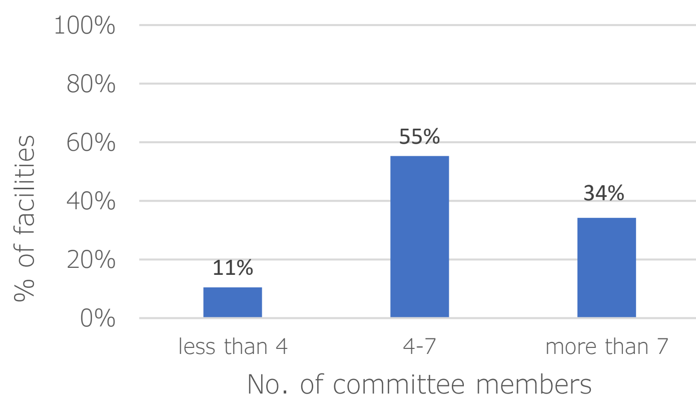


Figure 4.9: Number of energy committee members in the 3 types of facilities[2]

[2] Only facilities with a functional energy committee were considered

Most energy officers are not experts in energy management. Hence, facilities are encouraged to form energy committees to drive the EE agenda, but this is not a requirement in the regulations. The draft regulations propose that the owner of every designated facility shall appoint an energy management committee responsible for planning, monitoring and evaluation of energy management programmes. Most (75%) of the designated facilities that were surveyed in the three categories had a functional energy committee. For these facilities, the distribution of the number of committee members is as depicted in Figure 4.9

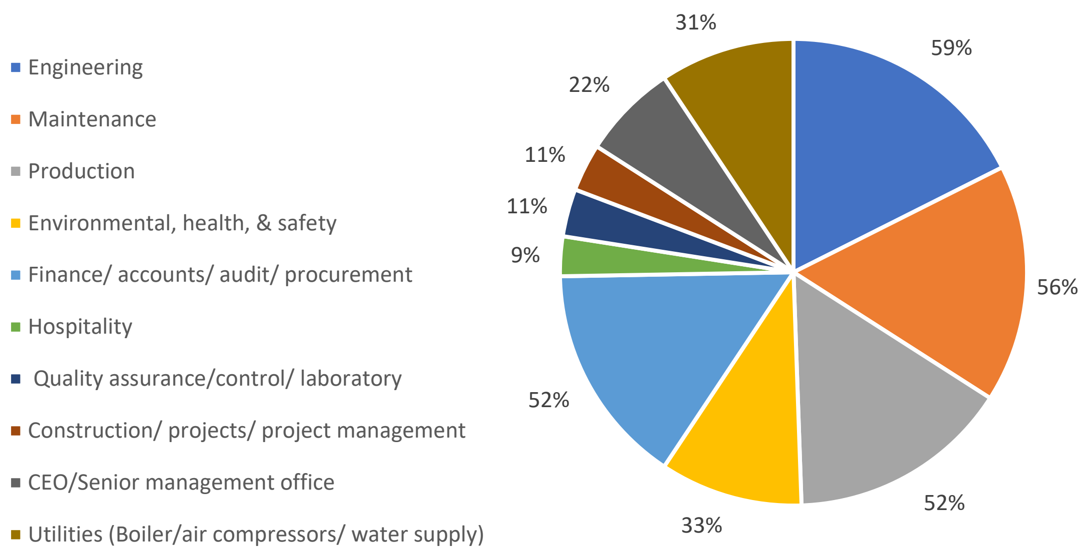


Figure 4.10: Departments represented by energy committee members in the 3 types of facilities

It can be seen from Figure 4.9 that 55% of the energy committees in all the three types of facilities that were surveyed had between 4-7 members. It is worth noting that sometimes the size of the committee is dependent on the facility size and activities carried out, and the bigger the facility and more diverse the activities, the larger the committee size. The membership of the committee should be diverse and drawn from all the departments/sections that influence energy consumption. Figure 4.10 shows the areas of specialisation/ departments from which the committee members were drawn from for the three types of facilities that participated in the survey.

It was found out that the committee members in most facilities were mainly drawn from engineering, maintenance, production, and finance and other related departments as seen from Figure 4.10. It is worth noting that in some facilities, engineering, maintenance, and utilities may all be under the same department/section. In addition, it can be seen that the senior management were represented in the committees of only 22% of the facilities. For successful implementation of EE initiatives, the senior management needs to buy into the importance of energy management and conservation. Thus, there is a need for this tier to be represented in the energy management committees. The draft regulations propose that members of the energy management committee should be drawn from the following departments/ sections in the facility: top management, energy manager, compliance, production/ operations, engineering/ maintenance, human resources and administration, procurement, and security. The proposed duties of the committee include: planning, monitoring and evaluation of energy management programmes; formulation of energy management policy; organising trainings for members of staff; formulation of guidelines for procurement of energy and energy consuming equipment and systems. Given the diverse backgrounds of the proposed committee members, there will be need to have courses that are tailor-made for non-technical people to bring all the members to some certain level of understanding of energy management so that they can perform their roles effectively.

4.4. Level of competence of the professionals working in the EE sector

4.4.1. Licensed energy auditors

The study sought the views of government and non-governmental agencies on whether the EE professionals in Kenya have the requisite skills and knowledge to handle various types of industrial, commercial, and institutional facilities. The agencies affirmed that most of the energy auditors have the skills and knowledge. They alluded to the fact that the energy auditors are well trained and exposed to handle EE in such facilities. Some of the agencies indicated that most of the energy auditors are competent in the following areas:

- Energy auditing processes
- Thermal systems (boilers and steam systems)
- Motors
- Power and energy consumption analysis
- Lighting systems such as LEDs
- Air conditioning systems
- Solar water heating systems
- Data collection, measurement and analysis.

However, some agencies noted that most facilities in Kenya use old technology in their systems. Thus, as much as energy auditors have the necessary educational skill sets, the ability to properly execute the same is limited by the technological exposure of facilities.

The study sought to establish the level of expertise of the energy auditors in performing various energy auditing tasks. The energy auditors were asked to do a self-assessment of their level of expertise in evaluating the energy efficiency performance of different systems as either basic, intermediate, or advanced. The general interpretation of the three levels of competence is; basic is beginner level or simple familiarity with the system/equipment, intermediate level is higher than beginner but not yet an expert whereas an expert has advanced level of competence and fully understands the system/equipment. The results of the self-assessment are given in Table 4.5

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Table 4.5: Level of expertise of energy auditors in evaluating EE performance

Type of system/equipment	Level of expertise/ % of auditors		
	Basic	*Intermediate*	*Advanced*
1. Compressed air systems			
a. Air compressors	12%	24%	65%
b. Compressed air distribution system	12%	24%	65%
c. Air dryer and receiver	12%	47%	41%
2. Power transmission systems			
a. Motors	0%	35%	65%
b. Belts/chains/gears	13%	38%	50%
c. Bearings	24%	41%	35%
3. Heating systems			
a. Boilers	6%	24%	71%
b. Steam distribution system	6%	35%	59%
c. Heat exchangers	0%	38%	63%
d. Condensate recovery system	12%	24%	65%
e. Electrical heaters	0%	0%	0%
4. Cooling systems			
a. Cooling towers	12%	29%	59%
b. Chillers	6%	41%	53%
5. Process heating systems	12%	29%	59%
6. Refrigeration systems	12%	41%	47%
7. Pumping systems			
a. Pumps	6%	29%	65%
b. Motor (prime mover)	6%	31%	63%
c. Piping and valves	6%	59%	35%
d. End-use equipment	6%	31%	63%
8. Fans/blowers	6%	41%	53%
9. HVAC systems	6%	53%	41%
10. Power factor correction	0%	35%	65%
11. Lighting systems	0%	31%	69%

As can be observed from Table 4.5, the majority (50% and above) of energy auditors had advanced level of expertise in evaluating the EE performance of compressed air systems (air compressors and compressed air distribution system), power transmission systems (motors, belts/chains/gears), heating systems (boilers, steam distribution system, heat exchangers, condensate recovery system), cooling systems (cooling towers, chillers), process heating systems, pumping systems (pumps, motor/prime mover, end-use equipment), fans/blowers, power factor correction, and lighting systems. It is noteworthy that for all the systems, there was a significant proportion (20% and more) of energy auditors whose level of expertise was either intermediate or basic.

It should also be recalled that the reviewed energy audit reports revealed that there was not much focus on the power transmission systems, process improvement, improvements of processes like heating systems, heat exchangers, cooling, pumping and fluid delivery mechanisms, compressed air system design, and optimization of lighting as reported in sub-section 4.2. Hence, even the energy auditors who in their own view had advanced level of expertise in evaluating these equipment/systems/processes would benefit from a system/process performance evaluation skills enhancement program.

To be able to assess the EE performance of energy consuming equipment and systems, it is necessary to carry out relevant measurements. The study sought to find out the level of expertise of energy auditors in carrying out measurements of various equipment and systems and their responses are presented in Figure 4.11.

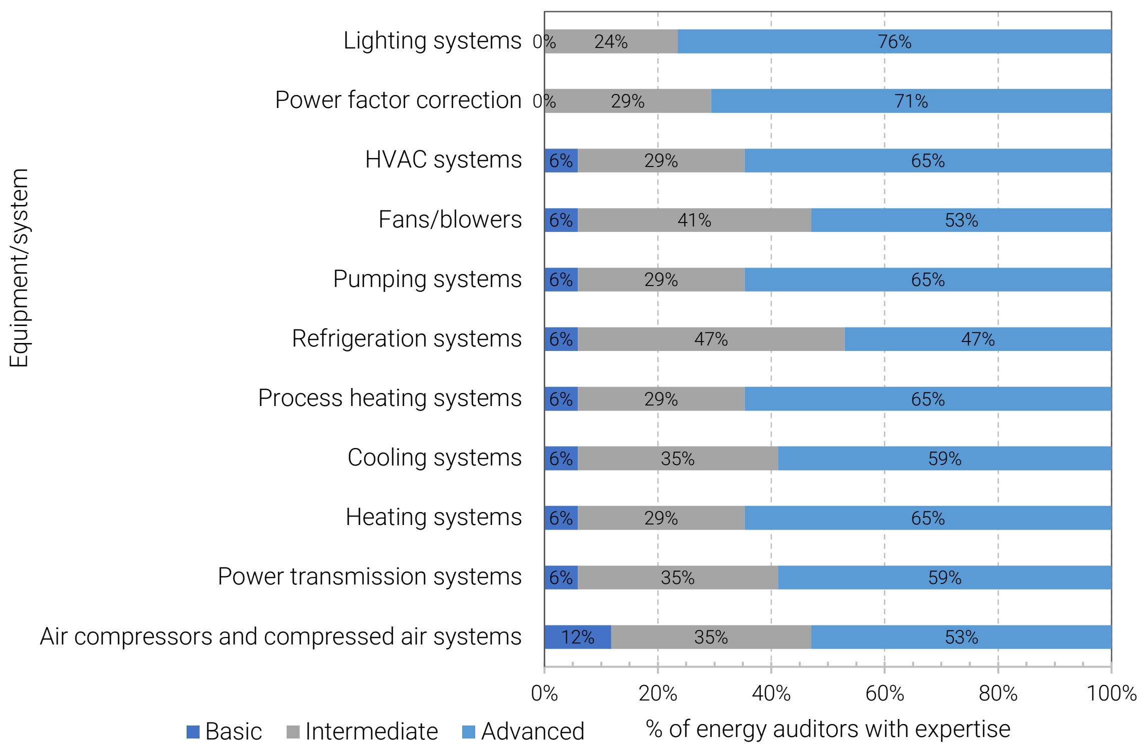

Figure 4.11: Level of expertise of energy auditors in carrying out measurements

According to the energy auditors' self-assessment, more than 50% of them had advanced level of expertise in carrying out relevant measurements of all equipment/systems except refrigeration systems as can be seen from Figure 4.11. However, for all systems and equipment, there was a significant proportion (more than 20%) of auditors whose level of expertise was either intermediate or basic. Again, these auditors would benefit from courses tailored to enhance their skills in identifying the useful parameters to measure, how to conduct the measurements, and how to use the measurements to determine the energy consumption of the equipment or system.

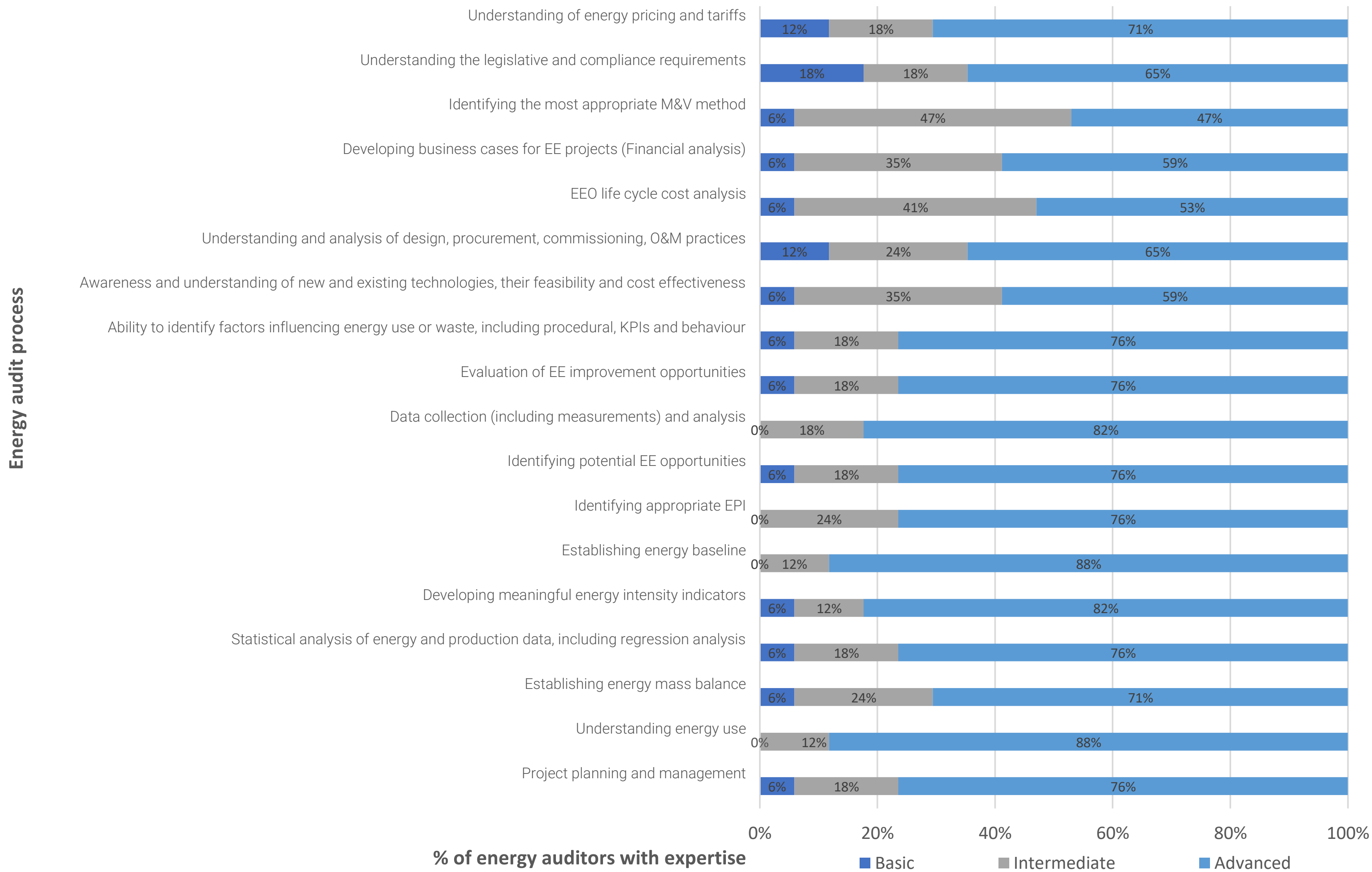

Figure 4.12: Energy auditors' level of expertise in auditing processes

The energy auditors should be guided by Kenya Standard KS ISO 50002 (identical to ISO 50002) in conducting audits as proposed in the draft regulations. Thus, the study sought to establish their level of expertise in some of the energy auditing processes outlined in the Standard. The energy auditors were asked to do a self-assessment of their level of expertise in different auditing processes as either basic, intermediate or advanced with same interpretation as earlier presented. The results are shown in Figure 4.12.

