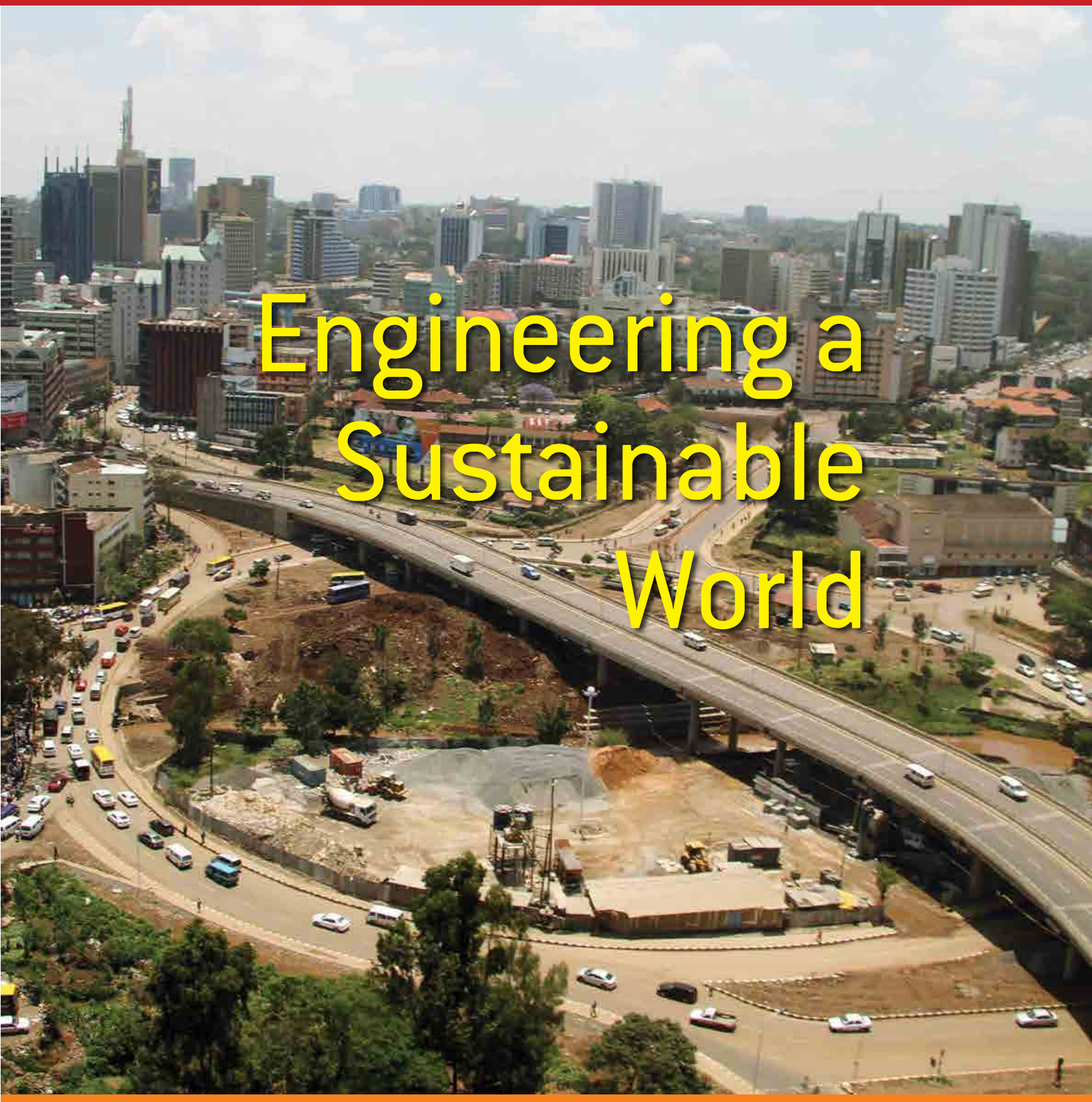
Engineering IN KENYA

ISSUE 001

PUBLISHED BY THE **INSTITUTION OF ENGINEERS OF KENYA** | **FEBRUARY** 2021



Engineering a Sustainable World

ENGINEERS BOARD OF KENYA
Enhancing Professionalism

OFFICIAL OPENING OF THE BOARD'S EXAMINATION CENTRE

The **New Professional Examination Centre** located at **Transcom Building Annex First Floor** was officially opened on 25th February 2021 .

The ceremony was graced by
Prof. Arch. Paul M. Maringa (PHD), CBS, Corp. Arch, (MaaK), MKIP

PRINCIPAL SECRETARY
State Department of Infrastructure
Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works

For the Virtual Tour of the Examination Centre, please visit our website at **www.ebk.go.ke**

ENGINEERS BOARD OF KENYA
Enhancing Professionalism

DID YOU KNOW THAT THE BOARD HAS DEVELOPED A NEW WEBSITE?

Current Website – www.ebk.or.ke	New Website – www.ebk.go.ke

Changing the website domain name to ***www.ebk.go.ke*** ensures that the Board conforms with ICT Authority laid down ICT Standards on Domain Naming policy for government agencies.

Features of the New Website: -

- Dynamic and has leveraged on the potential functionalities of the current software tools while displaying the content in a more organized, attractive, and user-friendly manner.
- Interactive, supports and promotes interactions and collaborations by both the internal and external users of the site. It has online polling capabilities & feedback forms.
- Mobile compatible and easily accessible to all users including visually impaired persons.
- Fast loading and a consistent design against all major browsers.
- Engineers Portal – allows prospective members to apply for registration online.
- Training & Development - Events Management System (EMS) Portal allows members to register for Continuous Professional Development events; Graduate Engineers Internship Program (GEIP) Portal coordinates all the activities of Graduate engineer's internship program.
- Offers a Virtual Tour of the Professional Examination Center, among other features.

Our new email addresses are: - registrar@ebk.go.ke || info@ebk.go.ke

Fortis Suites, Off Hospital Road, 9th Floor P. O. Box 30324 – 00100 NAIROBI
Office Tel.: +254-20-2719974, +254-722-509972, +254-735-330744

In this **Issue**

The 27Th IEK Conference

Institution's CSR Activities

Students voices

8

Are rainfall intensities changing? ....

46

Embracing Resilience in the World of Industrial Automation

2	Calendar of events 2021
4	Editorial
6	Message from the President
7	Hon. Secretary's Message
8	Are rainfall intensities changing, could it be climate change and what could be the impact on Engineering hydrologic design and structures?
12	KICC: An architectural icon that has stood the test of time
14	Innovation: Young woman engineer develops new technology to prevent train delays around the world
16	Communication An Indispensable Skill For Engineers
17	From the 27th IEK Annual International Conference: We need to be part of the solution
22	Post-Covid economic recovery: Rethinking Kenya's road infrastructure development model
30	Students voices
32	Women in Engineering
34	Design Consideration and Eco-Environmental Assessment for Electric Propulsion Ships: Case Study –Cruise Ship.
41	Embracing Resilience in the World of Industrial Automation
42	Exploring the Applicability and Challenges of Implementing Industry 4.0 Technologies in the Small and Medium Sized Industries in Kenya
46	IEK creates a path for engineering opportunities beyond borders
48	Compliance With Engineers Act 2011
50	IEK MEMBERSHIP
51	IEK Council profile

Engineering IN KENYA

PUBLISHER Institution of Engineers of Kenya

EDITORIAL BOARD

CHAIRPERSON Eng. Prof. Lawrence Gumbe
MEMBERS Eng. Nathaniel Matalanga (Ex-Officio)
Eng. Margaret Ogai (Ex-Officio)
Eng. Paul Ochola (Secretary)
Eng. Prof. Meoli Kashorda
Eng. Sammy Tangus
Eng. Jane Mutilili,

SECRETARIAT REPRESENTATIVES Eng. Linda Otieno
Nick Gatirima

PRODUCTION TEAM

CO-ORDINATOR Justus Agumba
TECHNICAL EDITOR Godfrey Ombogo
ADVERTISING Lucy Wambui
DISTRIBUTION ADMIN Violet Asiaba
DESIGN & LAYOUT Sherry Omoga

CONTRIBUTORS Maria Monayo
Peter Mutie
Eng. Margaret Ogai
Dr. Eng. Timothy Oketch
Dr. Evelyne Kihiu
James Gachanja
Joshua Kiprotich Kibii
Omar A. Abdulrehman Al-Baity
Mohamed M. ElGohary
Obadiah Burugu Nganga
Josiah Habwe

PRINTING Michimedia Limited

Engineering in Kenya Magazine is published bi-monthly by Michimedia Ltd for the Institution of Engineers of Kenya.

Calendar of events 2021

Date	Event
March 4	World Engineers' Day
March 10	Transportation modelling
March 11	Trainers of trainers for PES on effective mentorship
March 19	Agency based PIP for KenGen
March 20	Webinar on work/job interview preparation
March 26	Seismic retrofit of buildings President's dinner
April 2	Transforming business with migration from 4G to 6G via 5G network technologies
April 9	Leveraging on regulatory framework to boost automotive industry in Africa
April 15	Agency based pip for Huawei/Safaricom Tree planting activities in all IEK branches
April 20	Annual General Meeting
April 20 to May 20	Benevolent fund webinar
April 28	Engineers scheme of service webinar
May 6	Agency based PIP for GDC
May 7	Leveraging on e-resources for advancement of the engineering fraternity: launch of e-library
May 13	The future of Kenya's agricultural industry
May 19	Agency based PIP-county government (Nairobi/Kakamega/Kajiado/Garissa)
May 20 to September 3	Cement processing in Kenya – role of engineering
May 21	ADR webinar
June 4	Engineers ethics in building industry
June 10	Work zone safety
June 11	Agency based PIP-water service boards
June 25	President's dinner
July 2	Fast tracking manufacturing of telecommunications equipment and devices in Kenya: current status, challenges and the way forward
July 7	4th IEK women engineers summit
July 9	State of manufacturing in Kenya – potential and challenges
July 23	Engineers golf tournament
August 6	Industry 4.0 automation case study
August 12	Irrigation systems design
August 20	ADR webinar Digital transformation and driving efficiency using IOT
September 7	First IEK young engineers summits
September 8-10	28th IEK international conference
September 10	KAA/KQ Covid-19 impact
September 11	Engineering intervention with agricultural systems structures for post-harvest losses
September 17	ADR webinar
December 10-23	Selected CSR activities for branches
December 12	Standard Gauge Railway

Integrated Process Automation Solutions

Helping industrial process companies maximize productivity and optimize operational and maintenance cost

Apps, Analytics & Services

Ecostruxure™
Control Advisor

Ecostruxure™
Maintenance Advisor

Ecostruxture™
Profit Advisor

FLEX
Flexible Lean Execution

Process Automation Services
- Business Consulting
- Training / Learning
- Maintenance & Support
- Modernisation
- Migration
- 360° Life Cycle Management
- Cyber Security