It can be observed from Figure 4.12 that more than 50% of the auditors are of the view that they have advanced level of expertise in all the audit processes except identifying the most appropriate method of measuring and verifying energy performance improvement, where only 47% of them have advanced expertise. This is expected since only about 41% of the energy auditors have CMVP qualification as seen from Table 4.2. Majority (88%) of the energy auditors alluded to following local or international standards in conducting energy audits whereas the remaining 12% were not guided by any standard. The standards used by the energy auditors who participated in the study and the proportion using them is as shown in Table 4.6.

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Table 4.6: Standards used by energy auditors

Standard	Percentage of energy auditors using standard
ISO 50002 and ASHRAE Energy Audit Standards	7%
ISO 50001	20%
ISO 50001 and Energy Management Regulation 2012	20%
Energy Management Regulations 2012	33%
Not indicated	20%

As can be seen from table 4.6 , only 7% of the energy auditors use KS ISO 50002. The Standard specifies the process requirements leading to the identification of opportunities for the improvement of energy performance. The Standard also covers the general requirements and framework common to all types of establishments and organisations, and all forms of energy and energy use. It should be noted that ISO 50001 that is used by 40% of the energy auditors (ISO 50001 and ISO 50001 & Energy Management Regulation, 2012) does not give guidelines on how to conduct an energy audit. The Standard provides guidelines to enable organizations to establish the systems and processes necessary to improve energy performance, including energy efficiency, use, and consumption. This Standard also specifies energy management systems requirements which an organization can develop and implement an energy policy and establish objectives, targets and action plans which take into account legal requirements and information related to energy use. The Energy Management Regulations, 2012 are exclusively used by 33% of the energy auditors. However, the regulations too do not give guidance on the energy audit process, but rather guide on the salient aspects and structure of the audit report. The remaining 20% of the auditors did not give the standards used despite having responded in the affirmative. Thus, it is assumed that they were either not using the correct standard or they were not using any standard at all. Hence, it can be concluded that only 7% of the auditors apply the correct standard and the remaining 94% are not guided by any standards in conducting energy audits. The list of Kenyan Standards that are applicable to energy management processes are given in Appendix E.

From the foregoing, it is clear that there is need for a deliberate effort to be made to create awareness among the energy auditors on the existence of these standards and encourage them to apply them in their work. This will lead to uniformity in carrying out audits and M&V of the EE projects and hence, value addition in the EE sector.

4.4.2. Designated energy officers

Usually, an energy officer/manager is responsible for leading awareness programs, building support at all levels of the organisation for energy management initiatives and goals, monitoring energy consumption, drafting energy conservation plans/programs, coordinating implementation of ECMs, monitoring and verification of improvements in energy consumption, and reporting on the same. The energy officers were asked to do a self-assessment of their level of competence in various energy management functions that they are expected to play a role in as either basic, intermediate or advanced. The general interpretation of the three levels of competence is; basic is beginner level or simple familiarity with the function, intermediate level is higher than beginner but not yet an expert whereas at advanced level, the officer fully understands the function. The results for the facilities that had designated an energy officer (81% of the survey respondents) are presented in Figure 4.13.

It can be seen from Figure 4.13 that there is no energy management function that the majority (over 50%) of the energy officers possess advanced level of competence in. The function with the highest proportion of energy officers with advanced level of competence is energy bills analysis at 46% and lowest is evaluating financing options at 13%. Thus, for all the functions shown in Figure 4.13, the majority of the energy officers possess either basic or intermediate level of competence. There is therefore, need to improve their skills so that they can play their roles in energy management as expected which may lead to improvement in the implementation of ECMs. In addition, the energy officers would also benefit from some basic training in project costing so that they can appreciate the auditors’ work.

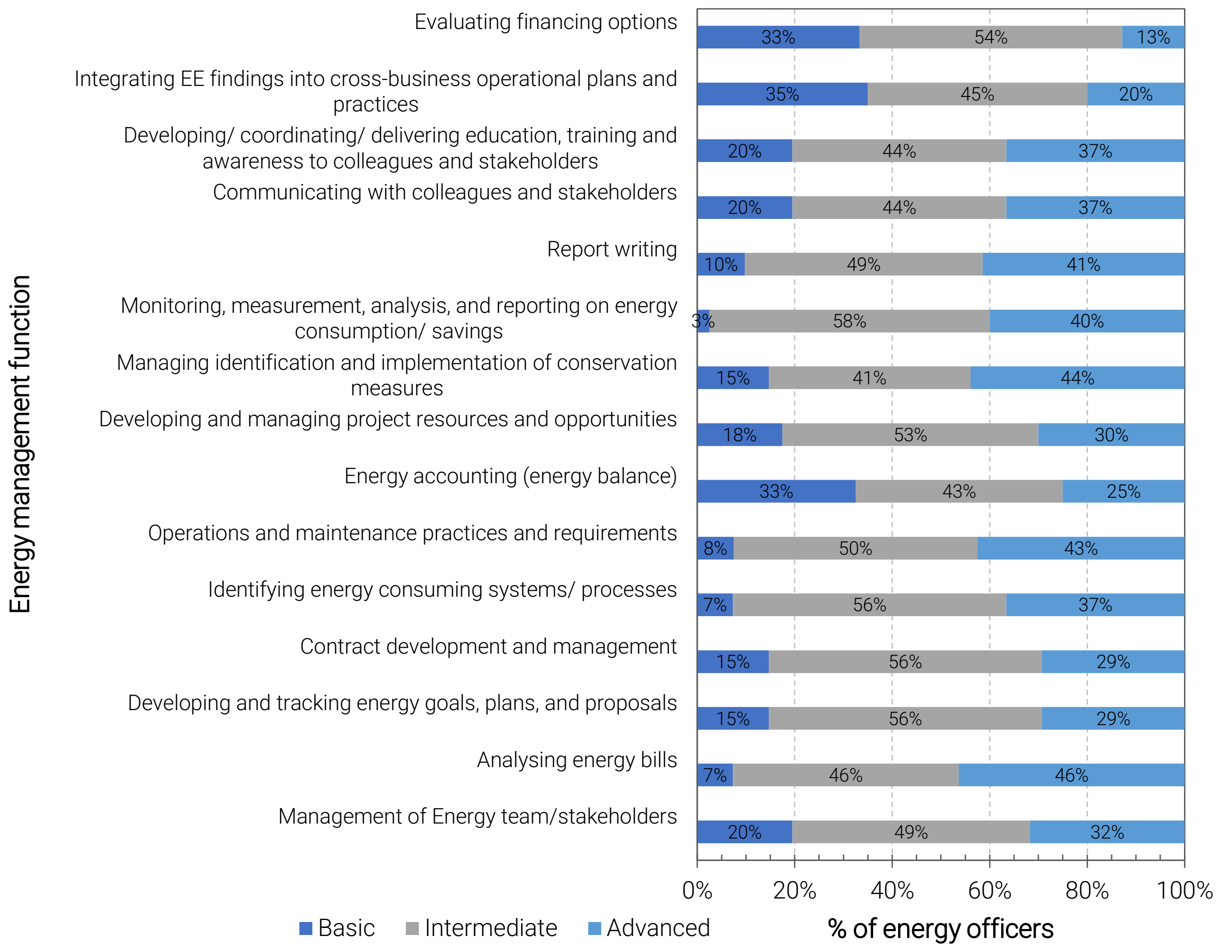


Figure 4.13: Designated energy officers' competence

4.5. EE courses run by different institutions in Kenya

4.5.1. Postgraduate programs

Both the energy management regulations, 2012 and the draft regulations, 2021 recognise Post Graduate Diploma in Energy Management and Master of Science in Energy Management qualifications for licensing energy auditors. Four Kenyan universities that offer energy related postgraduate programs that can be admissible for energy auditor licensing were identified. Some of the institutions did not provide all the information that was requested. Where possible, the gaps were filled by obtaining the information from their respective websites. The programs offered by the four universities are given in Table 4.7.

Table 4.7: Energy related master's degree programs offered by Kenyan universities

University Program (Duration)	Courses offered
UoN Master of Science in Energy Management (24 months)	Core courses • Energy Sources and Concepts • Research Methods • Processes in Energy Management • Project Management • Engineering Economic Analysis • Energy and Environment Elective courses • Refrigeration, Heat Pumps and Air-Conditioning • Steam Generation, Utilization and Waste Heat Recovery • Fluid Flow Systems • Maintenance Management • Metering and Tariffs in Energy Management • Control Systems • Energy Generation, Transmission and Economics • Instrumentation • Electrical Energy Utilities
MU Master of Science in Energy Studies (24 month)	Core courses • Introduction to Energy Studies • Renewable Energy Resources • Management of Energy Systems • Numerical Analysis & Computation • Fuels and Combustion • Energy Measurement Techniques • Research Techniques • Process Energy Management • Heating, Ventilation and Air Conditioning • Elective courses • Energy Efficiency in Buildings • Direct Energy Conversion • Energy Storage and Distribution • Waste to Energy
JKUAT Masters of Science, Energy Technology (24 months)	• Energy Use and Resource Management • Solar Thermal Energy • Wind Energy • Energy Economics and Policy • Biomass Energy • Hydro and Geothermal Energy • Photovoltaic Systems • Hybrid Systems • Seminar and report writing • Research Methodology • Environmental Impact Assessment and Audit
KU Master of Science, Renewable Energy Technology (24 months)	• Research Methodology • Energy Management • Advanced Heat Transfer • Energy Resources and Utilization • Biomass Conversion • Energetic and Power Generation Systems • Solar Energy • Wind and Hydropower Technologies

University Program (Duration)	Courses offered
	• Energy Modelling • Energy for Sustainable Development • Environmental Engineering • Environmental Management Tools and Accounting
MMU Master of Science in Renewable Energy and Technology (24 months)	• Renewable Energy Sources and Environment • Wind Energy Technology • Bioenergy and Conversion Processes • Solar Thermal Energy • Research Methods for Renewable Energy Systems • Hydropower Energy Technology • Solar Photovoltaic Systems • Geothermal Energy Systems • Energy Management and Auditing • Hybrid Renewable Energy Systems

All the four master's programs offering energy related courses run for 24 months as seen from Table 4.7. The programs offered by UoN and MU focus on energy management whereas those offered by JKUAT, KU, and MMU focus on energy technologies. In all the four programs, research methodology is a core course. In addition, Energy Measurement Techniques and Process Energy Management are both taught at MU only, whereas Processes in Energy Management and Project Management are taught at UoN only. Further, Energy Efficiency in Buildings is offered by MU only, as an elective course.

4.5.2. Short courses

Table 4.8 gives the energy management related short courses that are offered by various institutions and their durations.

Table 4.8: Energy management related short courses

Course	Duration
Certified Energy Manager (CEM)	5- 6 days
Certified Measurement and Verification (CMVP)	4 days
Energy Auditing	2-5 days/ 2 weeks
Energy Management for Financial Institutions	2 days
Energy Management for Technical/Energy Professionals	2-5 days
Energy Management for Non-Technical Professionals	2 days
Advanced Energy Auditing	5 days
Energy Awareness	2-3 days
Energy Management Systems End User Training (ENMS)	2 days
Energy Management Information Technology Training (EMITT)	5 days
Energy Management in Resource Efficient and Cleaner Production (RECP)	3 days
Boilers and Steam Systems	3 days
Electrical and Compressed Air Systems	3 days

Course	Duration
Solar PV	1-3 Week
Variable speed drives	1 Week
Boiler operation and maintenance	1 Week
Solar Water Heating	3 Weeks
Solar energy installation	1 month
Biogas Energy Technology	2 weeks
Carbon Footprint Analyst	3 days
Environmental Impact Assessment and Audit	3 weeks

It can be seen from table 4.8 that the short courses are conducted for a minimum of 2 days with the longest duration of 1 month. The courses range from the simple creation of awareness to the more complex certification courses targeting specialised audiences that seek to be energy professionals. Further, some of the courses focus on specific systems like electrical and compressed air systems, boilers and steam systems whereas others focus on the environment and carbon footprint analysis.

Photo by Tomáš Hustoles from Burst

5. Gaps identified in EE professionals' knowledge and skills, and training programs

This chapter presents the gaps that were identified in the knowledge and skills of the EE professionals that are required for current and future EE projects. The gaps in both the short-term courses and postgraduate programs offered by universities in the country are also presented.

5.1. Gaps in energy auditors' knowledge and skills

5.1.1. Gaps identified from audit reports review

Quality of audit reports

The Energy (Energy Management) Regulations, 2012 require designated facilities to submit an energy audit report to EPRA after the audit exercise, which is reviewed for quality check. The observations made on the report are usually communicated to the energy auditors for continual improvement in reporting the outcome of the energy audit exercise. If the issues raised are not deemed to be serious, the report is accepted, otherwise, the auditor is required to make corrections and re-submit the report. The remarks made by EPRA reviewers on the audit reports that were reviewed during the study are summarised in Table 5.1

Table 5.1: Summary of remarks made on audit reports by EPRA

Remark	Percentage of audit reports reviewed (%)
Report was ok and approved	51
Editorial errors	13
Data collection issues	7
Analysis shortcomings	26
Wrong facility description	1
Report rejected	2

It can be seen from Table 5.1 that 51% of the audit reports that were reviewed during the study were accepted without any quality issues being flagged out. Further, most of the shortcomings highlighted by EPRA reviewers were related to analysis of the collected data at 26% of the sampled reports. It is clear that there is potential for improvement in data analysis and reporting the energy audit findings. Ineffective communication reduces the chance of the facilities implementing viable ECMs and may discredit EE.

Some of the suggestions made by EPRA after reviewing the audit reports include:

<u>Historical data analysis</u>

- The diesel consumed by the backup generators needs to be converted to equivalent units of electricity then combined with the number of units of electricity drawn from KPLC to give an accurate indication of the annual electricity consumption
- Auditors should use uniform values of baseline parameters
- More historical data on consumption and power bills should have been requested

<u>Findings and observations</u>

- The percentage estimate used to calculate the savings due to behavioural change should be elaborated in terms of measurements of key aspects like real time monitoring and shop floor behaviour
- Determine motor loading, maintenance, and efficiency class of the machines
- Identify what appliances or sections of the facility are to be monitored

- When discussing air conditioning, it is prudent to describe it using energy efficiency ratio (EER) and coefficient of performance (COP)
- The use of the EER (kW/kW) and COP in estimating energy savings based on measured daily energy consumption of each unit is recommended
- The auditor recommends the use of soft starters but then computes energy savings instead of kVA demand savings
- The auditor should monitor and log the motor loading factors before advising the client on how to improve motor efficiency

Financial analysis

- IRR tool should be used in comparison with cost of money, for it to make sense
- Discounted cash flows should be determined before an IRR is computed
- When the cashflow is discounted, use the discounting formula
- The bank interest rates, and inflation should be used in the financial and economic analysis if this was factored in as a discount factor during the analysis
- The IRR and the payback period for all the projects should not be combined
- Escalation of rates should not be selected arbitrarily since the rate of escalation for energy and any other commodity are published by CBK

Reporting

- Introduce and cite tables and figures after inserting them in the report
- Make reference to tables and figures by their caption numbers and not using the terms “above” and “below”
- Improve report order/structure
- Move the bills and production data to be the first items in the findings section
- Baseline operating parameters, production data and energy consumption profile should be in the findings section

Others

- Include calibration certificates of the instruments used in annexes

The weaknesses flagged out by EPRA’s report reviewers raise issues touching on understanding of the energy consumption/accounting, establishing the baseline, taking measurements, data analysis, financial analysis, and report writing. The auditors would benefit from a skills enhancement program that addresses these weaknesses.

Development of energy mass balance diagram

An energy mass balance diagram is based on the laws of conservation of mass and energy i.e., mass and energy can neither be created nor destroyed. The diagram is a simple block diagram that shows the flow of all materials through a process (input, output, losses) and the corresponding energy consumption and losses. The energy auditors ought to develop an energy mass balance diagram to help in identification of the main energy consumption areas within a facility. This can be achieved by taking the equipment rating and estimated number of hours of operation.

Figure 5.1 shows the frequency of the mass balance diagram in audit reports for the three types of facilities.