Edge Control

Distributed Control System
EcoStruxure™ Foxboro DCS

Distributed Control System
EcoStruxure™ Hybrid DCS

Safety Instrumented System
EcoStruxure™ - Triconex®

SCADA & Telemetry
SCADAPack RTU
RealStream LiftStation

PAC / PLC
EcoStruxure™ Modicon

Software
SimSci, Wonderware,
Avantis, Ampla, **OASyS**

Connected Products

EcoStruxure™ Process Instrumentation

Temperature, Pressure, Flow, Level
Pneumatic Instruments

Valves, Valve Positioners, Controllers, Recorders

Liquid Analysers

Process (Gas) Analysers

Wireless (Wi-STAR)
IAN (WirelessHART)

iPMCC
Intelligent Power MCC

Trio Data Radios
Licensed UHF|VHF
Ethernet and Serial

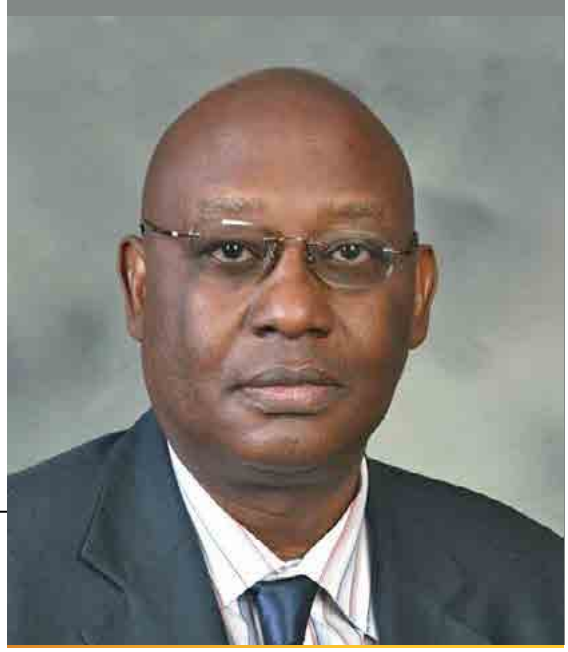
With Connected Products, Edge Control, and Apps, Analytics & Services, Schneider Electric's EcoStruxure enables the scalable design and operation of connected systems with best-in-class cybersecurity built in at each layer to drive measurable operational profitability improvements, safely.

www.se.com/processautomation

customercare.eastafr@schneider-electric.com

Life Is On Schneider Electric

ENG. PROF. LAWRENCE GUMBE
EDITOR



We are excited at the publication of this maiden edition of Engineering In Kenya magazine. Our target audience includes professionals, practitioners, policymakers, researchers, educators and other stakeholders in engineering and related fields. Our articles and advertisements shall always be well researched and written so as to appeal to our high-end audiences and to be informative to the public in Kenya and beyond.

EIK's circulation is controlled. It will be distributed to its target readers through hard and soft copies.

The modern world has largely been an engineering project. The structures, machines, processes and organisation, which have led to increased affluence, life expectancy, comfort and enlightenment are all due to engineering efforts.

Kenya's Vision 2030 aims to transform the country into a newly industrialised, middle-income economy, providing a high quality of life to all its citizens by the year 2030. This vision is largely an engineering one.

There are many definitions of engineering. A functional one is the creative application of scientific principles and mathematical methods to design and develop structures, machines, materials, devices, apparatus, systems, processes and organisations, under economic and safety constraints for the protection and improvement of lives.

The profession we know as engineering today emerged in the 1500s when specialists began using mathematics to design military fortifications. These special military architects would let craftsmen do the actual construction, thus becoming the first true engineers in the modern sense of the word. In the late 1800s, inventors began identifying with the engineering processes and the profession began to divide into special disciplines, such as civil, mechanical and electrical engineering.

Initially, engineers were trained at military academies or through industry apprenticeship programmes. Since the mid-1800s, more emphasis has been placed on formal training that includes significant courses in mathematics and science. For example, the Massachusetts Institute of Technology opened in 1865 with 15 students.

The largest engineering project in the last century in Kenya was the Uganda Railway. The railway was built from 1896–1901 between Mombasa and Kisumu. It was built by engineers from Britain and artisans from India. Local personnel to operate and maintain the railway had to be trained, mainly, in Kenya. Institutions of training of artisans and technicians were, therefore, created.

> ...the creative application of scientific principles and mathematical methods to design and develop structures, machines, materials, devices, apparatus, systems, processes and organisations, under economic and safety constraints for the protection and improvement of lives.

In more recent times, engineering has been taught in Kenya from 1956, when the Royal Technical College of East Africa (RTCEA) was established as the first institution of polytechnic status in East Africa. RTCEA eventually would become the present University of Nairobi (UoN), having gone through the stages of the Royal College, Nairobi, as a college under the University of London in 1960, the University College, Nairobi, as a constituent college of University of East Africa, in 1963, and finally as the University of Nairobi in 1970. As part of the University of East Africa, and even a few years thereafter as the University of Nairobi, UoN was the leading university for engineering education in East Africa.

Over the years, as a number of universities in Kenya came up, and some of them also started offering programmes in engineering. The new universities were Moi University, followed by Egerton University, the Jomo Kenyatta University of Agriculture and Technology and Masinde Muliro University of Science and Technology. Today, various aspects of engineering are offered in at least 14 universities in Kenya. Most of the engineering programmes have adopted the engineering science model as inspired by the University of Nairobi. Another reason that has inspired this is the fact that the engineering professional body in Kenya, the Engineers Board of Kenya (EBK), traditionally has only accredited programmes that have followed in the engineering science model.

Engineers are helping feed and support an increasingly urban world population that could reach 10 billion by the year 2050. They are working to ensure all people have access to clean, fresh water and adequate shelter. Engineering In Kenya magazine will therefore feature some of these solution-based engineering processes and operations in bi-monthly editions.

The magazine will endeavour to be informative, educative and entertaining. We assure you that we will strive to produce quality editions, which will advance engineering in Kenya and national development in general. Welcome!

ASSOCIATION OF CONSULTING ENGINEERS OF KENYA (ACEK)

Commodore Office Suites 6th Floor, Suite 6H Kindaruma Road, Kilimani
Tel: +254 20 2249085/0717 191 593
E-mail: acek@acek.co.ke, Website: www.acek.co.ke

The Association of Consulting Engineers of Kenya (ACEK) is a membership organization which was founded in 1968. Currently, there are 80 Members of the association. ACEK's main objective is to promote the advancement of professionalism within the consulting engineering industry and cooperation among consulting engineers. Our scope encompasses all engineering practice activities including providing a forum for government, public institutions, industry and trade representatives among others to interface with consulting engineers as a group and ascertain their collective views. The Association is a member of the International Federation of Consulting Engineers **(FIDIC)**, Member of **FIDIC AFRICA** (Group of African Member Associations), the Association of Professional Societies in East Africa **(APSEA)** and Kenya Private Sector Alliance **(KEPSA)**.

THE OBJECTIVES OF THE ASSOCIATION

(a) To establish a standard for the conduct of Consulting Engineers in Kenya;

(b) To serve the public in matters connected with engineering;

(c) To promote the training of Engineers in Kenya;

(d) To promote the advancement of the profession of Consulting Engineering;

(e) To associate Consulting Engineers for the purposes of co-operation and mutual advantage and consultation;

(f) To promote the professional interests, rights and powers of Consulting Engineers.

ACEK VISION

To be the body of reference representing business and professional interests of all consulting engineering firms in Kenya.

ACEK MISSION

To promote and improve the business and professional interests of our members in the built and natural environment, and while so doing, accept and uphold responsibilities to society and the environment.

ELIGIBILITY REQUIREMENTS FOR MEMBERSHIP

- ACEK Members profess to possess the relevant qualifications, expertise and facilities to offer the highest quality of service in their engineering disciplines of expertise while adhering to the highest ethical and professional standards.
- To join ACEK, an Engineer must be registered with the Engineers Board of Kenya (EBK) in the category of Registered Consulting Engineer.
- Must be a corporate member of the Institution of Engineers of Kenya (IEK).
- Must be actively practicing engineering as a partner, director or sole principal in a firm registered as a legal entity under the Laws of Kenya.

MEMBER BENEFITS

1. **Advocacy** - Close liaison with government and other industry bodies on contractual and legislative issues. Lobbying for better procurement laws.
2. **Networking & Knowledge Sharing with other consulting engineers both locally and globally.** ACEK organizes a number of events throughout the year, both local and internationally being a member of FIDIC Africa and FIDIC.
3. **Business Support to Members -** Identification and Sharing of business opportunities. Access to database of regional and international consulting firms.
4. **Capacity Building -** ACEK has well-coordinated local and international industry specific training. Members enjoy discounted training rates.
5. **Becoming a member of both FIDIC and FIDIC Africa through ACEK** ACEK is a member of FIDIC and Africa. Members automatically become members of these international organizations through ACEK.
6. **Public and Private Sector Support** The association acts as an interface between the public and consulting engineers.

FUTURE LEADERS

The ACEK Future Leaders is the group of young professionals under the age of 40. It was formed with the intention of providing FLs with the opportunity to participate actively Locally and Internationally with their peers and to develop the next generation of consulting engineering industry leaders.

FIDIC CONTRACTS TRAINING COURSES – 2017 CONDITIONS OF CONTRACT

1) **22nd – 23rd July 2021 - Module 1** (The Practical use of the 2017 FIDIC Conditions of Contract for Construction – Red Book and Design & Build – Yellow Book)
2) **26th -27th July 2021 - Module 4** "The Contract Management & Administration of the 2017 FIDIC Conditions of Contract" (Construction Contract and Plant& Design-Build -)
3) **25th - 26th November 2021 - Module 2** (Management of Claims and Dispute Resolution Under the FIDIC Contracts Red and Yellow Book 2017)
4) **29th - 30th November 2021 - Module 3** Understanding DABs- The program aims to: - explain the use of DABs in the FIDIC 2017 Construction and Plant and Design-Build Contracts and the application of Dispute Board rules and procedures

ENG. NATHANIEL MATALANGA

PRESIDENT
INSTITUTION OF ENGINEERS OF KENYA

It is a new dawn for the engineering fraternity in our country.

The inauguration of this platform opens up another avenue for engagement and information exchange, which is one of the ideals on which our society is founded. It also marks a major milestone in the implementation of our 2019 – 2023 strategic plan.

The magazine brings to fruition a long-held aspiration of the council, and the society in general, for a credible information platform. Information is power, particularly when it is specialized and targeted at a specific group like ourselves. It is even more critical in this age of fake news and alternative facts that calls for a credible source of information.

Through this platform, members can engage on myriad issues that touch on their welfare, maintaining a conducive environment for practicing and other topical issues. The magazine will greatly supplement ongoing efforts to fully operationalize our secretariat. It affords us a means to continue the vibrant conversations that we often hold at our annual conferences. It is also an additional communication platform to the newsletter and other existing channels.

Its launch comes at a pivotal time for the engineers of this country. The profession sits at the centre of the implementation of government infrastructure projects and ultimate realization of the national development agenda. Our contribution thus, is important in achieving the desired outcome and impact to improve the welfare of our compatriots. Through consistent information exchange amongst us, we can peer-review and contribute more meaningfully to these initiatives. The young can contribute fresh innovative thinking to the profession, while learning at the feet of their more experienced colleagues.

As you may have noticed, engineering, like many other professions has faced an onslaught from policymakers and other interest groups, who often attempt to manipulate processes for their own selfish benefit. The desperate attempts have even seen spirited campaigns to change laws to lock out professional contributions so as to create opportunities for manipulating key institutions. This makes it critical that we maintain open lines of communication and engagement on such pertinent issues. It also helps us to deliberate and speak in one loud voice.

> The profession sits at the centre of the implementation of government infrastructure projects and ultimate realisation of the national development agenda. Our contribution thus, is important in achieving the desired outcome and impact to improve the welfare of our compatriots.

Besides speaking amongst ourselves on issues that touch on our profession, this magazine provides a platform to sensitize the general public on the role of the engineer in society. Educating the public on what we do as professionals is an important objective of our strategic plan. This is the only way that this learned society will get the respect that it deserves. It will help enlist public support in ensuring that schemes of service and other issues that touch on our welfare, are harmonized across private and public (both national and county) sectors. This goes not only for the practicing engineers but also the teaching fraternity, for whom it is important that remuneration is maintained, commensurate to the rest of the profession.

Finally, I wish to pay tribute to the editorial committee under the leadership of Prof. Larry Gumbe, which has ably shepherded this process. On behalf of the council, I welcome you all to engage robustly with this platform.

ENG. MARGARET N. OGAI

HON. SECRETARY INSTITUTION OF ENGINEERS OF KENYA

The Institution of Engineers of Kenya (IEK) is the learned society of the engineering profession and co-operates with national and international institutions in developing and applying engineering to the benefit of humanity. The Institution has a membership of more than 9,000, ranging from professional and graduate engineers, engineering students, technologists and technicians. The membership is drawn from practicing engineers in various departments in national and county governments, universities, parastatals, industries, consultants, contractors and designers in energy, telecommunications, transportation, manufacturing, water supply and sanitation, housing, medical, agriculture, among others. Although members of IEK work in Kenya, there is a sizeable number of members based outside the country. Our members include senior practitioners, policymakers, researchers, educators and young professionals, and represent diverse interest in all sectors of the economy.

IEK undertakes a number of programmes to engage our membership and to support professional development, welfare of engineers and advocacy to promote engineering practice in Kenya. These include webinars, conferences, industrial visits, submission of memoranda on policy matters, among others. Readers are invited to refer to the IEK Calendar of Events 2021 which has been published on our website and in this magazine.

The highlight of last year was the 27th IEK Annual International Conference held in collaboration with the Engineers Board of Kenya (EBK) on November 24-27, 2020 at Pride Inn Paradise Beach Resort in Mombasa, Kenya. Under the theme, 'Engineering a Post COVID-19 Future', the conference presented a great opportunity to the delegates to reflect on the current and future challenges facing the human race. Inside this article is a full article and a pictorial page on the conference. We expect that the 28th conference slated for September 8-10 this year will even be more engaging. Another exciting item in our calendar of events this year is our first IEK young engineers' summit scheduled for September 7. In this summit we hope to interact with our fresh engineering graduates and continuing students and learn what their needs and expectations are in this profession, even as we mentor them to become great engineers.

IEK undertakes a number of programmes to engage our membership and to support professional development, welfare of engineers and advocacy to promote engineering practice in Kenya.

To further enhance membership engagement, the *Engineering In Kenya* (EIK) magazine will publish articles to provide engineers and associated professionals with relevant information on the current trends in engineering in Kenya and in the world. The magazine will also provide a much-needed forum for our members and associates to contribute well researched articles to foster thought leadership in matters engineering in Kenya and beyond. A dedicated editorial board has been established to manage the EIK publication under the general directions of the council. The Editorial Board will be supported by M/s Michi Media, who has been engaged to publish and distribute the magazine.

The IEK acknowledges and celebrates the contributions of our members, the Kenyan engineers, involved in development and management of engineering projects in the country. Continue with the good work that you do to create a difference and make this country a better place. Our sincere thanks to all involved in the successful production of this inaugural issue of the magazine. Special mention is made of the Editorial Board, the Secretariat, Publisher, advertisers and the authors of articles. We hope to continue working together to ensure the success of the future editions of the magazine.

Finally, we invite our members, associated professionals and partners to contribute articles for the future issues of the magazine. We also encourage you to assist in sourcing for advertising from organisations with whom you have connections as a new and one of the crucial revenue streams for the Institution of Engineers of Kenya. As the Secretariat, we hope you enjoy reading the magazine.

Are rainfall intensities changing, could it be climate change and what could be the impact on Engineering hydrologic design and structures?

By Joshua Kiprotich Kibii and Emmanuel Chessum Kipkorir

Introduction

Climate change can be defined as the natural cycle through which the earth and its atmosphere accommodate the changing amount of energy it receives from the sun (SAWS, 2005). The world climate has been changing over the decades. However, over the past two centuries' industrialization has caused changes exceeding natural variation (Benhin, 2006), hence the climate change debate. The focus on climate change has been growing at local, regional, and global levels. However, the discourse has always been on long term-challenges without trying to understand the current local issues. Kenya is a developing country, focused on sustainable development goals and the big four agenda (food security, affordable housing, manufacturing, and affordable health care). Climate change poses a threat to the realization of these goals. This paper, therefore, aims at highlighting current engineering issues in the design of hydrologic structures because of changing rainfall trends and stimulating further research in the same field.

The global climate has been changing gradually over the past centuries. This has taken place through cold and warm periods with cycles taking hundreds of years. The changes in temperature influencing rainfall taking place over centuries has been accommodated by the biosphere through adaptation. However, recent human activities over the past two decades have caused the climate to change too fast. Plants and animals have been unable to adapt to the fast-changing climate endangering the whole ecosystem (Burger et al., 2015). This interrelation in the ecosystem makes the study of climate change complicated as it involves relationships between the atmosphere, oceans, and land surfaces beyond the scope of this study.

Scientists have developed software known as general circulation models (GCMs) to simulate and predict climate. The models use the concentration of greenhouse gases in the atmosphere and other atmospheric variables to predict climatic conditions. The prediction results are of a non-uniform change in the climate. Land areas are predicted to warm up faster than oceans while polar latitudes heat faster than temperate latitudes. From the above statements, the impact of climate change in Kenya is expected to vary from the tropical coastal region to the temperate and arid interior. The general projection of the future by these models is an increasing rainfall intensity and uncommon heavy rainfall events happening often (Burger et al., 2015). Modelling of heavy rainfall events has shown that although the number of dry days is likely to increase when it rains the maximum and average rainfall are likely to increase. The combined effect of this is little variation or increase in the total annual rainfall.

From the illustration above, increased rainfall intensities are inherent and coupled with urbanization hence more impermeable surfaces, the time of concentration is bound to decrease, runoff increase, and risk of flooding increased as noted recently in Eldoret region. The emphasis of this paper is therefore to establish, based on existing historical rainfall data if the modelled climate predictions are evident, though on a small scale. It is however not the study intention to change the hydrological design principles. The changing rainfall trends are rather highlighted and the thought of consequences on existing design principles and assumptions stimulated.

Materials and Methods

Study Area. Eldoret town is the headquarters of Uasin Gishu County located in western Kenya. Eldoret region is on a highland plateau with an altitude of about 1,500 metres above sea level. The topography is higher at the east and gently slopes to the western border. Rainfall in the region is mainly influenced by topography and wind patterns. There are two main rainfall seasons, the 'long rains' occurring from March to September and 'short rains' occurring from October to December. The Sosiani

river flows through the middle of the town and is fed by several streams from the surrounding catchments that sometimes cause flooding in the town.

Rainfall Data. The historical rainfall data for Eldoret Meteorological Station was obtained from the meteorological department and any gaps filled with rainfall data sourced from CHIRPS: rainfall estimates from rain gauge and satellite observations. Daily rainfall data for 50 years (1970-2019), although short in the context of climate change, provided the study with an opportunity for detailed investigations of rainfall trends.

Data Analysis. The rainfall data obtained from Eldoret Meteorological Stations was subjected to data quality analysis. Outliers were deleted and treated as gaps in the data to be filled using CHIRPS data set. The 50 years daily time series was divided into five decades D1 (1970-1979), D2 (1980-1989), D3 (1990-1999), D4 (2000-2009), and D5 (2010-2019). Statistical analysis, linear trend line distributions, time lag comparison and moving average plots were applied to the data. Rainfall event was defined by rainfall ≥ 1 mm (Kibii et al., 2019). Rainfall events were also subjected to a similar analysis.

Results

Rainfall Amounts. The amount of daily rainfall received during the period 1970-2019, (50 years) was plotted in five decades as shown in Figure 1. The plot aimed to illustrate the variation in the amount of rainfall received over the different periods as well as time lag comparison.

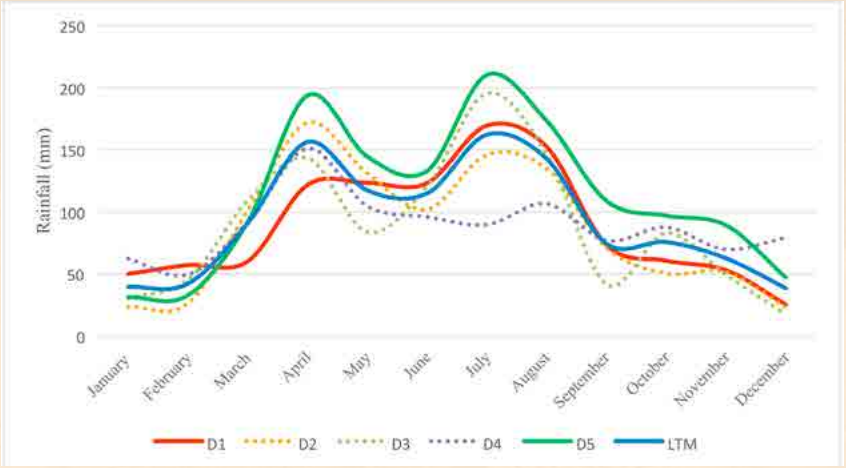


Figure 1: Graph showing amounts of daily rainfall at Eldoret Meteorological Station.