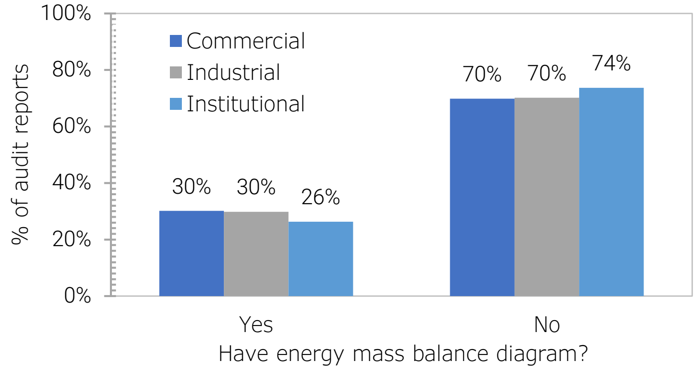


Figure 5.1: Energy mass balance diagram in audit reports

It can be observed from that only 30% each of the commercial and industrial facilities' audit reports and 26% of those for institutional facilities had an energy mass balance diagram. The auditors need to move away from using their expert judgement in deciding on the main energy consumers to a more verifiable approach like the mass balance diagram.

Clarity of ECMs

The regulations require energy auditors to include in the audit report a brief description of the current situation and the identified shortcomings, and the recommended remedial energy saving measures. They are also required to give detailed and clear calculations of the predicted annual energy and cost savings, and indicate the monitoring and verification process to be applied for each recommended measure. The level of clarity of these aspects of the recommended ECMs as documented in the audit reports was assessed as either very clear, clear, or not clear to the reader. The results of the assessment are given in Figure 5.2.

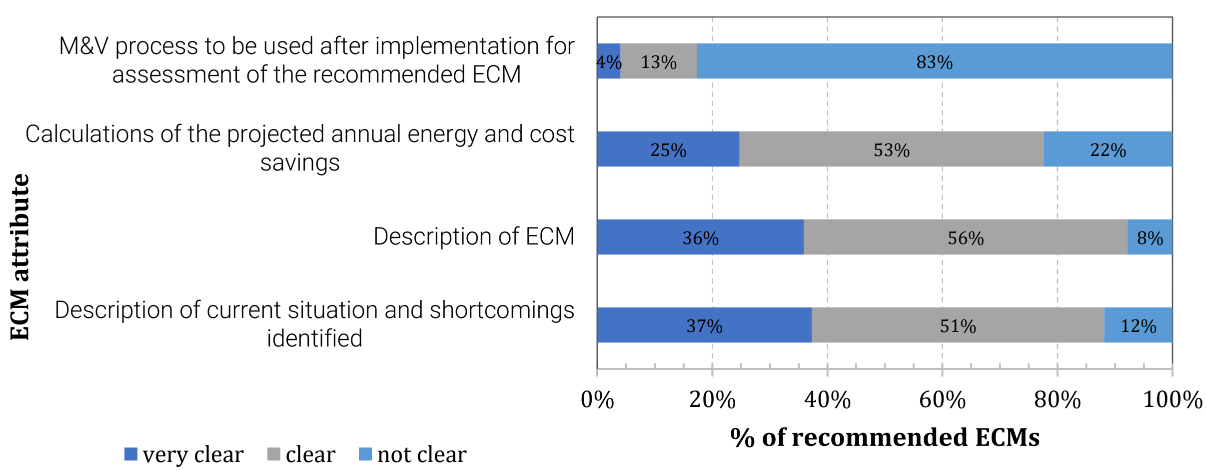


Figure 5.2: Clarity of the identified and documented ECMs

As can be observed from Figure 5.2, the description of the current situation and shortcomings identified, description of the recommended ECMs, and calculations of the projected annual energy and cost savings were either clearly or very clearly described for over 75% of the recommended ECMs. However, the M&V process to be used after ECM implementation for assessment of the energy consumption improvement was not clear in 83% of the audit reports that were reviewed, making this the weakest aspect of the reports. Additionally, calculations of the projected annual energy and cost savings were not clear in 22% of the audit reports reviewed. This is an indication that there are skills gaps in these areas.

ECMs investment indicators

The regulations stipulate that the audit report should include the projected investment cost and investment indicators such as payback period, return on investment (ROI) and internal rate of return (IRR). The energy auditors use various investment indicators as shown in Figure 5.3.

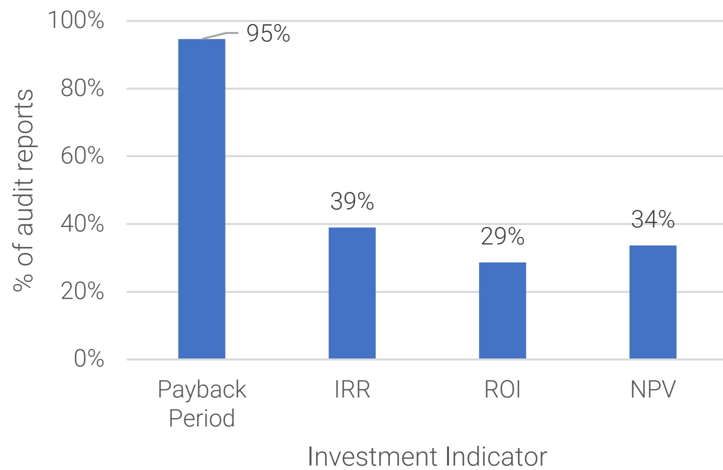


Figure 5.3: Investment indicators given in audit reports

It can be observed from Figure 5.3 that the payback period was the most commonly used investment indicator at 95% of the audit reports that were reviewed, followed by IRR and net present value (NPV) at 39% and 34%, respectively. The ROI was the least popular and was given in 29% of the reviewed reports. However, as reported earlier in sub-section 4.2, 61% of the reviewed audit reports were general energy audit (GEA) that do not require detailed financial analysis and hence, the high incidence rate of payback period reporting. In addition, some of the reports gave multiple investment indicators.

5.1.2. Gaps in expertise identified from energy auditors' self-assessment

As reported in section 4.4, the study sought to establish the level of expertise of the energy auditors in (i) evaluating the EE of different energy consuming equipment and systems, (ii) carrying out measurements used for evaluation of the systems and equipment EE, and (iii) processes of energy auditing. The levels of expertise were classified into basic, intermediate, and advanced. For the purposes of this project, based on the self-assessment results, it is deemed that the auditors with either basic or intermediate levels of expertise in any of the areas would require knowledge and/or skills enhancement. However, it is worth noting that it may not be necessary for all auditors to have advanced level of expertise in each area but rather attainment of a certain critical mass should be targeted.

Evaluation of equipment and systems EE performance

Table 5.2 shows the proportion of energy auditors whose level of expertise in evaluating EE performance of different energy consuming equipment/systems was either basic or intermediate.

Table 5.2: Proportion of energy auditors with skill/knowledge gaps in evaluating EE performance

Type of system/equipment	Percentage of energy auditors with basic / intermediate level of expertise
1. Compressed air systems	
a. Air compressors	35%
b. Compressed air distribution system	35%
c. Air dryer and receiver	59%
2. Power transmission systems	
a. Motors	35%
b. Belts/chains/gears	50%
c. Bearings	65%
3. Heating systems	
a. Boilers	29%
b. Steam distribution system	41%
c. Heat exchangers	38%
d. Condensate recovery system	35%
e. Electrical heaters	0%
4. Cooling systems	
a. Cooling towers	41%
b. Chillers	47%
5. Process heating systems	41%
6. Refrigeration systems	53%
7. Pumping systems	
a. Pumps	35%
b. Motor (prime mover)	38%
c. Piping and valves	65%
d. End-use equipment	38%
8. Fans/blowers	47%
9. HVAC systems	59%
10. Power factor correction	35%
11. Lighting systems	31%

As can be observed from Table 5.2, a significant proportion (over 40%) of the energy auditors had knowledge/skills gaps in evaluation of EE performance of the following energy consuming equipment/systems:

- Compressed air dryers and receivers
- Power transmission system - bearings, belts, chains, and gears
- Heating systems - Steam distribution system
- Cooling systems - Cooling towers, chillers
- Process heating systems
- Refrigeration systems
- Pumping systems - Piping and valves
- Fans/blowers
- HVAC systems.

Compressed air systems and motors & drives (power transmission systems) were identified as main energy consumers in over 80% of industrial facilities audit reports as seen in Figure 4.1: Main energy consuming equipment and systems used by designated facilities

In addition, pumping systems were also found to be commonly used by institutional and commercial facilities at 89% and 64%, respectively. Thus, there is a need to enhance the energy auditors' capacity to effectively evaluate the EE performance of these commonly used systems and others.

As earlier reported, most of the ECMs recommended by the energy auditors do not focus on power transmission systems, process improvement, improvements of processes like heating systems, heat exchangers, cooling, pumping and fluid delivery mechanisms, compressed air system design, and optimization of lighting. Hence, the energy auditors who in their own view had advanced level of expertise in evaluating these systems/ processes/ equipment would also benefit from a performance evaluation skills enhancement program in these areas.

Taking relevant measurements

Table 5.3shows the proportion of energy auditors whose level of expertise in taking relevant measurements used for evaluating EE of different energy consuming equipment/systems was either basic or intermediate.

Again, going by the same definition of the significant proportion (over 40%), it can be seen from Table 5.3 that there were skills/knowledge gaps in taking measurements used for evaluating EE of the following energy consuming equipment/systems:

- Air compressors and compressed air systems
- Power transmission systems
- Cooling systems
- Refrigeration systems
- Fans/blowers.

Some of the energy auditors' level of competence in evaluating the performance of the above systems was found to be wanting. It follows that the auditors with shortcomings in EE performance evaluation may not be competent in taking relevant measurements. Thus, they would benefit from a skills enhancement training in identifying and taking relevant measurements, and using the measurements to compute the energy wastage.

Table 5.3: Proportion of energy auditors with skill/knowledge gaps in taking measurements

Type of system/equipment	Percentage of energy auditors with basic / intermediate level of expertise
Air compressors and compressed air systems	47%
Power transmission systems	41%
Heating systems	35%
Cooling systems	41%
Process heating systems	35%
Refrigeration systems	53%
Pumping systems	35%
Fans/blowers	47%
HVAC systems	35%
Power factor correction	29%
Lighting systems	24%

Energy auditing processes

Table 5.4 shows the proportion of energy auditors with skills/knowledge gaps in different energy auditing processes most of which are highlighted in Kenya Standard KS ISO 50002.

Table 5.4: Proportion of energy auditors with skill/knowledge gaps in energy auditing processes

Audit Process	Percentage of energy auditors with basic / intermediate level of expertise
Project planning and management	24%
Understanding energy use	12%
Establishing energy mass balance	29%
Statistical analysis of energy and production data, including regression analysis	24%
Developing meaningful energy intensity indicators	18%
Establishing energy baseline	12%
Identifying appropriate EPI	24%
Identifying potential EE opportunities	24%
Data collection (including measurements) and analysis	18%
Evaluation of EE improvement opportunities	24%

Audit Process	Percentage of energy auditors with basic / intermediate level of expertise
Ability to identify factors influencing energy use or waste, including procedural, KPIs and behaviour	24%
Awareness and understanding of new and existing technologies, their feasibility and cost effectiveness	41%
Understanding and analysis of design, procurement, commissioning, O&M practices	35%
EE project life cycle cost analysis	47%
Developing business cases for EE projects (Financial analysis)	41%
Identifying the most appropriate M&V method	53%
Understanding the legislative and compliance requirements	35%
Understanding of energy pricing and tariffs	29%

It can be observed from Table 5.4 that only 14 out of the 18 (78%) auditing processes surveyed had less than 40% of the energy auditors with basic and intermediate levels of expertise, which is commendable. However, the following auditing processes that registered more than 40% proportion of auditors with either basic or intermediate levels of expertise need to be enhanced:

- Awareness and understanding of new and existing technologies, their feasibility and cost effectiveness
- EE project life cycle cost analysis
- Developing business cases for EE projects (Financial analysis)
- Identifying the most appropriate M&V method.

EE is dynamic and there are new technologies coming up from time to time. Thus, the EE professionals need to keep abreast with the happenings in the field by participating in trainings, workshops, conferences, and research on new developments. In addition, it has been found that the energy auditors were generally competent in the technical aspects of the energy auditing processes but weaknesses have been highlighted in their financial analysis and M&V competency. These two areas are very key because (i) the facilities invest in EE projects if they are economically viable (ii) it is paramount that the facilities are able to verify the accruing improvements after the EE projects are implemented. Thus, it is important that these knowledge gaps are addressed which may help in improving the implementation of ECMs and hence, realisation of the benefits of EE.

The draft Energy (Energy Management) Regulations, 2021 propose financial appraisal for each recommended ECM using life cycle costing (LCC). In addition, for investment grade audits (IGAs) the auditors will be expected to present various EE projects financing options available in the local market and carry out financial sensitivity analysis for each recommended ECM. They will also be required to carry out risk analysis of the EE projects and estimate the cost of carrying out M&V of each recommended ECM. It is prudent that the financial analysis and project costing skills of the energy auditors are urgently enhanced to ensure that they meet the market requirements of the future.

5.1.3. Energy auditors' gaps as seen by others

Some government and non-governmental agencies noted that the skills and knowledge possessed by energy auditors are more generalized in most cases and not specific for certain sectors or specific specialised systems. They also alluded to the general lack of skills and knowledge to perform measurement and verification (M&V). They highlighted that in some cases, the M&V plans given in IGAs fall short of industry practice. Further, some agencies were of the opinion that there was a general lack of knowledge in stating and calculating uncertainties associated with predicted energy savings. The specific gaps given by the agencies that were interviewed include:

Calculating energy and cost savings

- Little understanding of how to handle interactions of ECMs with the rest of the system
- Need to improve validation and documentation of the calculations of predicted energy savings to increase their credibility and reliability
- General lack of knowledge in stating and calculating uncertainties associated with predicted energy savings

Data collection, measurements, and analysis

- Most energy auditors are competent in data collection. However, there are weaknesses in analysing the data to draw the most relevant recommendations
- Some auditors are not able to interpret some of the data collected in terms of energy wastage/savings e.g., thermal camera images, voltage optimisation, supply voltage quality, power factor over-correction, centralised HVAC systems, MEPS for air conditioning
- There are some weaknesses in analysing thermo fluid systems. In the audit reports, the auditors do not consider systems such as boilers, cold rooms, pumping systems etc, in a holistic way. They only look at the power consumption of the equipment without considering all the components in those systems
- Inadequate skills in systems and processes analysis and evaluation which include air fan systems, motors, building envelop, refrigeration systems, and compressed air systems. Most of the auditors rarely go deep into the processes to give detailed recommendations. For example, a motor as a component aids a process but they dwell more on the motor than the process it aids
- Some auditors do not log the data correctly leading to erroneous analysis
- There is difficulty in accessing affordable modern audit equipment. A number of the auditors do not have the necessary equipment to perform a comprehensive energy audit and therefore, they rely on rented ones which makes them rush through the exercise to minimize cost
- The energy auditors are not equipment and process specific. This poses limitations on the ECMs they recommend to improve the EE in areas such as machine performance and process improvement
- A lot of repetition of ECMs, insufficient in-depth analysis of data and systems and lack of creativity
- Sometimes the implementation details given in the M&V plans are not realistic to the context at hand

Financial analysis

- Inadequate financial analysis skills. Economic and financial evaluation of the ECMs is not done to the appropriate level of detail and the investment indicator chosen should be aligned with the facility's decision-making criteria
- There are weaknesses in selling the EE projects to the facilities by making a good business case and effective communication of the ECMs and their benefits

Reporting

- Poor report writing; lack of proper format and sometimes there is no linkage in the parts of a report from the beginning to the end
- Sometimes there is too much information given on the ECM and very little on the situational analysis that led to the recommended ECM

Others

- Some auditors tend to force lighting related ECMs even when energy consumption by lighting takes a very small share of the total consumption
- Weaknesses in auditing commercial buildings with multiple tenants sharing some common areas/facilities
- When the same auditor conducts a repeat audit for a facility, there is a tendency to repeat the ECMs. This makes the facility operator to lose confidence in the energy audits
- Some of the recommended ECMs are not implementable especially when audits are done for compliance only
- The auditors lack a holistic system approach that includes aesthetics and use/functionality and blend these with EE
- Some energy auditors pay little attention to details, they are more interested in completing an audit and earn their money than coming up with a comprehensive and solution-oriented report. Some auditors give the easier generic recommendations instead of doing research and they don't want to spend much time on that specific task
- Sizing of solar PV systems during the audits is usually oversized/overestimated, and when it reaches to the client, a smaller size is offered
- Lack of continuous professional training, lack of international networking to learn from international best practices
- Most of licensed auditors are not active in the sector. Those available are not able to support audited companies in implementation of recommended ECMs creating implementation gaps. Table 5.5 gives a summary of the gaps in skills and knowledge in EE that have been identified in energy auditors who are currently working in the sector in Kenya.

Table 5.5: Summary of skills and knowledge gaps in energy auditors currently working in the sector

Area	Identified Gap
Motors	Analysis of the motor system including power transmission systems (e.g., belts, couplings) not covered in the audit reports
Pumping system	Most auditors are inadequate in the whole system analysis approach
Fan system	Most auditors are inadequate in the whole system analysis approach
Compressed air system	Most auditors are inadequate in the whole system analysis approach
HVAC system	Most auditors are inadequate in the whole system analysis approach
Steam distribution system	A significant proportion of auditors have basic or intermediate level of expertise in assessing the system performance
Energy accounting	Energy mass diagram missing in audit reports
Measurement planning	Choosing relevant parameter to measure and carrying out measurements
Computation of the projected energy savings	The auditors do not give adequate details for reproducibility of the results
Financial Appraisal	Insufficient information given in the audit report on the financial analysis, unrealistic project costs, no attempt to make business case for the EE projects
Report writing	Some reports are poorly structured, and poor presentation of the data collected during the audit
Energy consumption monitoring	The auditors do not specify what should be monitored
M&V process	The M&V process to be used to determine energy consumption improvement after ECM implementation is not clear in most reports
Energy management Standards	Most auditors are not aware of the applicable Kenya Standards
Project Risk Analysis	Future requirement
EE projects financing methods	Future requirement

It is clear from the foregoing that there are multiple gaps in the skills and knowledge of the energy auditors that need to be filled. These include areas such as taking relevant measurements during the audit, carrying out in-depth analysis of the data collected so that they can inform the recommendations on energy consumption improvement measures, computing the projected energy savings and making appropriate assumptions, carrying out financial analysis of the recommended intervention measures to come up with a viable business case, effective communication of the audit findings through the audit report, among others. It is also important to note that the agencies observe that the number of energy auditors in the country is not adequate to conduct energy audits and support facilities in implementation of EE projects. Thus, there is need to enhance the human resource capacity in the country as well as the skills of the current EE practitioners.

5.1.4. Designated energy officers' competence gaps identified from self-assessment

The energy officers were asked to do a self-assessment of their level of competence in various energy management functions that they are expected to handle as presented in sub-section 4.4.2.Table 5.6 shows the proportion of current energy officers with basic or intermediate level of competence in different energy management functions.

Table 5.6: Proportion of designated energy officers with competence gaps in energy management functions

Function	Percentage of energy officers with basic/ intermediate level of competence
Management of energy team/stakeholders	68%
Analysing energy bills	54%
Developing and tracking energy goals, plans, and proposals	71%
Contract development and management	71%
Identifying energy consuming systems/ processes	63%
Operations & maintenance practices and requirements	58%
Energy accounting (energy balance)	75%
Developing and managing project resources and opportunities	70%
Managing identification and implementation of conservation measures	56%
Monitoring, measurement, analysis, and reporting on energy consumption/ savings	60%
Report writing	59%
Communicating with colleagues and stakeholders	63%
Developing/ coordinating/ delivering education, training and awareness to colleagues and stakeholders	63%
Integrating EE findings into cross-business operational plans and practices	80%
Evaluating financing options	87%

It is evident from Table 5.6 that majority (over 50%) of the designated energy officers had basic or intermediate level of competence in all the 15 surveyed functions. The regulations do not prescribe any minimum requirements on the academic and/or professional qualifications of an energy officer and hence, the inadequacies in their level of competence in these functions. However, in addition to prescribing minimum academic qualification for licensing energy managers, the draft regulations propose that prospective license applicants should have attended trainings by recognised trainers in at least two of the following aspects: financial engineering, energy management, project management, measurement & verification, appliances energy efficiency, and report writing. If the draft regulations are adopted, the prescription of minimum qualifications for the energy managers will ensure that people with the right competencies and skills will drive the EE agenda in designated facilities and hence, move energy efficiency to higher levels.

5.2. Gaps in EE training programs

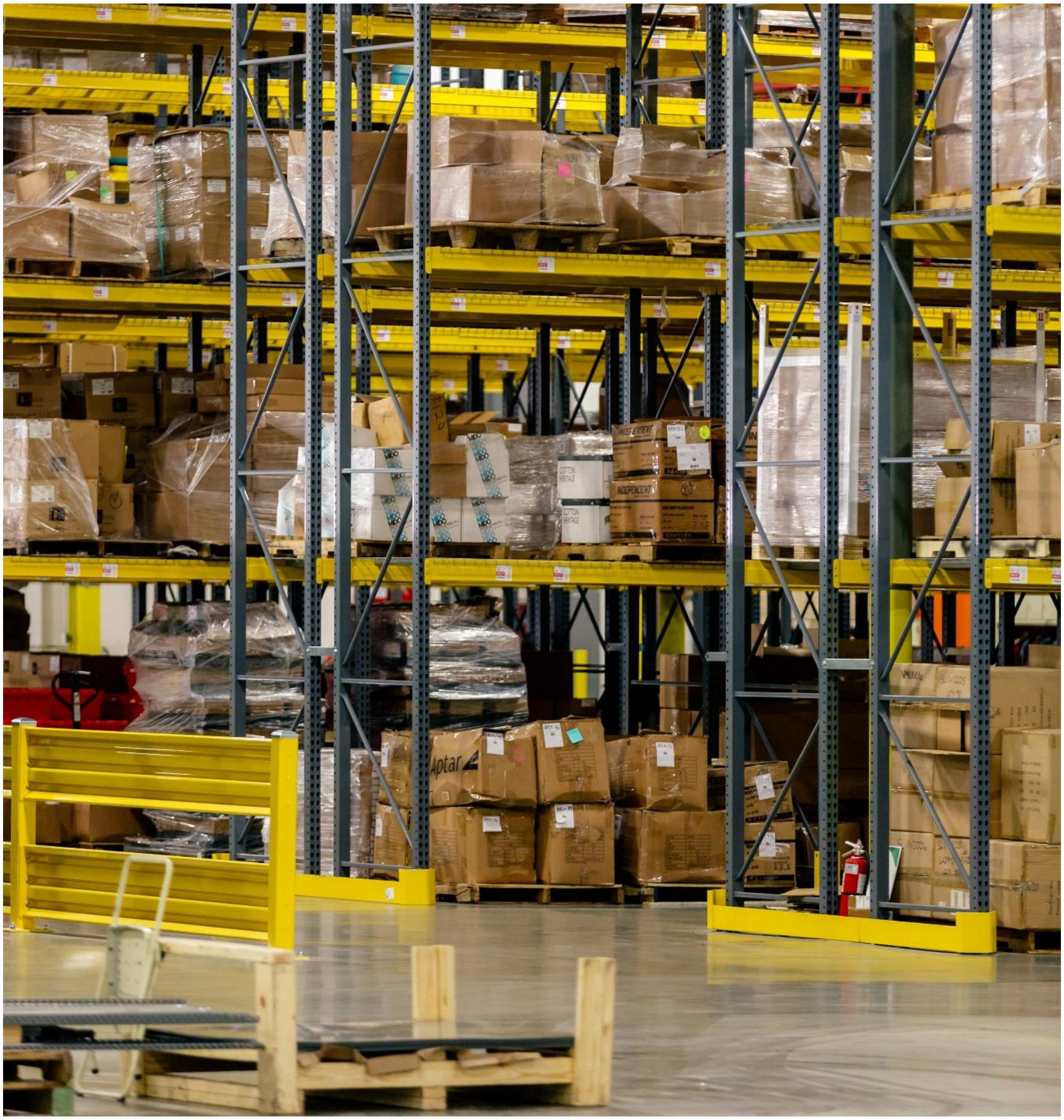
5.2.1. Short courses

Some of the short courses that the energy auditors alluded to having undertaken are not offered by the local trainers. Some of these include optimisation of compressed air, motors, steam, and fan systems; energy efficiency in the building sector; financial engineering for renewable energy; operation of energy service companies, among others. It may be necessary to have them offered to enhance the auditors' skills

5.2.2. Postgraduate programs

None of the universities had an active postgraduate diploma course running at the time of the survey. Further, the duration of study for all MSc courses was 24 months. None of the courses had a component where the candidates do practical work in a designated facility. Most postgraduate diploma programs run for a shorter time (usually 12 months) than MSc programs. Thus, such programs would be an attractive option for prospective EE professionals who may not be interested in going deep into research but have a leaning towards practical education.

Only one program offers a course in EE in buildings and none covers green buildings. Additionally, none of the courses teaches appliances efficiency despite the country having an energy standards and labelling program for a number of appliances. Further, regulations, standards, and best practices are also missing in all the courses. Hence, there is need to enhance training in these areas.



6. Enhancement of Energy Efficiency Training Programs in Kenya

In this chapter suggestion are made to improve the training on energy efficiency in the manufacturing and the commercial sectors in Kenya.

One of the best ways to improve energy efficiency is through energy management training which should be an integral part of an effective energy management strategy. The goal of the training programs should be to improve the performance of the EE professionals by enhancing their professional skills and knowledge hence, preparing them to respond to new challenges as they emerge.

In Kenya, there are a good number of facilities that are aware of the benefits of implementing energy conservation measures and some of these facilities have implemented some ECMs. As more and more facilities embrace energy management, one of the challenges that may be faced is a shortfall in skilled EE professionals in the market. Currently, the country has less than 100 licensed energy auditors who are actively practicing in the sector. This number of auditors is not able to carry out the energy audits and support audited companies in implementation of recommended ECMs thus, creating implementation gaps. Further, as earlier reported, most of the currently designated energy officers are not adequately equipped to effectively take up the role of energy manager.

The EE training programs offered in Kenya are presented in Chapter Four. This chapter presents recommendations on the short courses that can be offered to close the knowledge and skills gaps of the EE professionals currently working in the sector and the core courses that should be included in the EE postgraduate training programs.

6.1. Recommended short-term courses

Table 6.1 gives a summary of the gaps identified in skills and knowledge of energy auditors who are currently working in the EE sector in Kenya and the respective topics that can be taught to bridge the gaps

Table 6.1: Summary of skills and knowledge gaps in EE professionals currently working in the sector and proposed remedies

Area	Identified Gap	Proposed remedial topics to be taught
Motors	Analysis of the motor system including power transmission systems (e.g., belts, couplings) not covered in the audit reports	• Mechanical transmission systems • Efficiency of electric motor systems • Factors affecting electric motor system efficiency • Assessment of energy consumption of motor systems including taking measurements • Energy efficient motor systems • Variable frequency drives • Strategies to improve efficiency of electric motor systems • Motor repair
Pumping system	Most auditors are inadequate in the whole system analysis approach	• Pumping system components • Pumping system optimization (relating the fluid power to head, flow rate, valves

Area	Identified Gap	Proposed remedial topics to be taught
		relating fluid power to electrical power) and performance improvement opportunities
Fan system	Most auditors are inadequate in the whole system analysis approach	• Fan system components • Fan system performance improvement opportunities • Common fan system problems
Compressed air system	Most auditors are inadequate in the whole system analysis approach	• Components of a compressed air system • Understanding compressed air demand • System measurements • Compressed air system optimization and performance improvement opportunities
HVAC system	Most auditors are inadequate in the whole system analysis approach	• Components of a HVAC system • System measurements • HVAC system optimization and performance improvement opportunities
Steam distribution system	A significant proportion of auditors have basic or intermediate level of expertise in assessing the system performance	• Assessment of facility steam requirement • Steam system optimisation
Energy accounting	Energy mass diagram missing in most audit reports	• Assessment of individual equipment/system energy consumption • Whole facility energy input / output • Development of an energy balance diagram
Measurement planning	Choosing relevant parameter to measure and carrying out measurements	• Energy audit instrumentation and measurement • Identification of the important/ relevant measurable parameters for various systems e.g., air compressors and compressed air systems, power transmission systems, cooling systems, refrigeration systems, fans/blowers, pumping systems • How to measure the parameters • Application of the measured data in determining energy consumption/wastage
Computation of the projected energy savings	The auditors do not give adequate details for reproducibility of the results	• Interactions of ECMs with the rest of the system • Uncertainties associated with predicted energy savings
Financial appraisal	Insufficient information given in the audit report on the financial analysis, unrealistic project costs, no attempt to make business case for the EE projects	• Methods of project cost estimation (three-point, bottom-up, parametric, analogous, expert judgement) • Preparation of bill of quantities • Investment appraisal techniques • Sensitivity analysis

Area	Identified Gap	Proposed remedial topics to be taught
Report writing	Some reports are poorly structured, and poor presentation of the data collected during the audit	• Steps to effective report writing • Report planning • Report structure • Format considerations – visually appealing, easy-to-scan • Clarity and word choice • Grammar and syntax • The executive summary • Attributes of winning reports
Energy consumption monitoring	The auditors do not specify what should be monitored	• Need for monitoring • Parameters to be monitored • Quantifying energy savings resulting from monitoring
M&V process	The M&V process to be used to determine energy consumption improvement after ECM implementation is not clear in most reports	• M&V principles • M&V plan • Implementation of M&V plan • Uncertainties • M&V documentation
Energy management standards	Most auditors are not aware of the applicable Kenya Standards	• All Kenya Standards that are relevant to energy management
Project risk analysis	Future requirement	• Identifying underlying sources of risk in EE projects • Determining the pathways and triggers by which such risks can materialize • Estimating the potential consequences of these risks under various scenarios • Providing the means for mitigating and coping with these consequences • The role of ESCOs and performance-based contracting in mitigating risk
EE projects financing methods	Future requirement	• Sources of capital • Financiers • Suppliers

It has been highlighted in this report that there are no academic or professional qualifications currently prescribed for designated energy officers. However, moving forward, if the draft regulations are adopted, the facilities will be required to designate an accredited energy manager. The envisaged roles of energy managers as found from literature are presented in section 0. This study established that there are short comings in the skills and knowledge of the current energy officers that need to be closed for them to fit in the roles of the future energy managers.

From the topics highlighted in Table 6.1 that need to be taught to the energy auditors, an analysis of the requisite skills and knowledge for energy managers presented in Table 3.2, and the energy officers competences gaps in energy management functions presented in Table 5.6, the short courses in the areas given in Table 6.2 are recommended, which should target the practicing EE professionals.

Table 6.2: Recommended short courses topics for EE professionals

EE professionals	Short course area/topic
Energy auditors	• Energy systems optimisation; motor, pump, fan, compressed air, HVAC, steam, and industrial refrigeration systems • Energy measurement techniques and monitoring • Energy accounting & metering • Financial analysis of energy savings including sensitivity analysis • Energy efficiency project financing: mechanisms & resources to fund EE projects • Risk assessment and management for EE projects • Energy economics, financing energy projects, and performance contracting • Introduction to measurement and verification • EE related laws, rules, regulations, standards, codes, and policies • Emerging EE technologies and best practices • Energy audit report writing • Intellectual property rights
Energy managers	• Introduction to energy efficiency and energy management • Energy efficiency program implementation, reporting, and evaluation • Contract development and project management • Financial engineering • Appliances' energy efficiency • Operations & maintenance practices and requirements • Metering, monitoring, and targeting techniques • Energy performance measurement indicators • Introduction to measurement & verification • Energy accounting & metering • Financing EE projects and performance contracting • EE related laws, rules, regulations, standards, codes, and policies • Report writing • Mounting an effective staff awareness campaign • Effective communication

6.2. Recommended postgraduate courses

The Authority currently recognises either a postgraduate diploma or master of science degree in Energy Management for licensing of energy auditors. Thus, it is important that the postgraduate programs cover all the key areas of energy management to equip the candidates with the requisite knowledge to practise in the EE sector. Thus, from the benchmarking exercise with the courses offered in other jurisdictions presented in section 0 and the local demand for EE services presented in section 0, the following areas or topics are recommended to be included in the postgraduate programs that can be recognised for licensing.

- Energy management and auditing
- Process energy management

- Energy conservation and waste heat recovery
- Instrumentation and control for energy systems
- Energy modelling and optimization
- Energy use and resource management
- Energy measurement techniques
- Material and energy balance
- Energy, climate change, and carbon trade
- Solar thermal energy
- Energy efficiency in buildings
- Energy and water efficiency
- Energy management and transport
- Emerging EE technologies and best practices
- EE related laws, rules, regulations, standards, codes, and policies
- Measurement and verification
- Energy economics and planning
- Financial and project management
- EE project economics and evaluation
- Intellectual property rights

It is prudent that candidates who have a leaning towards enhancing their practical skills are afforded the opportunity through a postgraduate diploma program. Such a program can be offered in partnership with designated facilities through KAM. The program should be tailored in a such a way that the candidates would be required to carry out an energy audit under the guidance of a licensed energy auditor. The lecturers teaching the energy management courses would also benefit from the partnership and this would help bridge the existing gap between industry and academia.