Analysed results in Figure 1 gives the distribution of daily rainfall across the five decades and also the long term mean (LTM). The results in Figure 1 supports the findings of GCMs (Dunning et al., 2018) of increasing amounts of rainfall over the recent decades with the most recent decade D5 receiving a significantly higher amount compared to the previous decades. Comparing the time-lag, the amount of rainfall received during 'short rains' (October-December) is observed to be increasing over the past three decades with the recent decade having the highest increment. During the last decade (D5) rainfall amount is observed to be comparatively more than the long term mean vis a vis the other decades. Although natural variability is expected in the amount of rainfall received from decade to decade, there is an indication of a shift towards wetter climatic conditions.

Rainfall Events. Having defined rainfall event to be rainfall of at least 1 mm, daily rainfall events were plotted for the five decades to investigate the number of rainfall events resulting in rainfall amounts presented in Figure1 and also their distribution across the rainfall seasons. Figure 2 shows the number of rainfall events recorded in Eldoret over the same period.

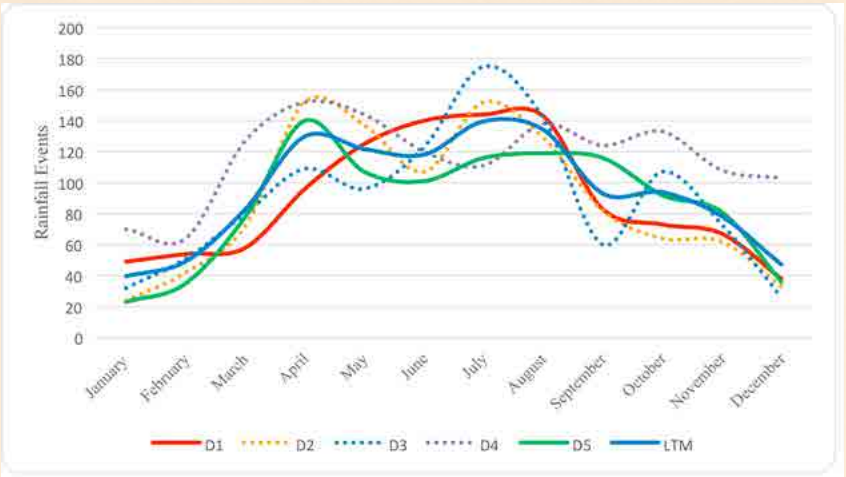


Figure 2: Graph showing daily rainfall events at Eldoret meteorological station.

From the results in Figure 2, it can be seen that the distribution of daily rainfall events has been varying across different decades. However, it is important to note that during the last decade (D5), the number of daily rainfall events

decreases comparatively to the long term mean and previous decades. Despite the natural variation, the change during decade D5 is still pronounced. Further, no change in measurement method has been reported for the station. Also, despite the observed increase in the amount of rainfall received during the short rains in decade D5, the rainfall events generally decrease. As it can be seen in Figures 1 and 2, the amount and number of rainfall events vary to the LTM as the change from dry to wet periods lasting several years is expected from the natural dry-wet cycles. The question, however, is as to whether the increasing trend in amounts of rainfall in Figure 1 and decreasing trend in the number of rainfall events in Figure 2 can be attributed to natural variation or climate change.

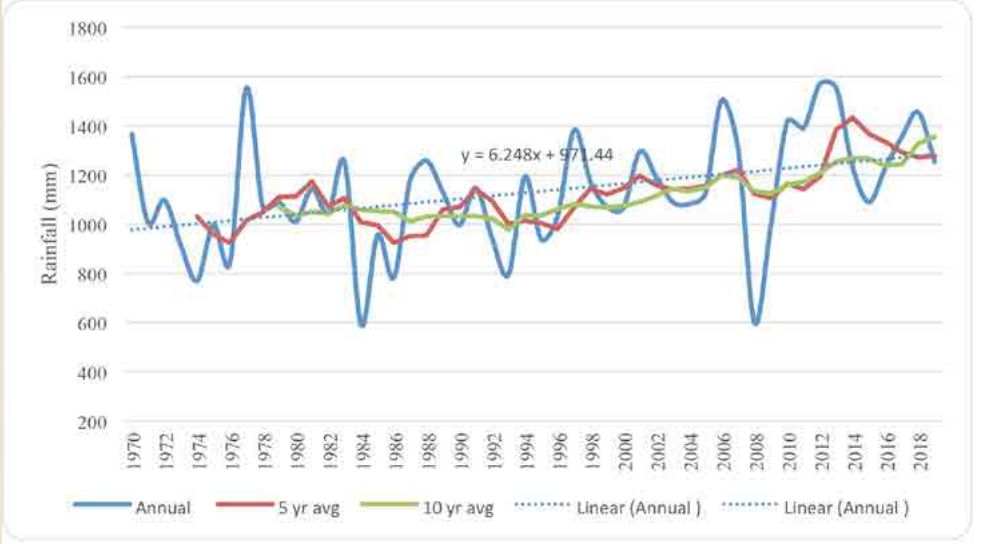


Figure 3: Graph showing total annual precipitation at Eldoret Meteorological Station.

Time Series Analysis. The annual rainfall for the period 1970 – 2019 as well as the 5 and the 10-year moving averages is shown in Figure 3. The annual rainfall has an increasing trend. The moving averages were computed with an aim at deriving periodicity arising from the natural cycles of wet and dry years and justification of the increasing rainfall intensities. Previous studies of periodicity in rainfall data have established a 21-year cycle (Alexander et al., 2005). Irrespective of a general increasing trend in annual rainfall and the moving averages, the 21-year cycles are also evident. The data indicates of an extremely wet year around 1978 and 1999 (21 years), followed by an extremely dry year around 1984 and 2005 (21 years) supporting the findings of Alexander et al., 2005. Therefore, it can be confidently observed that the year 2020 has been extremely wet after 1999 due to the natural cyclicity of rainfall (Caroline et al., 2020).

Figure 2 shows that rainfall events recorded during the last decade have significantly decreased in comparison to the other decades. On the other hand, the daily rainfall (Figure 1) and annual rainfall (Figure 3) have recorded a significant increasing trend. With fewer rainfall events and increasing daily and annual rainfall, the conclusion of increasing intensity is inferred at supporting predictions by GCMs. The mean annual rainfall for Eldoret Meteorological station calculated from 1970-2019 is 1100 mm and the number of rainfall events responsible for this amount of rainfall was 5640 events. The average annual rainfall for the last decade (D5) is about 1300 mm, an increase of about 18% of the long-term annual rainfall while the number of rainfall events responsible for the same period is 1044 events, a decrease of about 6% from the previous decade. It is therefore evident that the number of rainfall events is decreasing while the amount of rainfall is increasing hence constituting higher rainfall intensities. These findings are an indication of natural climatic cycles being exceeded which could be because of climate change.

Discussion

From literature, it is generally expected as indicated by GCMs that climate change will result in a decrease in the number of rainfall events and an increase in amounts of rainfall. Therefore, the objective of this study was to ascertain model predictions for Eldoret town, as with increased rainfall intensity and urbanization, runoff is expected to increase resulting in flooding. The selection of Eldoret town was objective because of the recent flooding (2020) which could have been caused by several factors. The town is experiencing increasing developments, and it can be approximated that nearly 75% of the catchment is made up of impermeable surfaces with little infiltration. Therefore, an increase in rainfall is expected to increase runoff. Over the past few years, the existing drainage systems in Eldoret town has been improved and new ones developed and sized based on historical rainfall data. The increase in rainfall intensity could therefore result in functional failure of these existing drainage structures as illustrated by an example of figures 4 (a) & (b).

Figure 4: (a) Lined drainage canal before heavy rainfall and (b) after a heavy rainfall causing flooding.

In the design of hydraulic structures, Engineers and hydrologists have always been keen on using the longest available historical rainfall data. This has been important in ensuring any short-term irregularities arising from measuring or recording errors are minimized and does not affect the design. Climate change because of human activities has resulted in a change in rainfall patterns as already observed. However, the question is the combination of pre-climate change data (natural cycles) to the climate change data to obtain long term trends to be used for design?

This may therefore mean that an engineer in future could find themselves with data of over a hundred years but only 20 years of the data to be coming from the acceptable climate change era. The historical 1:15 year recurrence interval intensity could be, say, 20 mm/h for a given rainfall duration. If rainfall intensity has increased due to climate change, for example, Eldoret town as observed, the climate change data with 1:15 year recurrence interval rainfall intensity might have increased to 30 mm/h. This would mean therefore that the Engineer could as well result in under-designing a hydrologic structure or even a stormwater system which is unsafe. On the other hand, should the rainfall intensities be decreasing, the combinations of pre-climate change and climate change data would result in an overdesign which is uneconomical. It is therefore imperative that Engineers and hydrologists should be keener in identifying short term trends and apply their mind in design rather than just analyzing the longest available data set for design and use of standard drawings. Figure 5 is an example of a bridge that is under construction in Eldoret, but the water level is already high, is it an under/ overdesign?

Figure 5: (a) Bridge under construction showing water levels during dry and (b) rainy seasons.

The detailed analysis of Eldoret meteorological station rainfall data yielded in increasing rainfall intensities because of decreasing rainfall events and increasing amount of rainfall. Therefore, the logical deduction is the increasing rainfall intensity coupled with urbanization has resulted in an increased runoff, straining the existing drainage structures designed using historical data, hence flooding.

Conclusions

Climate change is a complex system involving the interaction of many variables such as greenhouse gasses, solar radiation, topography, sea, and ocean temperatures amongst others. Trying to extrapolate the effects that change on these variables have on climate is not easy. Accepting the respect this topic deserves, we can only claim to have partial ideas on trends resulting from it.

Further studies should therefore be done to verify that the expected rainfall trends are taking place regionally and not just in one station. The natural climate variability and cyclicity should also be appreciated and adapted to while focusing on what could be the effects of climate change. This would lead to a better understanding of the effects of climate on rainfall intensities, amounts and frequency, hence proper design, and improvement in the management of engineering hydrologic structures.

Finally, it is not the intention of this study to change the existing proven engineering design principles and assumptions. It is rather to highlight the possible effects of changing rainfall trends and the consequences it has on existing hydrologic structures, design principles and assumptions theoretically.

The writers are lecturers in Moi University, Department of Civil and Structural Engineering

KICC: An architectural icon that has stood the test of time

When Tom Mboya called the Department of Architecture in the Ministry of Public Works, then headed by Chief Architect David Mutiso sometime in the 1960s, his brief was simple and straight forward. KANU, the ruling party, wanted a four-storey building that would be its headquarters.