6.3. Other recommendations

i) The Kenya National Energy Efficiency and Conservation Strategy identified five thematic sectors for improvement of energy efficiency and conservation. These include households, buildings, industry and agriculture, transport, and power utilities sectors. The strategy established targets for each sector to be accomplished within a five-year timeline up to 2025. Transport and power utilities sectors are beyond the scope of this study.

The targets for the household sector will mainly be achieved through development of MEPS for household appliances and equipment, and standards for fuels and cookers. Some of the targets for the buildings sector include development of MEPS for buildings, improvement of the energy performance of new buildings, improvement of the energy efficiency of lighting in existing public buildings, and promotion of new, green public buildings. Previously, the households and buildings sectors have not been the focus of EE efforts in the country. Thus, to achieve the desired results, it is important that adequate capacity is developed by introducing training programs that specifically address the needs of these sectors.

ii) One of the main goals for the industrial and agricultural sector is to improve the acceptance of energy audits and implementation of energy audit recommendations. The strategy indicates that this can be achieved through improvement of competence and number of professionals trained to carry out energy audits and verify energy savings. In addition, the strategy recognises the need for development of customised curricula for energy management, audit, and M&V trainings that matches the Kenyan conditions. The strategy also recognises the need to establish local accreditation programmes for certified investment grade auditors and certified energy savings verifiers. It has been observed that the number of EE professionals who have the requisite knowledge and skills to conduct audits and oversee implementation of the recommended ECMs is insufficient. Thus, it is important that work on development of the curricula for training EE professionals (energy auditors and energy managers) to work in various sectors of the economy is embarked on so that more professionals can be trained to boost the numbers.

iii) Currently, the auditors' skills are generalized and not specific to particular sectors or specific specialised systems. As the EE sector grows, there will be need to have specialised sectoral training in manufacturing processes for the auditors to deal with issues that are common to specific sectors of the economy. For example, agricultural produce, cement, and dairy, among others.

iv) No single member of the energy committee is expected to be proficient in all areas of energy management. However, the members should collectively possess the following knowledge and skills:
   a. Management skills
   b. Knowledge of regulations, standards, and best practices in EE
   c. Financial and accounting skills
   d. EE technical knowledge
   e. Communication and interpersonal skills.

   It would be beneficial to have a basic level training for the energy committee members tailored to cover these topics.

v) As a long-term goal, energy management can be integrated into education courses at tertiary institutions and universities to prepare the workforce of the future. Energy management system concepts may be easily integrated into courses for engineering or technical students, as their curricula already include many energy-related topics.

vi) The culture of energy conservation needs to be inculcated among the populace from an early age. This can be achieved by integrating EE right from the early stages of formal education all the way to college level. Kenya is in the process of changing to a new education system -Competency Based Curriculum- and this affords a very good opportunity for the integration of energy management.

6.4. Way forward

Kenya has come a long way in the journey of energy efficiency and conservation which has been promoted since the early 2000s. The Energy (Energy Management) Regulations, 2012 that were effected in 2013 have led to improvement in the quality of services provided in the EE sector. However, life is dynamic and so is the field of energy efficiency. To keep pace with the changes in the field requires continual learning by the practitioners in the sector to enhance their knowledge and skills.

The Kenya National Energy Efficiency and Conservation Strategy (NEECS) recognises the need for enhancing capacity-building for professionals in the energy sector to achieve the country's energy efficiency goals. The gaps that have been identified in knowledge and skills of the energy auditors who are currently working in the EE sector should serve to inform what is required to move the sector to the next level so that the gains of EE can be enhanced.

Moving forward, more and more facilities need to buy into the idea of energy conservation as a way of making their businesses more competitive. It is worth noting that some facilities have already taken advantage and implemented the low hanging fruits that are not capital intensive, and they need to move to the next level of energy efficiency. This calls for EE professionals with good understanding of various energy consuming processes and systems. The professionals should also be able to make a business case for energy efficiency and integrate energy efficiency into the facility’s operations. Thus, it is paramount that the country develops adequate capacity of people with the right knowledge and skills to move energy efficiency to the next level. Ultimately, the country will need to develop a customised training curriculum for EE professionals that addresses the local needs.

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Annexures

APPENDIX A: SAMPLE DESIGN

A.1. The sampling technique

There are several designated facilities, licensed energy auditors, development partners, government agencies and promoters of energy efficiency who are stakeholders in energy management in Kenya. It was not feasible for all of them to participate in the study. In this section, the general distribution of actors based on the Terms of Reference (ToRs) formulated by UNEP CCC, with a careful consideration of the study objectives and expected outputs are discussed. The following four categories of stakeholders were identified to be of interest:

i. The facilities that had conducted energy audits and submitted audit reports to the Authority including industrial, commercial, and institutional establishments.
ii. Licensed energy auditors.
iii. The EE professionals training institutions comprising of universities and other institutions offering short courses.
iv. Government and non-governmental agencies who are involved in energy management.

The Authority provided the lists of facilities that had submitted audit reports and the licensed auditors. The classification and populations of these actors is as captured in Table A.1.

Table A.1: Stakeholders population

Targeted stakeholder category		Population (N)
Audited facilities	Commercial	806
	Industrial	683
	Institutional	99
Energy auditors		87
TOTAL		1675

The designated facilities whose audit reports were reviewed and those that were selected to participate in the interviews were randomly picked without consideration of the nature of their business. After the two exercises were completed, the facilities were classified into different sectors as shown in Table A.2.

Table A.2: Classification of facilities by sector

Facility type	Sector
Commercial	• Hospitality • Horticultural • Water & sewerage companies (WASCO) • Offices & retail (O&R) buildings • Supermarkets • Others
Industrial	• Food & beverage • Pharmaceutical • Metals & allied • Agricultural produce • Cement • Plastics • Textile & apparels • Others
Institutional	• Universities/research • Hospitals • Schools • Recreational amenities • Others

THE TRAINING INSTITUTIONS THAT OFFER EE TRAINING THAT WERE TARGETED IN THE PROJECT ARE GIVEN IN

Table A.3.

Table A.3: Targeted EE training institutions

Category of Training Institution	Name of institution
Universities	• University of Nairobi (UoN) • Kenyatta University (KU) • Jomo Kenyatta University of Agriculture & Technology (JKUAT) • Moi University (MU) • Multimedia University of Kenya (MMU)
Other training institutions (short courses)	• KAM • AEPEA • Strathmore Energy Research Centre (SERC) • Centurion Systems Limited • Davis & Shirtliff Knowledge Centre • Eenovators Limited • KAD Controls Ltd • Kenya National Cleaner Production Centre Trust

All the thirteen (13) EE training institutions given in

Table A.3 were targeted for participation in the survey.
The government and non-governmental agencies that were targeted comprised of EPRA, Ministry of Energy, KIRDI, GIZ, UNIDO, KAM, KEPSA, and SUNREF.

A.2. Sampling methods

Owing to the large number of facilities, licensed energy auditors, government and non-governmental agencies, and development partners, a few respondents were sampled. In determining the sampling technique to apply for this survey, the pros and cons of the various techniques were considered and two sampling methods were settled for. These choices were based on the nature of the survey and the categories of stakeholders identified. The methods chosen were the purposive and stratified sampling techniques. The decision to combine the two sampling methods was informed by the profile of the targeted respondents and the expected outcome of the survey. The rationale for each of the two sampling methods is presented in

Table A.4.

Table A.4: Sampling methods

Sampling Method	Rationale
Purposive sampling	Informed by the fact that the survey targeted respondents that were within a specific sub-sector i.e., energy efficiency, the survey employed the purposive sampling technique to identify key actors who may provide essential information to the survey. These comprised of government and non-governmental agencies that are stakeholders in energy efficiency/management (EPRA, MoE, KIRDI, GIZ, UNIDO, KAM, KEPSA, SUNREF).
Stratified sampling	Based on the argument that the research was targeting several respondent clusters who included designated facilities and licensed energy auditors as is defined in the Energy (Energy Management) Regulations, 2012. The clusters as identified from the data provided are given in **Error! Reference source not found.**.

A.3. The sample size

In determining the appropriate sample size of respondents (facilities and energy auditors) that would be adequate to bring out instructive and well-balanced output for the survey, various logistical factors were considered as follows:

- Distribution of stakeholders was wide spread across the whole country (47 counties)
- There was limited time and resources to conduct the study
- Majority of the stakeholders were confined in the major cities and towns

- That it would take between 30 – 40 minutes to administer each questionnaire

Thus, the variables used for determining the sample sizes are given in Table A.5.

Table A.5: Variables used for determining sample size

Variable:	Value:	Rationale:
Confidence level	95%	Set at 95% because the survey was dealing with a finite population that was known and confirmed to be relevant to the study and thus, they represented a true population parameter.
Population proportion *(p)*	0.5	Sample of the population that was likely to have similar characteristics. Set to the conservative 0.5 the standard for finite populations.
Margin of Error (*E*)	0.05	A provision for the variance in results from a survey conducted using random sampling. Determined to be approximately 5% for a finite population and within a confidence level of 95%.
Alpha value (œ)	0.025	A statistical value used to determine the *Z*-score and is arrived at using the formulae œ = (1 – Confidence level) x 0.5 œ = (1-0.95) x 0.5 œ = 0.025
Z-score *(z)*	1.96	The number of standard deviations from the mean score associated with the population size. Obtained using the formulae: z= probability function[3] (1 – Alpha value) = 1.96
Sample size (*n*)	Varied	Based on the database lists for the various stakeholder categories
Population size *(N)*	Varied	This was differentiated by the various respondent clusters as obtained from the databases. The specific distribution of the various respondent clusters is presented in Table A.1.

The generic statistical sampling formula given in (A.1) was applied to determine the overall sample size *n*, to be 312.

$$n = \frac{z^2p(1-p)/E^2}{1+\left\{z^2p(1-p)/E^2N\right\}} \quad \text{... (A.1)}$$

The sample sizes for each stratum were calculated using proportionate stratification; the sample size of each stratum is proportionate to the population size of the stratum. Strata sample sizes are determined as;

[3] Probability function is a formula computed using weighted averages of the study variables and is used to validate the Z-score (z) value

$n_i = \frac{N_i}{N} \times n$ .... (A.2)

Where n_i is the sample size for stratum i, N_i is the population size for stratum i, N is total population size, and n is total sample size.

The sample sizes for this study for the finite respondent populations in their respective respondent clusters are given in Table A.6.

Table A.6: Respondent clusters' sample size

Targeted stakeholder category		Population (N_i)	Sample population (n_i)	% of N_i
Audited facilities	Commercial	806	150	18.6
	Industrial	683	127	18.6
	Institutional	99	18	18.2
Energy auditors		87	17	19.5
TOTAL		1675	312	18.6%[4]

After desktop review of the 295 sample audit reports, site visits were made to a few facilities for verification and further data collection. Yamane formulae given in (A.3) was used to determine the sample size of the facilities to be visited to be seventy-five (75).

$$n = \frac{N}{1 + NE^2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots .. (A.3)$$

Where n is the sample size, N population size and E is the margin of Error.
The margin of error E for this second-tier sampling is 0.1. This value was chosen in view of the fact that most of the information required for the project would be obtained from the audit reports and the energy auditors. In addition, due to budget constraints, there was need to reduce the field data collection cost by reducing the sample size.

Finally, the number of facilities to be visited per stratum was determined using proportionate stratification formulae (2.2) and given in Table A.7

Table A.7: Sample size of facilities to be visited

Targeted stakeholder category		Population (N_i)	Sample population (n_i)	% of N_i
Audited facilities	Commercial	150	38	25.3
	Industrial	127	32	25.2
	Institutional	18	5	27.8
TOTAL		295	75	25.4

[4] Sample population as a percentage of the total population

APPENDIX B: INFORMATION GATHERING TOOLS

B.1. DESIGNATED FACILITY PROFILE

Facility Name	
Physical Location	
County	
Telephone contact	
E-mail Address	
Website	
Nature of Business	
Contact Person	
Title of Contact Person	
Date of visit	

B.2. ENERGY AUDITOR PROFILE

Name	
County	
Telephone contact	
E-mail Address	

B.3. TRAINING INSTITUTION PROFILE

Name	
Physical Location	
County	
Telephone contact	
E-mail Address	
Website	
Type (University/ Other)	
Contact Person	
Title of Contact Person	
Date of visit	

B.4. FACILITIES

Please tick (☐) as appropriate

SECTION A

1. How many energy audits of your facility have been conducted?

1. One ☐	2. Two ☐	3. More than two ☐

2. How long ago was the last audit conducted?

1) Less than 1 year ☐	(2) 1-3 years ☐	3) Over 3 years ☐

3. Does your facility have a designated energy manager/officer/champion?

1. Yes ☐	2. No ☐

4. Does your facility have a functional energy committee?

1. Yes ☐	2. No ☐

5. If your response above is *Yes*, how many members does the energy committee have?

1. Less than 4 ☐	2. 4 – 7 ☐	2. More than 7 ☐

6. Please indicate the energy committee members' area of specialization or department/section they represent.

1. Engineering	☐	2. Maintenance	☐
3. Production	☐	4. Environmental health & safety	☐
5. Finance/ accounts/ audit/ procurement	☐	6. Hospitality	☐
7. Quality assurance/control/ laboratory	☐	8. Construction/ projects/ project management	☐
9. CEO/Senior management office	☐	10. Utilities (Boiler/air compressors/ water supply etc.)	☐
11. Others (please specify)			

7. Which are the MAIN sources of energy at your facility? This SHOULD NOT include transport.

1. Electricity	☐	2. Fuel oil	☐
3. Biomass	☐	4. LPG	☐
5. Others (please specify)			

8. Which of the following equipment and systems are used in your facility?

1. Air compressor and compressed air systems	☐	2. Variable frequency drives	☐
3. Motors and drives	☐	4. Electric heaters	☐
5. Pumps	☐	6. Fans	☐
7. Boiler and steam distribution systems	☐	8. HVAC systems	☐
9. Power factor correction capacitor bank	☐	10. Lighting	☐
11. Lifts/ escalators /moving walks	☐	12. Others (please specify)	

9. Which of the following ECMs were recommended for implementation during the energy audit(s)?

1. Air compressors optimisation	☐	2. Use VFD	☐
3. Use high efficiency motors	☐	4. Match motor to load / right sizing motors	☐
5. Install boiler economiser	☐	6. Optimise pumps and/or fans	☐
7. Install power factor correction bank	☐	8. Optimise boiler combustion	☐
9. Condensate recovery	☐	10. Improve maintenance and monitoring	☐
11. Other(s) Please specify			

10. Did you experience any technical challenges in implementing the ECMs?

1. Yes ☐	2. No ☐

11. If your answer above is yes, which challenge(s) were encountered?

1. Lack of skilled personnel	☐
2. Energy efficient technologies are not readily available locally	☐
3. Limited know-how on running new technology based-equipment	☐
4. ECMs documented in the audit report were not well understood	☐
5. The audit report lacked adequate/relevant information on the ECMs	☐

6. Unrealistic ECMs implementation cost	☐
7. Other (please specify)	

12. Does your facility have energy sub-meters?

1. Yes	☐	2. No	☐

13. Does your facility keep records of energy consumption and cost, and production data?

1. Yes	☐	2. No	☐

14. If your answer above is *YES*, are the data analysed?

1. Yes	☐	2. No	☐

15. If the data are analysed, who is responsible for coming up with remedial action if necessary?

____

16. Does your facility set energy consumption performance targets?

1. Yes	☐	2. No	☐

17. If your response above is Yes, please give the performance index used

____

18. Which energy management related course(s) have your employees undertaken?

1. Energy Management/energy audit	☐	2. Fans and pumps	☐
3. Measurement and Verification	☐	4. Electrical and compressed air systems	☐
5. Boilers and steam systems	☐	6. Motors, PLCs, VFDs	☐
7. HVAC		8. None	☐
9. Other (specify)			

SECTION B
TO BE COMPLETED BY THE ENERGY MANAGER/OFFICER

19. What is your job title? ____

20. How long have you been employed at this facility?

1. < 1 year ☐	2. 1 -5 years ☐	3. More than 5 years ☐

21. How long have you been the energy manager/ officer/ champion at this facility?

1. < 1 year ☐	2. 1 -5 years ☐	3. More than 5 years ☐

22. Have you ever been appointed an energy manager at any other facility?

1. Yes ☐	2. No ☐

23. If your response above is *YES*, how long had you served as an energy manager in previous employment(s)?

1. < 1 year ☐	2. 1 -5 years ☐	3. More than 5 years ☐

24. What is your highest academic qualification?

1. Certificate ☐	2. Diploma ☐	3. Higher National Diploma ☐
4. Bachelor's Degree ☐	5. Postgraduate Degree ☐	6. Other (Specify)

25. Please give your area of training

1. Engineering/ technology ☐	2. Finance/ business studies ☐	3. Procurement/supplies management ☐
4. Computing/ Information & Communication Technology ☐	5. Other (Specify)	

26. Which energy management related course(s) have you ever undertaken?

1. Energy Management ☐	2. Energy Auditing ☐
3. Measurement and Verification ☐	4. Electrical and compressed air systems ☐
5. Boilers and steam systems ☐	6. Motors, Programmable Logic Controllers (PLCs), Variable Speed Drives (VSDs) ☐
7. Refrigeration and air conditioning/ HVAC systems ☐	8. Pumping systems and fans ☐
9. Report writing ☐	10. Financial analysis ☐
11. Project management ☐	12. None ☐
13. Other (specify)	

27. Please indicate your level of competence in the following functions

Function	*Basic*	*Intermediate*	*Advanced*
Management of energy team/stakeholders	☐	☐	☐
Analysing energy bills	☐	☐	☐
Developing and tracking energy goals, plans, and proposals	☐	☐	☐
Contract development and management	☐	☐	☐
Identifying energy consuming systems/processes	☐	☐	☐
Operations and maintenance practices and requirements	☐	☐	☐

Energy accounting (energy balance)	☐	☐	☐
Developing and managing project resources and opportunities	☐	☐	☐
Managing identification and implementation of conservation measures	☐	☐	☐
Monitoring, measurement, analysis, and reporting on energy consumption/ savings	☐	☐	☐
Report writing	☐	☐	☐
Communicating with colleagues and stakeholders	☐	☐	☐
Developing/coordinating/ delivering education, training and awareness to colleagues and stakeholders	☐	☐	☐
Integrating EE findings into cross-business operational plans and practices	☐	☐	☐
Evaluating financing options	☐	☐	☐

28. Give suggestions on what training would enhance the skills and knowledge of energy managers

____

____

____

____

____

THANK YOU FOR YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE

B.5. ENERGY EFFICIENCY PROFESSIONALS

Please tick (☐) as appropriate

1. What class of energy auditor license do you hold?

1. *A* ☐	2. *B* ☐

2. How long have you been conducting energy audits?

(1) Less than 1 year ☐	(2) 1 - 5 years ☐	(3) Over 5 years ☐

3. Please give the following information on the energy management related professional qualification(s) you hold.

Qualification (e.g. CEM⍰, CEA⍰, Post Graduate Diploma in Energy Management, MSc in Energy Management)	Name of training institution	Year of qualification

4. Have you ever attended any other training courses relevant to energy efficiency / management?

1. Yes ☐	2. No ☐

5. If your answer above is *Yes,* please provide the following information

Name of course	Name of training institution	Year trained

6. What type(s) of facilities have you audited?

Type of facility	Energy consumption (kWh equivalent: Large > 1,200,000, medium 180,000 - 1,200,000, small < 180,000)	
Industrial	Large	☐
	Medium	☐
	Small (SME)	☐
Commercial (Hotels)	Large	☐
	Medium	☐
	Small (SME)	☐
Commercial (Office buildings, horticultural facilities)	Large	☐
	Medium	☐
	Small (SME)	☐
Commercial (Horticultural)	Large	☐
	Medium	☐
	Small (SME)	☐
Institutional (Hospitals, learning, research, religious)	Large	☐
	Medium	☐
	Small (SME)	☐

7. Are you guided by any local or international standards in conducting energy audits?

1. Yes ☐	2. No ☐

8. If your answer above is *Yes*, please give the standard(s) used

____

9. Please indicate your level of expertise in EVALUATING THE ENERGY EFFICIENCY PERFORMANCE of each of the following systems.

Type of system/equipment	Level of expertise		
	Basic	Intermediate	Advanced
1. Compressed air systems			
a. Air compressors	☐	☐	☐
b. Compressed air distribution system	☐	☐	☐
c. Air dryer and receiver	☐	☐	☐
2. Power transmission systems			
a. Motors	☐	☐	☐
b. Belts/chains/gears	☐	☐	☐
c. Bearings	☐	☐	☐
3. Heating systems			
a. Boilers	☐	☐	☐
b. Steam distribution system	☐	☐	☐
c. Heat exchangers	☐	☐	☐
d. Condensate recovery system	☐	☐	☐
e. Electrical heaters	☐	☐	☐
4. Cooling systems			
a. Cooling towers	☐	☐	☐
b. Chillers	☐	☐	☐
5. Process heating systems	☐	☐	☐
6. Refrigeration systems	☐	☐	☐
7. Pumping systems			
a. Pumps	☐	☐	☐
b. Motor (prime mover)	☐	☐	☐
c. Piping and valves	☐	☐	☐
d. End-use equipment	☐	☐	☐
8. Fans/blowers	☐	☐	☐
9. HVAC systems	☐	☐	☐
10. Power factor correction	☐	☐	☐
11. Lighting systems	☐	☐	☐

10. Please indicate your level of expertise in CARRYING OUT RELEVANT MEASUREMENTS of the following systems/equipment for evaluation of EE that you propose/recommend during energy audits.

Type of system/equipment	Level of expertise		
	Basic	Intermediate	Advanced
1. Air compressors and compressed air systems	☐	☐	☐
2. Power transmission systems	☐	☐	☐

3. Heating systems	☐	☐	☐
4. Cooling systems	☐	☐	☐
5. Process heating systems	☐	☐	☐
6. Refrigeration systems	☐	☐	☐
7. Pumping systems	☐	☐	☐
8. Fans/blowers	☐	☐	☐
9. HVAC systems	☐	☐	☐
10. Power factor correction	☐	☐	☐
11. Lighting systems	☐	☐	☐

11. Please indicate your level of expertise in the following PROCESSES OF ENERGY AUDITING.

Audit Process	Level of expertise		
	Basic	Intermediate	Advanced
Project planning and management	☐	☐	☐
Understanding energy use	☐	☐	☐
Establishing energy mass balance	☐	☐	☐
Statistical analysis of energy and production data, including regression analysis	☐	☐	☐
Developing meaningful energy intensity indicators	☐	☐	☐
Establishing energy baseline	☐	☐	☐
Identifying appropriate energy performance indicators	☐	☐	☐
Identifying potential EE opportunities	☐	☐	☐
Data collection (including measurements) and analysis	☐	☐	☐
Evaluation of EE improvement opportunities	☐	☐	☐
Ability to identify factors influencing energy use or waste, including procedural, key performance indicators and behaviour	☐	☐	☐
Awareness and understanding of new and existing technologies, their feasibility and cost effectiveness	☐	☐	☐
Understanding and analysis of design, procurement, commissioning, operational and maintenance practices	☐	☐	☐
EEO life cycle cost analysis	☐	☐	☐
Developing business cases for EE projects (Financial analysis)	☐	☐	☐
Identifying the most appropriate method of measuring and verifying energy performance improvement	☐	☐	☐
Understanding the legislative and compliance requirements	☐	☐	☐
Understanding of energy pricing and tariffs	☐	☐	☐

12. Give suggestions on how the energy management/audit training in Kenya can be improved i.e. content, time taken to cover the training, level of detail, dynamism with sector trends, relevance to the Kenyan context, and any other aspects

____
____
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____
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____

13. Give suggestions on what additional training would enhance the skills and knowledge of prospective energy auditors

____
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____
____
____
____

THANK YOU FOR YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE

B.6. TRAINING INSTITUTIONS

1. Please list the energy management/energy efficiency related degree/postgraduate diploma programs offered by your institution.

S. No.	Program name	Duration (months)
1.		
2.		
3.		

2. Please list the courses in each program

Program name: ____

S. No.	Courses
CORE	
1.	
2.	
3.	
4.	
5.	
6.	
ELECTIVES	
7.	
8.	
9.	
10.	
11.	
12.	

Program name: ____

S. No.	Courses
CORE	
1.	
2.	
3.	

4.	
5.	
6.	
ELECTIVES	
7.	
8.	
9.	
10.	
11.	
12.	

Program name: ____

S. No.	Courses
CORE	
1.	
2.	
3.	
4.	
5.	
6.	
ELECTIVES	
7.	
8.	
9.	
10.	
11.	
12.	

3. How long has your institution been running the energy management/efficiency programs in (1)?

Program no.	Duration for which the Program has been running		
1	1. Less than 1 year ☐	2. One – five years ☐	3. More than 5 years ☐

2	1. Less than 1 year ☐	2. One – five years ☐	3. More than 5 years ☐
3	1. Less than 1 year ☐	2. One – five years ☐	3. More than 5 years ☐

4. How many energy management/efficiency trainers does your institution have?

(1) 1-3 ☐	(2) 4-6 ☐	(3) More than 6 ☐

5. How many students have successfully completed since inception of the programs?

(1) Less than 100 ☐	(2) 100 - 250 ☐	(3) 250 - 500 ☐	(4) Over 500 ☐
(1) Less than 100 ☐	(2) 100 - 250 ☐	(3) 250 - 500 ☐	(4) Over 500 ☐
(1) Less than 100 ☐	(2) 100 - 250 ☐	(3) 250 - 500 ☐	(4) Over 500 ☐

6. Which sectors of the economy do most of your graduates work in?

____

____

7. Please suggest changes to the degree/postgraduate diploma programs that you think could enhance the skills and knowledge of the EE professionals graduating from your institution

____

____

____

____

8. Please list the energy management/efficiency related short courses offered by your institution.

Course name	Duration (months)

9. Which sectors of the economy are most of your short-course attendees drawn from?

____

____

____

10. Please suggest short courses that you think can enhance the skills and knowledge of the EE professionals currently working in Kenya

____

____

____

____

____

THANK YOU FOR YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE

Training Institutions to be interviewed.

Universities (Degree programs)	University of Nairobi
	Kenyatta University
	Jomo Kenyatta University of Agriculture & Technology
	Moi University
Other trainers (Short courses)	KAM
	AEPEA
	Strathmore University Energy Research Centre
	Centurion Systems Ltd.
	Davis & Shirtliff Knowledge Centre
	Eenovators Ltd.
	KAD Controls Ltd
	Kenya National Cleaner Production Centre Trust

B.7. DIRECT INTERVIEW QUESTIONS

QUESTIONS TO GOVERNMENT AND NON-GOVERNMENTAL ORGANISATIONS' OFFICERS

1. Kindly provide a brief overview on how your organization has been involved in energy efficiency (EE) in the last five (5) years?
   - As a promoter of energy efficiency
   - As a Policy Administrator
   - Financier
   - Other
2. Do you think the EE professionals in Kenya have the requisite skills and knowledge to handle EE in the following classes of facilities?
   a. Industrial (different sectors)
   b. Commercial (agricultural, hospitality etc.), and
   c. Institutional facilities?

   Discuss.
3. In your opinion, which areas are most EE professionals competent in?
4. What shortcomings have you witnessed/observed in energy auditors working in Kenya?
5. What is your opinion on the ECMs recommended by energy auditors for industrial, commercial, and institutional facilities e.g. are they authentic or generic and repeated for several facilities?
6. Do the auditors demonstrate competence in analysis of the EE opportunities in facilities with different types of energy consuming systems e.g. boilers and steam systems; air compressors and compressed air systems; heating, ventilation, and air conditioning (HVAC) systems; manufacturing process?
7. What are your remarks on the quality of energy audit reports both in content and form? For example, are the ECMs realistic, are adequate details given on the implementation costs and savings accruing from ECM implementation, investment indicators (payback period, ROI, IRR), monitoring and verification process.
8. Are there any specific areas of training you would recommend for the practising EE professionals?
9. The Energy Act 2019 requires designated facilities to designate an accredited energy manager. What skills and knowledge do you deem appropriate for the energy managers to effectively perform their roles?
10. Please give suggestions on changes/modifications that are needed to improve the degree/postgraduate diploma programs that are offered by the local institutions, so that the graduates are able to adequately handle EE projects.

Government and Non-Governmental Institutions to be interviewed.

Government ministries and agencies	MOE
	Ministry of Industry, Trade and Cooperatives
	EPRA
NGOs/Development Partners	KAM
	KEPSA
	UNIDO
	GIZ

Financier	SUNREF

B.8. AUDIT REPORT REVIEW DATA COLLECTION TEMPLATE

1. Facility name:
2. Audit Report Date (mm/year):
3. Lead auditor:
4. Nature of business:
5. Type of facility

1. Industrial ☐	2. Commercial ☐	3. Institutional ☐

6. Type of audit

1. IGA ☐	2. GEA ☐	3. Other (Specify)

7. Main sources of energy

1. Electricity ☐	2. Fuel oil ☐
3. Biomass ☐	4. LPG ☐
5.	6.

8. Main energy consuming equipment and systems

1. Air compressor and compressed air systems ☐	2. Variable frequency drives ☐
3. Motors and drives ☐	4. Electric heaters ☐
5. Pumps ☐	6. Fans ☐
7. Boiler and steam distribution systems ☐	8. HVAC systems ☐
9. Power factor correction capacitor bank ☐	10. Lighting ☐
11. Lifts/ escalators /moving walks ☐	12.

9. Recommended ECMs

ECM1:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM2:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM3:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM4:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM5:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐

Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM6:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM7:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM8:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM9:

Description	Level of clarity		
	Very Clear	Clear	Not clear

Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

ECM10:

Description	Level of clarity		
	Very Clear	Clear	Not clear
Description of current situation and shortcomings identified	☐	☐	☐
Description of ECM	☐	☐	☐
Calculations of the projected annual energy and cost savings	☐	☐	☐
M&V process to be used after implementation for assessment of the recommended ECM	☐	☐	☐

10. Investment indicators used

Payback period ☐	IRR ☐	ROI ☐	NPV ☐

APPENDIX C: LIST OF RESPONDENTS AND RESPONSE STATISTICS

C.1. Reviewed energy audit reports

S. No.	***Audited Facility Name***	***Audit report date***
	Commercial	
1	Aberdare Country Club	May-18
2	Accacia Premier Hotel Kisumu	Oct-16
3	Acceler Global Logistics Nairobi	Sep-15
4	African Bloom	Aug-15
5	African Gas and oil Company Ltd	Dec-19
6	Agricultural Development Corporation	Aug-17
7	Agriflora Kenya Ltd, Njoro	Jun-16
8	Airtel Networks Ltd, Building	Aug-19
9	Airtel Networks Ltd, Eldoret	May-18
10	Airtel Networks Ltd, Nakuru Base station	Apr-18
11	Airtel Networks Ltd, Parkside Towers	Nov-18
12	Atrium	Sep-15
13	Bank of Africa Ltd	Nov-18
14	Bank of Africa Ltd, Re-Insurance Plaza	Nov-15
15	Baobab Beach Resort	Nov-15
16	Bible Translation and Literacy (BTL), Ruiru	Sep-14
17	Bollore Transport	Nov-19
18	C. Dorman Ltd	Sep-15
19	Carnivore Restaurant	Sep-15
20	CBK Pension House	Jun-13
21	Chai Trading Company	Jun-15
22	Chester House Ltd	Nov-15
23	CIC Plaza I & II	Jan-16
24	Citibank	Aug-15
25	Cook 'N Lite Ltd	Oct-16
26	Crowne Plaza Nairobi	Oct-16
27	Dawa Corporate Offices Complex	Feb-19
28	Delta Corner Office Block	Jun-15
29	Delta Riverside	Jan-16
30	DHL World Wide Express	Aug-15
31	Diamond Trust Bank Centre, Nairobi	Jun-15
32	DWA Estate Ltd	Feb-18
33	Eastlands Hotel	Nov-16
34	Eden Square	Jun-15
35	Engen Kenya Ltd	Jun-16
36	Equinox Horticulture ltd,	Dec-18