During meetings that were later held with the first president of Kenya, Jomo Kenyatta, the architect noted that President Kenyatta had envisioned a landmark building that would epitomise self-governance and independence. He also wanted the builtform to capture the core of black civilisation.

When construction began in December 1967, the government took over the project from Kanu, which could not fund it. The construction was done in three phases, with Phase I being the podium, Phase II the tower and Phase III the plenary hall.

The resultant building was a 28-storey Kenyatta International Conference Centre (KICC), standing tall and proud, watching over Nairobi. The base of the tower is a podium, which also holds the amphitheatre. It was completed in 1973, in time for a global meeting of the World Bank and International Monetary Fund (IMF) in September of that year.

This building is a breathtaking landmark within the capital city and most dwellers would tell you that when they visited Nairobi for the first time, part of their itinerary was to visit the KICC and record the history in a photo.

It is no surprise that this amazing building is one of the top places to visit in Nairobi, for the view of the Nairobi skyline that it promises.

> ...It was meant to stand out as a master piece whose facilities you can't find anywhere else in Kenya or Africa. To date that remains true...

The spaces provided for include offices within the tower, an amphitheatre with a capacity of 800 people, which has been a popular venue for international meetings, a plenary hall that seats 4,000 people, and conference halls of different sizes.

At the rooftop is a revolving restaurant, which offers panoramic views of the city. The restaurant runs on a motor mechanism that makes a complete 360 degrees turn in 76 minutes.

At the core of the building, which is the centre of the tower, are services lifts, four passenger lifts, toilets and ducts for electrical and plumbing services.

A staircase, which can be accessed from the elevated ground floor, terminates at the helipad, on the roof which receives small helicopters. The helipad – it is the only building in the region with a helipad – also acts as a view point to the city, a popular spot for many local and foreign tourists looking for a good view of the city.

But the building is not world famous for its vistas only, it is an undefeated conference facility where the high and mighty of the world, including former US President Barack Obama, have sat and shared their ideas to change the world.

In that sense, KICC – later renamed the Kenyatta International Convention Centre – is the theatre for world changing ideas.

Eng Samuel Njagi Charagu, the acting Secretary of the National Building Inspectorate, says this is enough testimony that the iconic building has lived to its billing.

"It was meant to stand out as a master piece whose facilities you can't find anywhere else in Kenya or Africa. To date that remains true," says Eng Charagu.

On its website, the KICC says the building was "designed by Norwegian architect Karl Henrik Nøstvik and our own David Mutiso".

Mutiso once told a TV interview that the KICC design was inspired by a donkey's penis, but many other accounts have indicated that the inspiration behind the master piece is an African hut.

"The president wanted something personal. So, he required us to get instructions directly from him. We started sketching a simple four-storey building, but overtime the president kept revising his vision of the eventual building and wanted something higher and higher," Mutiso said in the interview two years ago.

The façade of KICC has utilised an African texture, brown terracotta materials with a small motif defining the location of the windows.

The amphitheatre captures the traditional African hut. The general shape of the building is made of several platonic solid shapes that have been combined to give a

notable outcome. Cuboids have been used for the plenary hall and podium, cylinder for office tower and cones for amphitheatre and helipad.

KICC, with its brown exterior and dark windows, is as synonymous to Kenya as its flag. It is arguably one of the most recognisable buildings in the world, along with the likes of the Empire State Building in New York.

Nairobi City has evolved around KICC, with many buildings inspired by the engineering and architectural work that went into the masterpiece.

It is no longer the tallest building in Nairobi, that crown was lost to Britam Towers, Times Tower, UAP Towers and several other buildings that have taken over the race for the sky.

None of the above structures is, however, the heart and soul of Nairobi City that KICC is.

It is the axis that Nairobi has developed around and the lens through which most of the world see Nairobi.

Its site is a prime location within Nairobi's CBD, with prominent neighbours including City Hall and Holy Family Basilica to the North, Parliament and Jomo Kenyatta Masouleum to the West, AGs chambers, Office of the President and Foreign Affairs building to the South and Jogoo House and Nairobi Law Courts to the East.

Another part of it is excelling in a modern world and taking the cake as the best conference facility in Africa.

Eng Charagu says what stands out most is the centre's amphitheatre and its unique hall.

"You can never find these anywhere else in Africa. The conference facilities are also breathtaking," says the civil engineer.

Eng Charagu is hopeful that with the current advanced technology, more master pieces that rival KICC or even more iconic will come up in the future. But for now, KICC keeps the crown.

Project Team

Client: *Kenya African National Union (KANU)*

Architect: *David Mutiso and Karl Henrik Nostivik*

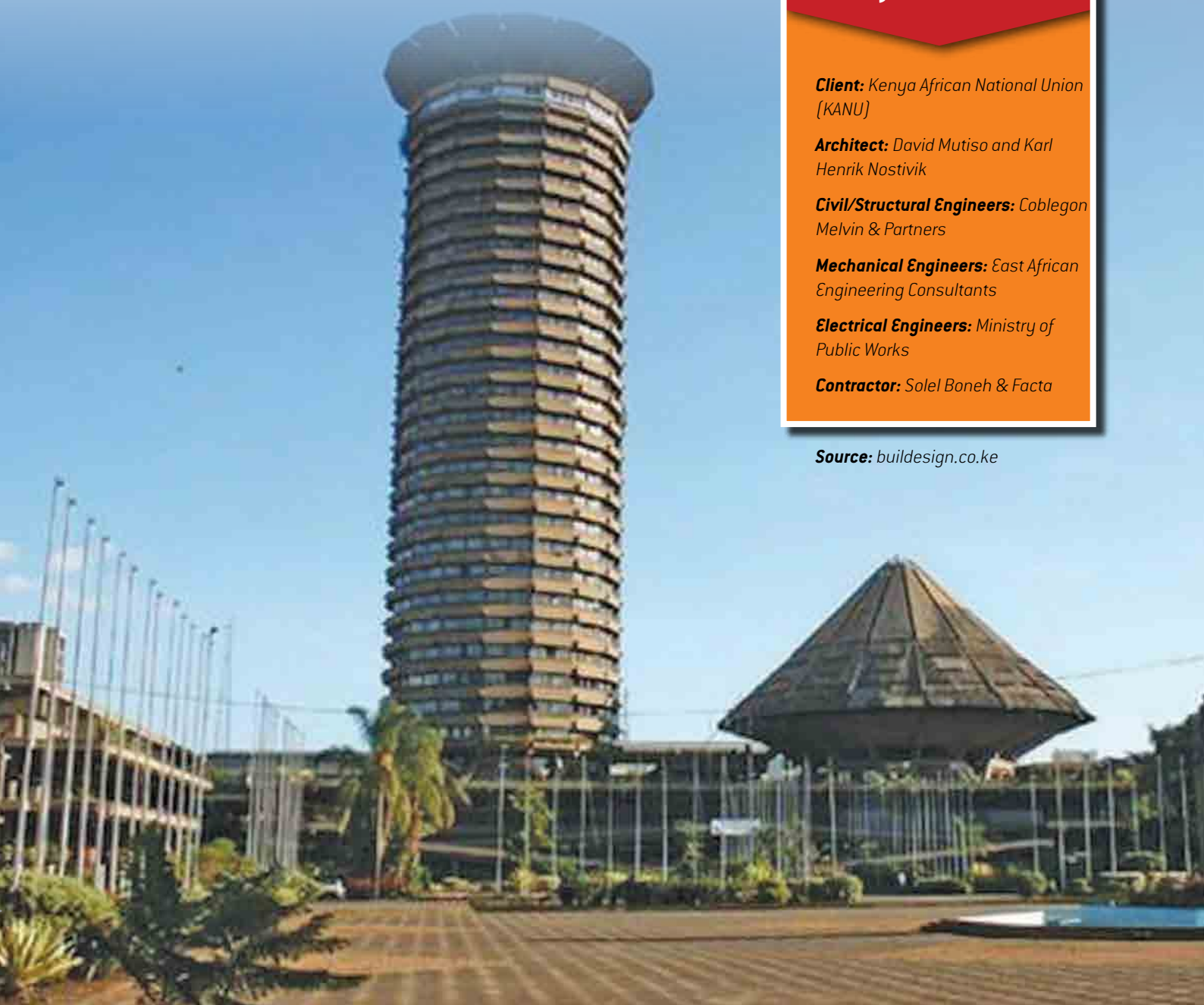
Civil/Structural Engineers: *Coblegon Melvin & Partners*

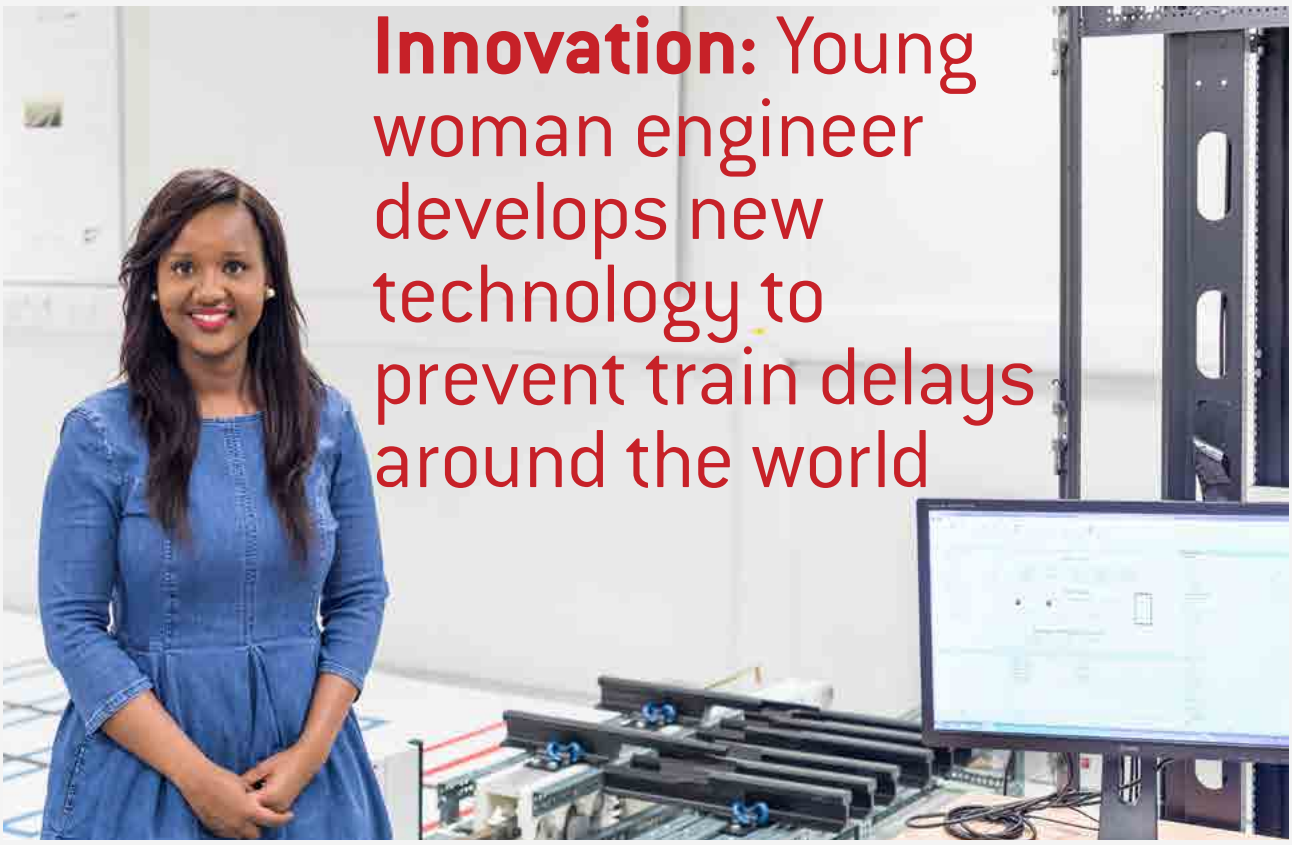
Mechanical Engineers: *East African Engineering Consultants*