S. No.	*Audited Facility Name*	*Audit report date*
37	Equity Bank Mombasa Moi Av	Oct-19
38	Equity Centre	Jan-17
39	Everflora Ltd	May-16
40	Finance House	Oct-15
41	Galleria Mall	Dec-15
42	General Motors East Africa Ltd	Nov-16
43	Gilani's Supermarket Ltd	Aug-18
44	Golden Tulip Farms Limited	Jun-19
45	Greenspan Mall Ltd	Jun-15
46	HassConsult Ltd, Gigiri Square	Jun-15
47	Hemmingways Hotel, Nairobi	Jan-19
48	Hilton Hotel, Nairobi	May-16
49	Hurlingam Court Building	May-16
50	I&M Bank Towers	May-15
51	IBM Research Africa	Dec-19
52	ICEA Building	Jul-15
53	Imperial Hotel Kisumu	Mar-17
54	Innscor Ltd, Embakasi	Nov-15
55	Intercontinental Hotel	Aug-18
56	Isinya Roses Ltd	Aug-15
57	Jacaranda Hotel Westlands	Feb-17
58	Jubilee Centre, Place and Customer Care	Nov-18
59	Jubilee Insurance, Jubilee Arcade Mombasa	Nov-18
60	Jubilee Insurance, Jubilee Exchange Building Nairobi	Nov-18
61	Junction Mall	Jun-15
62	Kakamega Golf Hotel	Oct-17
63	KAM House	Mar-18
64	Kenya Airports Authority, Kisumu Airport	Feb-12
65	Kenya Airports Authority, Wilson Airport	Jun-19
66	Kenya Airways	Dec-12
67	Kenya Commercial Bank, Karen Leadership Centre	Sep-15
68	Kenya Commercial Bank, KENCOM House	Sep-15
69	Kenya Pipeline Company Ltd, Volume 2	Apr-20
70	Kenya Ports Authority, Mombasa	Feb-15
71	Kenya Ports Authority, Nairobi	Feb-15
72	KICC	May-14
73	Lavington Mall	Dec-14
74	Leisure Lodge Beach & Golf Resort Ltd	Aug-18
75	Lion Place Building	May-15
76	Longhorn Publishers PLC	Sep-19
77	Maji Mazuri Flowers Ltd	Jul-15
78	Mayfair Casino	May-15
79	Medina Palms and Residence Watamu	Dec-19

S. No.	*Audited Facility Name*	*Audit report date*
80	Meridian Hotel	Feb-17
81	Mjengo Ltd, Thika	Jul-18
82	Nairobi Business Park Ltd	Sep-15
83	Nairobi Java House, Gigiri	Dce-14
84	Nairobi Safari Club	Sep-15
85	Nairobi Serena Hotel	Dec-15
86	Nation Centre Building	Nov-15
87	National Bank, Harambee Avenue	Dec-16
88	National Oil Corporation Head Office	Jun-18
89	National Oil Corporation of Kenya	Jun-17
90	Nyeri Water and Sewerage Co. Ltd	Jul-18
91	Oloolaiser WSP- Kiserian Dam Water Scheme	Jun-15
92	Oloolaiser WSP- Ongata Kataka Water Scheme	Mar-15
93	Oserian Development Co. Ltd, Naivasha	Jan-16
94	Othaya water Co	Sep-13
95	Panari Hotel	Sep-15
96	Pension Towers	Oct-15
97	Penta Flowers, Juja Farm	Jun-15
98	Phoenix House	Jul-15
99	PJ Dave, Isinya	Jul-15
100	Plantation Plants Kenya Ltd	Oct-15
101	Pollen Ltd	Aug-15
102	Radisson Blu Hotel, Nairobi	Mar-18
103	Rafiki Foundation	2013
104	Rahimtula Tower	Sep-15
105	Red Court Hotel (Boma Inn)	May-16
106	Red Land Roses Ltd	Dec-18
107	Ruiru-Juja Water & Sewerage Company	Mar-13
108	Sameer Business Park	Jan-19
109	Sankara Hotel	Jul-15
110	Sarova Stanley Hotel	Nov-19
111	Selecta Kenya Farm, Juja	Dec-15
112	Sierra Flora Ltd	Aug-15
113	Simba Corp - Head Office	Dec-18
114	Simbi Roses	Apr-14
115	Sopa Lodge, Naivasha	Mar-18
116	Sopa Lodge, Nakuru	Mar-18
117	Sopa Lodge, Samburu	Mar-18
118	Southern Shipping Services Ltd	Sep-19
119	Swahili Beach Hotel	May-20
120	Swissport Cargo Complex	Sep-15
121	Tamarind Village	Dec-15
122	Teleposta Towers	Dec-15

S. No.	*Audited Facility Name*	*Audit report date*
123	The Boma	Feb-19
124	The Sands at Nomad	Sep-18
125	Thika Water and Sewerage Co	Aug-18
126	Timaflor Ltd	Sep-15
127	T-Mall	May-15
128	Toyota Kenya	Feb-19
129	TRM	Oct-14
130	Uchumi Capital Centre, Mombasa Road	Apr-13
131	Uchumi Jipange	Jan-13
132	Uchumi Langata Hyper	Apr-13
133	Uchumi Rongai Maasai Mall	Feb-13
134	Uchumi Supermarket Nakuru	Feb-13
135	United Mall Kisumu	Jul-15
136	Victoria House	Dec-12
137	Villa Rosa Kempinski	Jul-15
138	Vivo Energy-JKIA	Jun-14
139	Vivo Energy-Mombasa Terminal	Aug-14
140	Vivo Malindi International Airport	Mar-20
141	Wananchi Group	Dec-16
142	West Side Mall Nakuru	Aug-18
143	Williamson House	Aug-18
144	Windsor Golf Hotel and Country Club	Mar-17
145	Yaya Towers & Hotel	Jun-19
146	Yaya Towers Shopping Mall	May-15
	Industrial	
147	ABM	May-18
148	African Cotton Industries Limited	Aug-15
149	Agro Chemical & Food Co. Ltd	Jun-15
150	All Pack Industries	Jul-18
151	Alloy Steel Casting Ltd	Jul-14
152	Almasi Beverages, Eldoret	Dec-18
153	Almasi Beverages, Nyeri	Apr-17
154	Aqua Plast Kenya Ltd	Jul-15
155	Aquila Development Company	Sep-15
156	Ashut Plastics Ltd	Sep-17
157	ASP Company	Nov-18
158	Atta Kenya	Aug-15
159	Banbros Ltd	Nov-18
160	Basco Products Ltd	Apr-14
161	Base Titanium Ltd	Sep-18
162	Bata Shoe Company Ltd	Sep-15
163	BAT-Thika	Jul-14
164	Betatrad Kenya	Jul-15

S. No.	*Audited Facility Name*	*Audit report date*
165	Bidco Africa Limited, Ruiru	Jan-19
166	Bidco Africa Limited, Thika	Sep-17
167	Blowplast Ltd	Nov-14
168	BOC Kenya Ltd	Aug-15
169	Bombolulu Workshops & Cultural Centre	Dec-13
170	British American Tobacco (BAT) Ltd Nairobi	Jan-18
171	Brookside (Engineer)	Jun-13
172	Brookside Dairy K. Ltd, Kisumu	Apr-16
173	Brookside Dairy K. Ltd, Ruiru	Mar-19
174	Butali Sugar Mill Limited	Sep-15
175	Capwell Industries Ltd	Aug-18
176	Chandaria Industries Ltd	Aug-18
177	Chebut Tea Factory	Jan-16
178	Chemelil Sugar	Oct-14
179	Choice Meats Ltd	Jun-18
180	Corrugated Sheets (Galvanizing Plant)	Oct-15
181	Corrugated Sheets (Reinforced Steel Division)	Jan-17
182	Crown Beverage Ltd	Sep-15
183	Dawa Ltd	Sep-18
184	Deepa Industries Ltd	Apr-15
185	Del Monte Kenya Ltd Thika	Aug-15
186	Devki Steel Mills Limited - Athi River Plant	Oct-15
187	Diamond Industries	May-12
188	Doshi Group of Companies - PVC Division	Oct-14
189	Doshi Group of Companies - Steel Division	Jun-17
190	East African Cables Ltd (Industrial Area)	Jul-15
191	Edible Oil Products Ltd	Mar-13
192	Equator Bottlers, Lake Victoria	Aug-18
193	Excel Chemicals Ltd	Oct-15
194	Farmers Choice Ltd	Jul-15
195	Friendship Container Manufacturers Ltd	Jan-18
196	Frigoken Ltd.	Jun-18
197	Gal Baking Services Ltd	Dec-15
198	Galaxy Paints and Coatings	Aug-17
199	Galaxy Plastics	Oct-18
200	General Plastics Ltd	Mar-19
201	Gitugi Tea Factory	May-17
202	Gulf Power Ltd	Sep-17
203	Haco Industries	Aug-18
204	Happy Cow Ltd	Oct-15
205	Henkel Kenya Ltd	Nov-14
206	Iberafrica Power (EA) Ltd	Nov-16
207	Impala Glass Industries Ltd	Sep-14

S. No.	*Audited Facility Name*	*Audit report date*
208	Insteel Ltd	Feb-14
209	Interconsumer Products Ltd	Jan-16
210	James Finlay (K) Ltd, Chomogonday Factory	Nov-18
211	James Finlay (k) Ltd, Saosa	Aug-15
212	Kabasora Millers Ltd	Oct-15
213	Kapa Oil Refineries Ltd	Nov-18
214	KAPI Ltd	Mar-15
215	Kartasi Industries Ltd	Jan-18
216	Kay Construction Company Ltd	Oct-15
217	Kazuri 2000 Ltd	Jul-15
218	Keitt Exporters Ltd	Jan-13
219	Kel Chemicals Ltd	Sep-18
220	Ken Knit Ltd	Jun-15
221	Kenafric Bakery ltd	Sep-15
222	KENGEN Olkaria II	Feb-19
223	Kens Metal Industries Limited	Oct-18
224	Kenya Breweries - Brewing Section	Feb-19
225	Kenya Clay Products Ltd	Feb-18
226	Kenya Nut Company Ltd	Aug-15
227	Kenya Sweets Ltd	Jul-18
228	Kenya Wine Agencies Ltd	Nov-18
229	Kevian Kenya Ltd	Mar-15
230	Kimfay East Africa Ltd	Jan-19
231	Label Convertors Ltd	Sep-15
232	Laneeb Plastics Ltd	Apr-14
233	London Distillers (K) Ltd	Aug-19
234	Mabati Rolling Mills Ltd, Athi River	Jan-17
235	Mabati Rolling Mills Ltd, Mariakani	Aug-18
236	Maisha Flour Mills Ltd	Sep-18
237	Mantrack Ltd	Nov-15
238	Megapak Ltd	Jul-15
239	Mombasa Cement	Jul-15
240	Mombasa Cement - Athi River	Oct-18
241	Morris and Co Ltd	Mar-13
242	Mutsimoto Ltd	Apr-15
243	Mzuri Sweet Ltd	Jan-16
244	Nairobi Bottlers Ltd - Umoja Pre-foam Plant	Jun-18
245	Nairobi Flour Mills Ltd	May-14
246	Nampak Kenya Ltd	May-17
247	Nation Media Group, Printing Press	Oct-17
248	New KCC Kilgoris Cooling Plant	Feb-13
249	New KCC Nakuru	Feb-13
250	Njoro Canning Factory	Jun-17

S. No.	Audited Facility Name	Audit report date
251	Nodor Kenya EPZ Ltd	Jun-15
252	Norda Industries Nairobi	Oct-15
253	Packaging Manufacturers Ltd	Nov-15
254	Panesar Kenya Ltd	Nov-16
255	Pipe Manufacturers Ltd	Jul-15
256	PZ Cussons EA Ltd	Nov-15
257	Rafiki Millers Ltd	Aug-15
258	Re-suns Spices Ltd	Jun-15
259	Roseto Ltd, Nakuru	Jul-15
260	Roto Moulders Ltd	Mar-17
261	Saj Ceramics Ltd	Sep-18
262	SC Johnson Ltd	May-17
263	Silpack Industries Ltd	Apr-15
264	Sotik Tea Company Limited, Arroket Factory	Aug-15
265	Spin Knit Nakuru	Nov-15
266	Spinners and Spinners Ltd, Ruiru	Nov-17
267	Standard Group	Feb-18
268	Standard Rolling Mills	Jul-15
269	Styroplast Ltd	Sep-14
270	Sunflag Spinning Mill Ltd	Jun-15
271	Supra Textiles Ltd, Lunga Lunga Road	Jun-15
272	Supra Textiles Ltd, Sosio Road	Jun-15
273	Tetra Pak Factory Nairobi	Jul-15
274	Thika Coffee Mills	Sep-14
275	Tononoka Steels Limited	Nov-18
276	Twiga Chemical Industries Limited	Aug-18
277	Unga Farm Care Nakuru	Feb-17
278	United Millers Ltd. HQ Kisumu	Jul-15
279	Universal Corporation Ltd	Apr-19
280	Wrigley Company (EA) Ltd	Apr-13
	Institutional	
281	African Population and Health Research Centre	Mar-16
282	Aga Khan University Hospital	Sep-15
283	Banda School	Feb-14
284	Brookhouse School, Nairobi	Nov-16
285	Dedan Kimathi University of Technology	Aug-14
286	Guru Nanak Hospital	May-16
287	Kenya Utalii College	Dec-17
288	Kenyatta National Hospital - Electrical & Thermal Systems	Sep-13
289	Kenyatta University - Nyayo Zone	Mar-14
290	KEPHIS Headquarters	Aug-14
291	Mater Hospital	Mar-15
292	Moi International Sports Centre, Kasarani	Jun-16

S. No.	Audited Facility Name	Audit report date
293	MP Shah Hospital	Feb-17
294	Nairobi Gymkhana	Aug-15
295	Oshwal Academy - Nairobi	Jul-15
296	Strathmore University	Sep-15
297	Technical university of Kenya (TUK)	Jun-14
298	Thika Level 5 Hospital	Jan-15
299	United States International University (USIU) - Africa	Jun-16
300	World Vision Kenya	Jan-16

C.2. Government and non-governmental agencies

Government ministries and agencies	MOE
	KIRDI
	KEBS
	EPRA
NGOs/Development Partners	KAM
	KEPSA
	EACREEE
	GIZ
Financier	SUNREF
	Ecoligo

C.3. Energy audit reports reviews and stakeholders' response statistics

The study was conducted through review of energy audit reports, administration of questionnaires, and interviews. A total of 299 audit reports were reviewed, out of 1,588 that had been submitted to EPRA as required by the Energy (Energy Management) Regulations, 2012. Table C.1 gives the distribution of the reviewed reports by type of facility.

TABLE C.1: DISTRIBUTION OF REVIEWED AUDIT REPORTS

Type of facility	Population size	Sample population size	Actual No. reviewed	Percentage of total reports reviewed
Commercial	806	150	146	49%
Industrial	683	127	134	45%
Institutional	99	18	19	6%
Total	1,588	295	299	100%

It can be seen from Table C.1 that the targeted quota for the commercial facilities' audit reports review was not met. However, this was compensated for by increasing the quotas for the industrial and institutional facilities.

The stakeholders who were interviewed during the study included licensed energy auditors, training institutions that offer EE related courses, and selected designated industrial, commercial, and institutional facilities that are obliged to carry out energy audits as per the Energy (Energy Management)

Regulations, 2012. In addition, government and non-governmental agencies that are players in the EE sector also participated in the survey. Table C.2 gives a summary of the targeted populations and the actual participation in the interviews.