Electrical Engineers: *Ministry of Public Works*

Contractor: *Solel Boneh & Facta*

Source: *buildesign.co.ke*





Innovation: Young woman engineer develops new technology to prevent train delays around the world

A young woman East African engineer has developed a technology aimed at preventing trains from delays due to failures while switching from one railway track to another as they change routes.

Dr (Mrs) Precious Kaijuka Mwongera received her PhD in Control Systems Engineering from Loughborough University, UK last year, at the age of 29.

In her PhD study, Dr Mwongera says the challenge that motivated her research was that despite advances in technology, railway track switches have predominantly maintained their design over the past 200 years and remain the largest single cause of failure.

Railway networks are fitted with these switches and crossings that enable trains to move from one track to another in order to change routes. Dr Mwongera, 30, says she identified a research gap from the fact that current practice to rectify and prevent failures of these switches is simple regular maintenance.

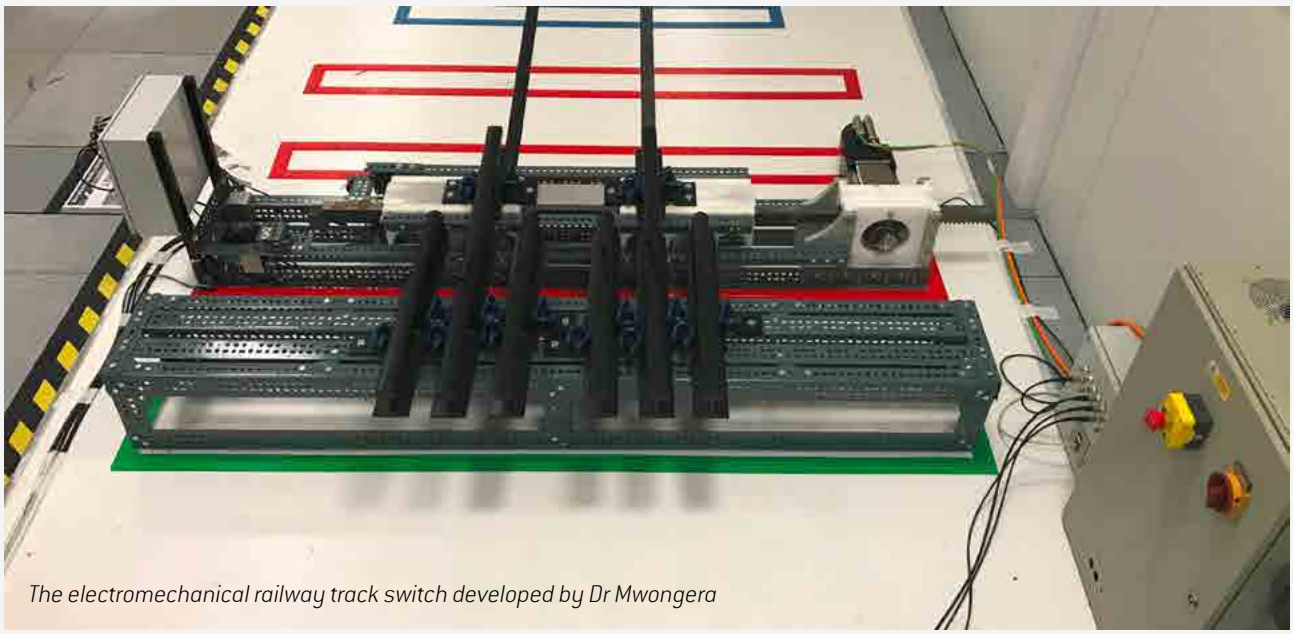
Train derails as it tried to switch tracks at Potters Bar in the UK on May 10, 2002. (Photo from a Progress Report by the HSE Investigation Board May 2003)

Switch failures impact railway service requiring emergency intervention by the maintenance team to restore operation. Dr Mwongera therefore developed a new technology that uses a software solution to incorporate multi-channel redundancy of actuation in the event of both sensor and actuator faults.

In the event of a failure, the faulty channel is isolated and trains continue to run until it is convenient to replace the faulty parts. Modelling for the British mainline network indicates that the new track switch solution would have prevented delays to trains in around 90 percent of railway switch failures between 2010 and 2013.

The Technology

Dr Mwongera's research began by modelling of a new type of electromechanical railway track switch. This new switch introduces redundancy in actuation for the first time on railway networks.



The electromechanical railway track switch developed by Dr Mwongera

Unlike conventional track switch machines, this switch needs closed loop feedback control to operate. She therefore developed two model-based control methods and tested both that met the requirements for use in a redundantly actuated track switch.

A fault tolerant control scheme for sensor faults was also implemented and it was demonstrated that using a reliable fault tolerant control configuration prevent railway service disruption in the presence of up to two sensor faults. A lab-scale demonstrator of the innovative switch with an actuator and stub switch rail ends was constructed in the lab as proof of concept to which the fault tolerant algorithms were applied.

Overall, the research shows that redundancy in actuation with a suitable control scheme provides benefits in achieving post-fault availability of a redundantly actuated electromechanical railway track switch in the presence of multiple sensor and actuator faults.

Dr Mwongera's innovation becomes the world's first implementation of a fault-tolerant scheme on a railway switch and her innovation was featured on multiple media sites, including the BBC. The overall intention of her PhD research is to highlight that through introduction of redundancy in railway track switching, rail network performance could be drastically improved in the areas of availability and reliability.

Dr. Mwongera currently works as a technical lead in an engineering multinational company and has previously worked in the financial technology sector in United Kingdom and United States and public sector in Uganda. She is keen on applying innovative technology solutions to different industries in East Africa and has a passion for mentoring young girls into pursuing Science, Technology, Engineering and Mathematics (STEM) education and careers. She founded an organisation called sheSTEMs Network in East Africa that exposes the younger STEM students to women role models while providing mentorship and training.

COMMUNICATION AN INDISPENSABLE SKILL FOR ENGINEERS

By Peter Mutie, FAPRA, FPRSK

A story is told of a chief engineer in an electricity generating power plant who had sent his team of three to collect a generator to replace an ageing one in the power station. While the team was on the way back to deliver the precious generator, their vehicle rolled several times. And the boss, seated in his office and watching the ticking clock, was informed by his secretary about the accident. "Sir, the lorry transporting the generator has rolled," said the woman in a low tone. "What?" asked the boss. "Was the generator damaged?" he thundered. So, the big question is, what was more precious? The generator or the lives of the team transporting it?

Communication is an indispensable skill for all professionals, whether engineers, accountants, doctors or any other profession. Indeed, leadership communication for engineers who are in leadership positions is as critical as engineering knowledge. This is so because if you cannot communicate effectively, you will not succeed in leadership. Engineers in leadership positions lead human beings, not machines. And there lies the need for leadership communication acumen to build trust, inspire loyalty and lead effectively.

Whatever else leadership may be, it is experienced publicly. A leader is judged on three fundamental public leadership attributes, all related to communication. They include:

- The leader's bearing – how the leader carries himself or herself
- The words the leader uses to engage others
- The manner in which the leader engages others

Strategic communication is a powerful tool for delivering business results. However, like any other powerful tool, it can cause significant self-inflicted damage if not used carefully and efficiently. There are many cases of leaders who have caused themselves self-inflicted damages, terminating their careers in tragic ways.

Some of the indispensable communications skills that are necessary for engineers include leadership communication, crisis communication management and media relations skills. Others are public speaking and leadership etiquette. Any leader or senior corporate leader who is not well canvassed with these skills lacks critical leadership attributes and will most probably face challenges in steering their positions.

Whether a CEO or head of a department or function, an engineer should communicate effectively with the team he or she leads to deliver better results. More importantly, those in senior leadership positions are also expected to drive the brand of the organisations they lead. Brands are built through effective communication and other symbolic actions that leaders take. Engineers are no exception. Simply put, strategic communication is an indispensable leadership skill for engineers.

> Communication is an indispensable skill for all professionals, whether engineers, accountants, doctors or any other profession.

The writer is a leading global PR professional with experience spanning over two decades. He is a former President of the Public Relations Society of Kenya, former President of the African Public Relations Association, a current Board member of the Global Alliance for Public Relations and Communications Management and the Chair of Africa Council for Global Alliance.

From the 27th IEK Annual International Conference:

We need to be part of the solution

By Eng. Margaret N. Ogai

The Institution of Engineers of Kenya (IEK), in collaboration with the Engineers Board of Kenya (EBK) held the 27th IEK Annual International Conference on November 24-27, 2020 at Pride Inn Paradise Beach Resort in Mombasa, Kenya.

The Conference whose theme was "Engineering a Post COVID-19 Future" presented a great opportunity to the delegates to reflect on the current and future challenges facing the human race.

Engineers, being problem solvers, have a rare and special opportunity to find out scientific and engineering solutions to the challenges ranging from the increasing world population to climate change. The Conference was graced by senior Government officials, leading engineers and technocrats in Africa and International delegates from different parts of the world.

The Conference sub-themes included:

- Engineering the Sustainable Development Goals (SDGs).
- Big Four Agenda and Vision 2030
- Smart Cities and Intelligent Infrastructure
- Development of National, County, and Regional Value Chains
- 4th Industrial Revolution and Industry 4.0
- Academia, Research and Development
- Climate Change Resilience

The event started off with the Women Engineers summit whose theme was "Leveraging Opportunities for Women Engineers". The event attended by over 300 women was organised by the Women Engineers chapter led by Eng. Christine Ogut. The chapter provides women engineers with unique opportunities to listen, discuss, share ideas and connect with leading women engineers beyond our borders from both industry and academia. Speaking at the event, the Honorary Secretary, Eng. Margaret Ogai, said the purpose for bringing Women Engineers together was to provide a platform for networking and professional development. These sentiments were echoed by the Vice President

and Chair, Women in Engineering-Federation of African Engineering Organisations (WIE-FAEO), Eng. Yetunde Holloway, when she said, "In order to climb the corporate ladder, you should work smarter, boost your education, build a stronger professional network and become an industry expert."

The chief guest for the conference was Transport, Infrastructure, Housing and Urban Development Cabinet Secretary James Wainaina Macharia, EGH, who graced the opening ceremony, albeit virtually. He reassured engineers that his Ministry was directly in charge of the Housing pillar as well as a critical enabler in all other pillars of the Big Four Agenda through the provision of requisite infrastructure such as roads, seaports, airports and railways, just to name a few.

Key Note Speakers

"The WFEO engineering plan encourages engineering education and professional development through developing engineering capacity for a sustainable world."

- Dr. José Manuel Vieira, President-elect, WFEO

"The Agricultural Sector Transformation and Growth Strategy (ASTGS) has nine flagships designed to increase small-scale farmers' incomes, increase agricultural output and value addition."

- Eng. Wangai Ndirangu, Chairman, KeNHA

The highlight of the Conference was the unveiling of the Engineers Identification Cards by the EBK in partnership with the National Bank of Kenya (NBK). The card that also comes with the feature of customised Visa Smart Card provides an easy identification mechanism that engineers can carry and use wherever they are. Speaking during the unveiling, EBK Chief Executive Officer, Eng. Nicholas Musuni, said the new card would also be used for payment of subscriptions and other monies to the Board.

"The need for an identification card arose from the realisation that there was no mechanism for engineers to easily identify themselves to the public or relevant authorities, especially when providing services outside an office environment."
As the curtains fell on the three-day event, the Executive Vice President, FNSE-WFEO, Eng. Mustafa Shehu, said the main purpose of the IEK Conference was to learn from each other and that engineers should appreciate the IEK activities and feel the necessity of being a member of the Institution.

Conference Sponsors

- Nuclear Power and Energy Agency (NuPEA)
- Kenya National Highways Authority (KeNHA)
- Kenya Urban Roads Authority (KURA)
- Energy and Petroleum Regulatory Authority (EPRA)
- Kenya Ports Authority
- National Housing Authority (NHC)
- National Construction Authority (NCA)
- Kenya Roads Board (KRB)
- Stockholm Environmental Institute (SEI)

Institution's CSR Activities: Committed to making a better community

By Maria Monayo

The Institution of Engineers of Kenya (IEK) prides itself in contributing to the social and economic well-being of the society in which it operates. Through its Corporate Social Responsibility (CSR), the IEK Council works with its members and other stakeholders to identify areas of participation and attention. As an organisation, we are responsible for the community in which we operate.

The World Bank estimated that the COVID-19 crisis could force 40 to 60 million people into extreme poverty, most of which in sub-Saharan Africa. Measures to stop the spread of COVID-19 disrupted labour markets and led to significant income loss for many households, with the low-income household being the hardest hit. The Government of Kenya puts in place several stringent measures to curb the spread of the virus, including limiting movement, closure of public spaces with high human traffic such as schools and public events, dusk-to-dawn curfew and rules to ensure hygiene and social distancing.

However, these precautionary measures posed negative economic impacts on businesses and workers. With the rising job cuts and struggling businesses from the reduction in working hours, the disruptions would be felt in both the short and long terms.

The IEK launched the COVID-19 response fund in light of the harsh realities posed by the pandemic. With the lockdown, travel restrictions and imposition of the curfew, low-income households were set to suffer the most with the loss of daily earnings.

The fund, which saw several vulnerable groups across the country receive handwashing kits, masks, food items, desks, stationery, among others, was launched on April 9, 2020 at the Annual General Meeting (AGM) with an initial target of Ksh10 million. The IEK sent out an appeal to all its members to contribute towards the noble cause. Through aggressive online campaigns and stakeholder engagement, the COVID-19 response fund raised a total of *******

The fund was spearheaded by IEK Council member, Eng. Grace Kagondu, as the team lead, with the support of the secretariat, led by the CEO, Eng. Linda Otieno.
One beneficiary of the fund was Carolina for Kibera, a non-governmental organization (NGO) whose mission is to alleviate poverty through community-led change.

Under their girls' empowerment programme, Binti Pamoja, which addresses adolescent girls' immediate and long-term safety, dignity and development needs, IEK donated Ksh300,000. This was donated in form of handwashing kits, food, clothing and hygiene packs.
IEK Covid fund also donated Ksh150,000 to Numerical Machining Complex (NMC) to aid in the

manufacture of a prototype ventilator to be used in managing COVID-19 effect on patients.

> "The funds will go a long way in procuring critical components that are currently not available locally, thereby ensuring continuation of the project, which has now moved to about 90% completion,"

said Eng. Kagondu during the cheque hand over at the IEK head office on August 13, 2020.

Numerical Machining Complex is an engineering firm offering mechanical and engineering services to the agricultural, industrial and automotive sectors in the East African market. The ISO-certified firm empowers businesses through innovation. The NMC has established itself as a market leader in provision of high precision industrial and automotive parts.

Several children's homes across the country were visited in collaboration with the IEK branches. Through the Central Kenya Branch, the IEK supported Dedan Kimathi University of Technology (DeKUT) in the manufacture of masks with a donation of Ksh250,000. DeKUT was also manufacturing a ventilator to support COVID-19 patients.

The final leg of IEK COVID-19 CSR initiative was accomplished on December 6, 2020 with 40 desks and chairs donated to a primary school in Kibagare informal settlement, which feeds and educates children from vulnerable families, including orphans.

Kshs. **300,000** Girls' empowerment programme, Binti Pamoja — **August 13, 2020**

Kshs. **150,000** Numerical Machining Complex (NMC) — **August 12, 2020**

Kshs. **250,000** support to Dedan Kimathi University of Technology (DeKUT) in the manufacture of masks — **August 14, 2020**

40 desks/ Chairs — **December 6, 2020**

COVID DONATIONS

One of the primary goals for setting up the COVID fund was to cushion vulnerable groups from the economic effects of the pandemic. In line with that, the IEK donated foodstuff to the New Life Home Trust fraternity

NAIROBI

Still on the Christmas Cheer Initiative, the IEK team in Nairobi led by 1st Vice President, Eng. Lucy Wanjiku Mutinda, 2nd Vice President, Eng. Eric Ohaga, and Council Member, Eng. Grace Kagondu, met and donated foodstuff to the GOTTA (Getting Over Trials and Tribulations of Adulthood) CITY community - a youth society based in Embakasi East, Nairobi.

INNOVATION

In support of innovations to help combat the COVID-19 pandemic, the IEK donated part of the COVID funds to Kenyatta University students who developed a prototype ventilator to aid their operations.

SOUTH RIFT

IEK South Rift Branch, in partnership with Engineers Fraternity Kenya, on December 21, 2020 did their Christmas CSR by donating gifts to New Life Home Trust in Nakuru.

CENTRAL

As part of the members-driven Christmas Cheer Initiative, IEK's Central Branch visited Kenya Connections Kids Home in Chuka and donated food and other household necessities.

NORTH EASTERN

In fulfillment of the Christmas Cheer Initiative, the interim leadership of IEK's North Eastern Branch visited Kilimani Children's Home in Isiolo town and gifted them with foodstuff and other essential household items.

Post-COVID economic recovery: Rethinking Kenya's road infrastructure development model

1 INTRODUCTION

1.1 Study Background

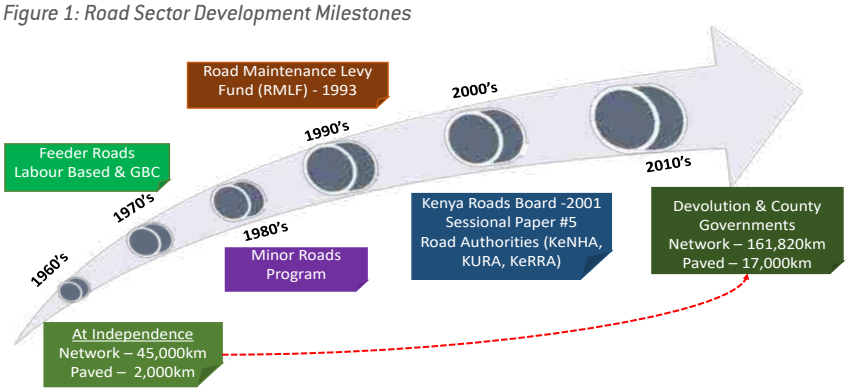
The road sector is a crucial enabler of development in Kenya. The sector is the dominant contributor to GDP accounting for 6 per cent of GDP, 15 per cent of typical household financial budget and a third of the country's energy consumption and carbon emissions and has a modal share of over 69 per cent over the period 2007-2018. Over 90 per cent of Kenya's passengers and goods are transported by road. While investments in road infrastructure have progressed well over the years, some shortfall has been forecasted thus casting doubts on the future network expansion and maintenance condition.

The occurrence of COVID-19 pandemic and its impacts on transport as well as in the general economy are, therefore, of great significance to the road infrastructure sector. COVID-19 has impacted Kenya's economy and travel patterns thereby disrupting its recent broad-based economic growth path and casting doubt on availability of future funding for the transport sector. Consequently, an understanding of those impacts and the actions necessary to mitigate any undesirable results is therefore necessary.

1.2 Kenya's Road Development journey since Independence

When Kenya attained independence in 1963, the country had approximately 45,000km of roads of which 2,000km was paved and the rest were earth and gravel roads. This has increased to 161,820 km total network with 17,000 km of paved ones as illustrated in **Figure 1**.

Figure 1: Road Sector Development Milestones



Multiple programs were adopted by the GoK in 1970s, 80s and 90s to spearhead road network development and expansion culminating in the establishment of the Road Maintenance Levy Fund (RMLF) in 1993 and establishment of the Kenya Road Board in 1991 to manage it. Finally, the three (3) Authorities (KeNHA, KeRRA, KURA) were established through the Sessional Paper No. 5 of 2006 to be responsible for designated portions of the road network.