TABLE C.2: STAKEHOLDERS' RESPONSE DATA

Participant category		***Population size***	***Sample population size***	***No. of Respondents***	***Response rate (%)***
Facilities	Commercial	150	38	23	61
	Industrial	127	32	27	84
	Institutional	18	5	4	80
	Total	295	75	54	72
Training Institutions	Degree programs	5	4	4	100
	Short courses	8	8	6	75
	Total	13	12	10	83
Government and Non-Governmental Agencies		-	10	10	100
Licensed energy auditors		87	17	17	100

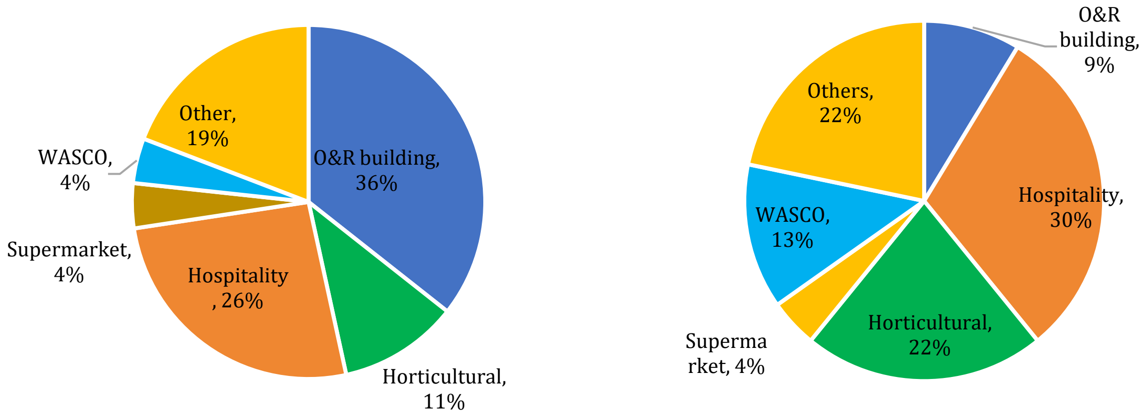
The number of facilities that were targeted to participate in the interviews was not met for the three categories as can be seen from Table C.2; the overall response rate was 72%. The field work was conducted during the COVID-19 pandemic that negatively impacted most businesses in Kenya and globally. The lowest participation was by the commercial facilities at 61% response rate. These facilities are mainly in hotel and horticulture businesses that were hit hard by the pandemic. In fact, some of the businesses were not operational during the period when the field work was conducted.

All the targeted training institutions that offer relevant postgraduate programs participated in the study as can be observed from Table C.2. It is worth noting that some of the training institutions did not give complete information on the courses offered or did not return the questionnaire. Thus, these gaps were filled in with information obtained from the respective institution's website. Further, all the targeted licensed energy auditors participated in the study and all of them held Class *A* licenses. The total population of the agencies promoting EE in the country was not known beforehand and the eight that were initially targeted to participate were picked randomly based on the knowledge of the sector. However, as the interviews progressed, the interviewees gave more referrals to other agencies that were also EE promoters. Eventually, ten government and non-governmental agencies participated.

Overall, the total interview responses were 91 reflecting a response rate of about 80%. This response rate is acceptable based on (Baruch & Holtom, 2008) and (Mugenda & Mugenda, 2003) assertions that a response rate of 50% or more is acceptable for analyses and making an inference.

Designated facilities participation by sector

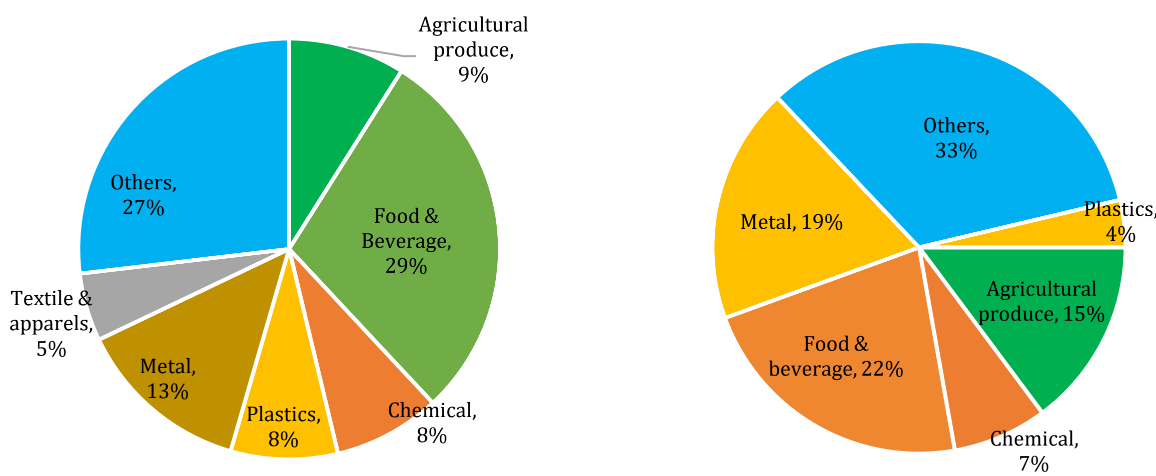
The composition of the reviewed audit reports and interview participation by commercial facilities in different sectors as classified in Table 2.1 is shown in Figure C.1.



(a) Audit reports review (b) Interview participation

FIGURE C.1: COMMERCIAL FACILITIES

It can be seen from Figure C.1(a) that office & retail (O&R) buildings took the biggest share of the commercial facilities audit reports that were reviewed at 36% followed by those for facilities operating in the hospitality sector at 26%. The smallest proportion was for the water & sewerage companies (WASCOs) and supermarkets each at 4%. It can also be observed from Figure C.1(b) that the hospitality sector accounted for the largest share of participants in the interviews at 30% followed by horticultural sector at 22%. The facilities classified as others included transport logistics, communication base stations, airports, publishers, among others. The overall response rate of designated commercial facilities in interviews was 61% as seen from Table C.2. This rate though acceptable for making inferences, may have caused the disparities in the proportions of participants in the interviews compared to the reviewed audit reports e.g., 9% O&R buildings for interviews versus 36% for report review.
Figure C.2 shows the composition of the reviewed audit reports and participation in the interviews by industrial facilities in different sectors as classified in Table 2.1.

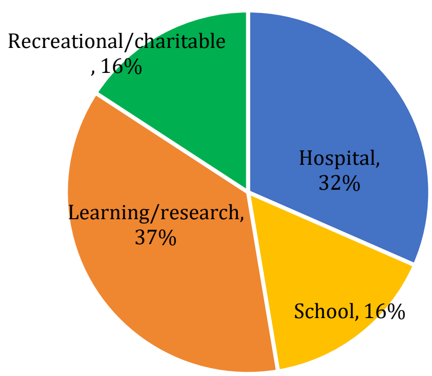


(a) Audit reports review (b) Interviews

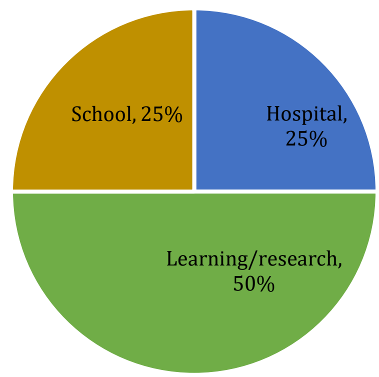
FIGURE C.2: INDUSTRIAL FACILITIES

It can be observed from Figure C.2 that the sector with the most reviewed reports and highest participation in the interviews for industrial facilities is the food and beverage sector at 29% and 22% respectively, followed by those dealing with metals at 13% and 19%. The sector with the smallest proportion of reviewed reports is the textile and apparels at 5%; none of the facilities in this sector participated in the interviews. The facilities classified as others include those in packaging, timber/wood, mining, beauty & cosmetics, pharmaceutical, power generation, cement, among others.

Figure C.3 shows the composition of the reviewed audit reports and participation in the interviews by institutional facilities in different sectors as classified in Table 2.1.



(a) Audit reports review



(b) Interview

FIGURE C.3:INSTITUTIONAL FACILITIES

The highest proportion of the audit reports reviewed for institutional facilities were for university/ college/research institutions at 37% followed by those for hospitals at 32% as can be seen from

Figure C.3(a). The recreational/charitable institutions did not participate in the interviews; the total number of institutions that participated were four. Of these, the learning/research institutional facilities led at 50% and those in the school and hospital categories each had 25% participation. The percentage frequencies are high due to the low number of participants and hence, need to be treated with caution.

APPENDIX D: ECMS DOCUMENTED IN THE AUDIT REPORTS

D.1. Institutional facilities

i) Electrical ECMs

Lighting

- Use of LED lights to replace conventional lighting technologies
- Use occupancy sensors to control lighting and cooling load
- Use of electronic ballast

Air compressors and compressed air systems

- Seal compressed air leaks

HVAC and refrigeration systems

- Install air conditioning energy savers (ACES) on split type air conditioners
- Installation of air curtains
- Chiller systems
- Cold rooms improvement

Others

- Retrofit immersion electric heaters with solar water heaters
- Install forced draft fan on incinerator.
- Power factor correction
- Energy saving by turning off computers when not in use
- Electrical load monitoring and targeting
- Energy management, monitoring and evaluation
- Building energy management system
- Phase/ load balancing
- Voltage optimization and stabilization
- Use programmable timers to lower base load at night
- Machine and equipment maintenance
- Sub metering
- Tariff migration
- Installation of harmonic filters.

ii) Thermal ECMs

- Boiler efficiency improvement
- Modification of steam distribution system
- Shutting out steam in un-used machines
- Insulation of steam pipes
- Recover and reuse steam cooling water from sterilizer unit
- Replacement of HFO boiler with energy efficient briquette fired boiler
- Install LPG gas saver on gas pipe

- Install biogas digester for kitchen and use LPG as backup for kitchen cooking
- Water pumping & piping design
- Kitchen equipment replacement

iii) General ECMs

- Installation of solar PV for street lighting
- Solar PV system installation/ Grid tied solar PV
- Installation of micro hydro power plant
- Institution energy management system
- Install 10,000-litre tanks at laundry section.
- Water supply system and conservation
- Water reticulation, bore hole and swimming pool
- Energy efficiency awareness training/ Energy savings through staff training on energy efficiency.

D.2. Industrial facilities

i) Electrical ECMs

Lighting

- Lighting retrofit: Switch to LED lighting
- Use of occupancy sensors
- Automate the lighting and connected load circuitry
- Install solar PV street lighting system for outdoor lighting

Air compressors and compressed air systems

- Fix compressed air leaks
- Variable speed drive for instrument air compressors
- Eliminate the compressed air leakage and wastage

Motors & drives

- Install electronic soft starter to replace normal star-delta starter
- Upgrade conventional clutch and brake bag cutting machines with servo motors
- Install energy efficient motors
- Complete the pending electric motor sizing rationalization
- Use of star delta converter
- Install VSD on fans and mills

HVAC and refrigeration systems

- Air Handling Units (AHU) VFDs
- Install ACES for air conditioners
- Chiller improvements
- Replace cooling tower with vacuum cooler
- Cold room air curtains

Others

- Optimization of the supply voltages and maintaining them within energy economy zones
- Install a dynamic voltage optimizer to correct supply voltages
- Management of high base loads in offices and other sections of the facility
- Load factor improvement through strategic load growth management
- Idle machines load management
- kVA demand monitoring and load management
- Real time power monitoring and kVA demand management
- Service power factor correction capacitor bank
- Installation of additional power factor correction capacitors
- Rewiring and cable design, selection of PFC banks for harmonic filters and resonance controls
- Power distribution: Ensure balancing of loads
- Installation of harmonic filters
- Retrofit immersion electric heaters with solar water heaters
- Install dust extractors timers
- Install controls on the Overhead Traveller Cleaner
- Install diesel heat generator to replace electric heating
- Install combined cycle power generator for auxiliary
- Reduce machine vibrations
- Application of inverter type welding units
- Optimization of withering fans blade angles
- Replacement of silicon-controlled rectifier (SCR) with insulated-gate bipolar transistor (IGBT) type rectifiers
- Changing billing tariff from CI1 to CI2
- Alternative energy generating measures - Installation of solar photovoltaic system
- Installation of sub-meters

ii) Thermal ECMs

- Boiler combustion optimization
- Heat recovery (Economizer retrofit into chimney)
- Insulation of bare sections of steam and condensate pipes
- Repair of the faulty/leaking steam pipes
- Waste Heat recovery for thermic boiler lines
- Use of wood logs (eucalyptus) instead of briquettes
- Install silos head temperature indicators
- Consider use of fiberglass reinforced plastic (FRP) blades in humidification plant
- Steam distribution system enhancement
- Insulation of printing LPG oven’s hot surfaces
- Energy resource harnessing: Improve energy/fuel mix

iii) General ECMs

- Staff trainings
- Energy Management System
- Use of existing EMS/SCADA system to improve plant's energy performance
- Improved water utilization.

D.3. Commercial facilities

i) Electrical ECMs

Lighting

- Install LEDs lights
- Lighting retrofit and controls
- Occupancy and openings sensors

Air compressors and compressed air systems

- Eliminate compressor air leaks

Motors & drives

- Variable speed drives
- Motor loading analysis
- Variable frequency drive (VFDs) controls

HVAC and refrigeration systems

- Air conditioner piping insulation and lagging
- Installation of air curtains in cold rooms
- Temperature control in the server room
- Install ACES on the split type AC units
- Operation of chillers / freezers
- Speed regulation of chiller circulation pump

Others

- Load monitoring and management
- Conduct proper electrical load balancing on site
- Install voltage optimization system
- Energy conservation by reducing the lighting feeder voltage
- Load shifting/shedding to save on kVA demand charges
- Install electricity monitoring and control system
- Improve on the phase balancing and power factor for the main electricity supply
- Installation of harmonic filters
- Power factor improvement
- Genset controls
- Pump replacement
- Automation of exhaust and circulation fan systems
- Use of programmable timers on some plugged loads like water dispenser
- Electrical energy demand controls
- Elimination of base load using 7 days multiparameter programmable timers
- Energy fuel mix improvement with 140 kWp mini hydro

- Energy saving on computers
- Management of idle machines
- Separate meters for tenants
- Cleaning of lint filters in drying machines

ii) *Thermal ECMs*

- Biogas plant installation
- Solar water heating
- Solar thermal to replace one calorifier
- Steam accumulator for the boiler
- Installation of an economizer - boiler stack
- Open charcoal grill

iii) *General ECMs*

- Use of SCADA for monitoring
- Roof-top/ grid tied solar PV system
- Use of deep cycle batteries for forklifts
- Cover the dams to minimize evaporation
- Hydropower generation
- Energy metering and monitoring
- Improve water billing and accounting to improve revenue
- ISO 50001: energy management through awareness, behavioural change and energy policy implementation
- Green lease

APPENDIX E: KENYAN STANDARDS APPLICABLE TO ENERGY MANAGEMENT

1. KS 2750:2017 Measurement and verification of energy savings
2. KS 2805-1: 2018 Energy Audits - Part 1: Buildings
3. KS 2805-2:2020, Energy audits Part 2: Processes
4. KS ISO 11011: 2013 Compressed air - Energy Efficiency - Assessment
5. KS ISO/IEC 13273-1:2015, Energy efficiency and renewable energy sources — Common international terminology -- Part 1: Energy efficiency
6. KS ISO 25745-1:2012 Energy performance of lifts, escalators and moving walks - Part 1: Energy measurement and verification
7. KS ISO 25745-2: 2015 Energy performance of lifts, escalators and moving walks - Part 2: Energy calculation and classification for lifts (elevators)
8. KS ISO 25745-3:2015 Energy performance of lifts, escalators and moving walks - Part 3: Energy calculation and classification of escalators and moving walks
9. KS ISO 50001:2018 Energy management systems – Requirements with guidance for use
10. KS ISO 50002: 2014 Energy audits – Requirements with guidance for use
11. KS ISO 50003: 2014 Energy management systems- Requirements for bodies providing audit and certification of energy management systems
12. KS ISO 50004: 2014, Energy management systems -- Guidance for the implementation, maintenance and improvement of an energy management system
13. KS ISO 50006: 2014 Energy management systems- Measuring energy performance using energy baselines and Energy performance indicators – General principles and guidance
14. KS ISO 50007:2017, Energy services — Guidelines for the assessment and improvement of the energy service to users
15. KS ISO/TS 50008:2018, Energy management and energy savings — Building energy data management for energy performance — Guidance for a systemic data exchange approach
16. KS ISO 50015: 2014 Energy management systems- Measurement and verification of energy performance of organizations – General principles and guidance
17. KS ISO 50021:2019, Energy management and energy savings — General guidelines for selecting energy savings evaluators
18. KS ISO 50045:2019 Technical guidelines for the evaluation of energy savings of thermal power plants

19. KS ISO/TS 50044:2019 Energy saving projects (EnSPs) — Guidelines for economic and financial evaluation
20. KS ISO 50046:2019, General methods for predicting energy savings

MEPS

21. KS 2446-1: 2013 Self ballasted lamps for general lighting services – Part 1: Minimum Energy Performance Standards (MEPS) requirements
22. KS 2449-1: 2013 Rotating electrical machines -General requirements - Part 1: Three-phase cage induction motors — minimum energy performance standards
23. KS 2463:2019 Non-ducted air conditioners — Testing and rating performance
24. KS 2464:2020 Performance of household electrical Appliances - Refrigerating appliances Part 2: Minimum energy performance standard requirements