1.3 Problem statement:

With COVID 19 and its impacts on the economy and travel patterns, pertinent issues and questions that need to be addressed include:

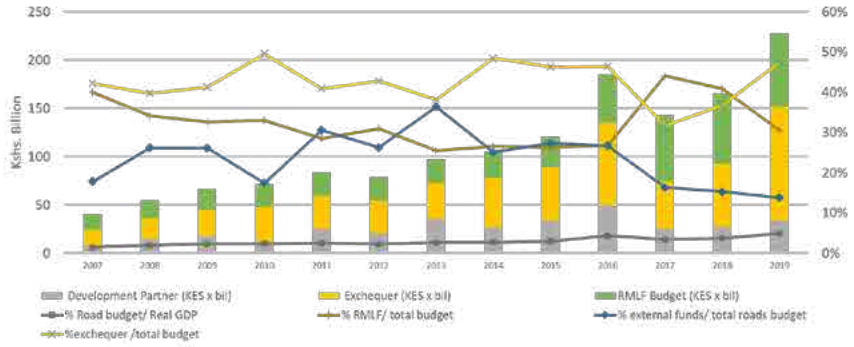
1. Will the historical models in management and investments in the road sector remain relevant and practical given COVID-19 lessons?
2. What are the socio-economic impacts of the pandemic and can we quantity the magnitude given the pandemic is novel?
3. What are the likely future impacts and what can we do today, to mitigate them?
4. In the Post COVID-19 era, how should the road transport sector development models change to respond to the new normal?

1.4 Study Objectives:

The specific objectives were therefore as follows:

1. To review historical road sector investments, policies and resulting socio-economic factors, identify past trends; and
2. To review the effects of COVID -19 on road infrastructure investment, development and use and discuss potential mitigation measures

Figure 2: Road Budgets for the last 10 years



Source: KRB, 2020 and State Department of Infrastructure.

Overall, a total of **KSh1.205 Trillion** was spent on the road network development and maintenance over the eight year period from 2012/13 to 2019/20. If the post COVID era leads to reduced collections from RMLF, there is need to explore alternative financing options.

2 FUNDING AND ROAD NETWORK CONDITION

2.1 Historical Investments in the Road Sector:

The key sources of funding for road infrastructure development and maintenance are GoK exchequer and county government revenue funds and Road maintenance levy fund as depicted in Figure 2. County Governments also apply County Revenue funds for road development and are apportioned 15 per cent of RMLF for county road maintenance. However, the existing sources of funding are insufficient to meet the road network development and maintenance needs.

2.2 Summary of Road inventory and Characteristics

Kenya has a total road network length of 160,886km as shown in Table 1. The network is under the responsibility of five authorities/ agencies namely KeNHA, KURA, KERRA, KWS and Counties with over 70% of the entire network. Paved roads comprise 15%, with Gravel and Earth surfaces accounting for the 20% and 65% respectively.

Table 1: Length of road network by surface type

Agency	Total (Km)	Paved (Km)	Gravel (Km)	Earth (Km)
KeNHA	18,224.74	9,186.76	8,457.97	580.01
KURA	2,610.06	1,172.55	245.77	1,191.73
KeRRA	19,492.94	3,908.77	3,798.98	11,785.19
KWS	6,562.07	14.00	1,456.00	5,092.07
County	113,996.20	9,594.45	17,699.69	86,702.06
Grand Total	**160,886.00**	**23,876.53**	**31,658.42**	**105,351.05**
		15%	**20%**	65%

Source: Kenya Roads Board (2019)

The state of the roads is 78 per cent of paved roads and 49 per cent of unpaved roads respectively are in good/ fair condition. There has been improvement in the overall condition of the road network over the last ten years. From 2009 to 2018, the total road network with the paved increasing by 27% with a corresponding 2% reduction in the length of unpaved roads as shown in Figure 3. This trend is however threated due to the shortfall and impacts of COVID.

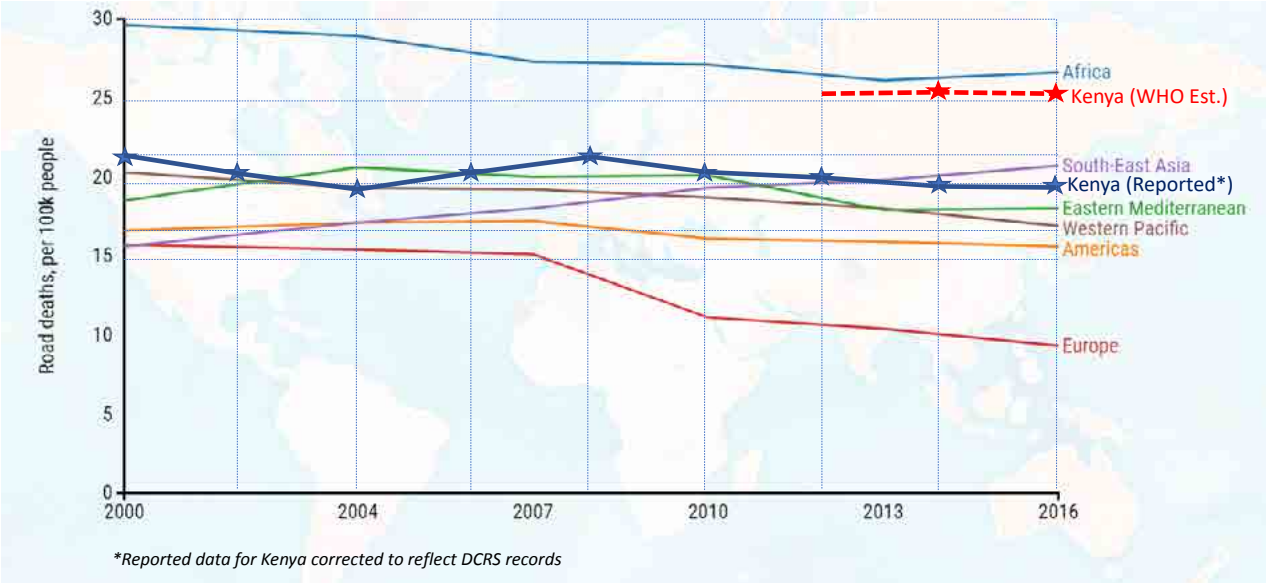
Figure 3: Changes in Network Size and Surface Condition

Source – RICS (County Data may not be well captured)

Travel demand on the country's road network has increased steadily over the years with the total travel of 85 Billion Km in 2015, mirroring the growth of motorization as measured by the number of registered vehicles in the country. This trend translates into an annual growth rate of approximately 12%. It is noteworthy that despite the above investments in the road sector, majority of trips (50%) are made walking, 11% by matatus and 4% on owned and boda boda bicycles. Private vehicles and motorcycles each account for 2% only.

Road Safety is also of great concern to the country. On average over 3,000 fatalities occur on the Kenyan road each year. As shown in **Figure 4**, WHO estimates of 27.8 fatalities per 100,000 population. These rates are higher than for Europe or America where there are higher rates of motorization (500-800 vehicles/1,000 population) but with significant investment of resources in Road Safety. The socio-economic cost of road trauma in Kenya represents an estimated 5.6% of the country's GDP.

Figure 4: Global Road Safety Indicators



Source: WHO and authors computations

2.3 Socio - Economic Indicators:

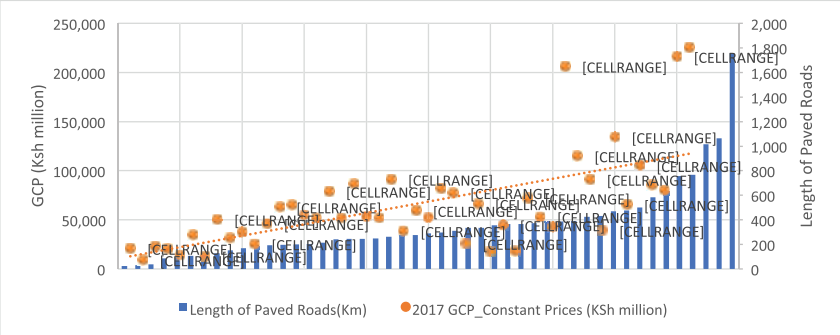
A sustained rate of investment in infrastructure is required to spur and sustain economic growth, hence there is a strong correlation between road infrastructure and key national development indicators.

The average length of county paved roads in in Kenya is about 361km with a standard deviation of about 308 indicating high disparities of roads between counties. The disparities are further shown in the rural access index (RAI) with the proportion of the rural population who live within 2 km of an all-season road in some counties scoring as low as 11%.

Counties in Kenya have experienced robust economic growth with total Gross County Product (GCP) increasing from Ksh4,263,910 million in 2013 to Ksh7,524,710 million in 2017.

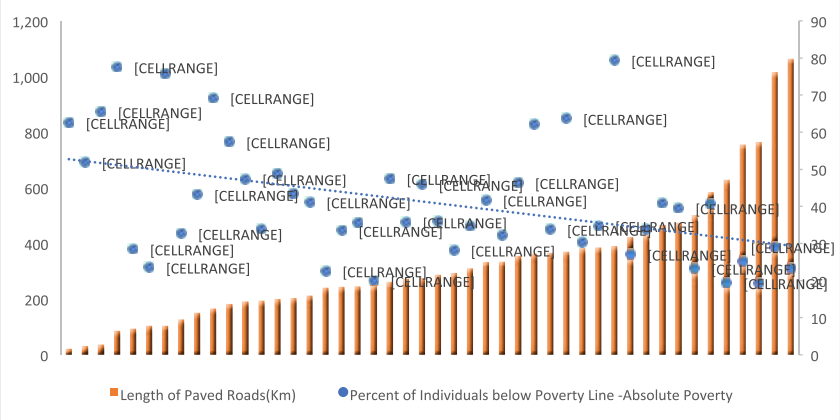
An assessment of the strength and direction of association between road infrastructure and county GCP, poverty reduction and food prices indicate presence of fairly high correlation between the variables of interest (**Figure 5 &6**). This strong positive correlation between County's GCP and length of paved roads constitutes promising evidence that improvement in the quality of roads in counties could spur county's economic activities. The results indicate that road infrastructure is a vital enabler to county's economic performance showing that good road infrastructure is capable of reducing transaction of markets access and hence making food prices stable and households food secure.

Figure 5:Length of County Paved Roads and GCP per County



Source: Authors computations

Figure 6: Length of County Paved Roads and County Absolute Poverty Levels



Source: Authors computations

3 COVID-19 Impacts on Travel and Economy

3.1 The COVID-19 Pandemic:

COVID-19 was first reported in Wuhan China at the end of 2019 but spread quickly to the rest of the world by the first quarter of 2020. As at October 2020, over 47 million people had been infected worldwide, with 1.2 million people dead. In Kenya, there were over 58,000 confirmed cases with over 1,000 dead.

To limit the spread of COVID-19, more than 200 countries and territories worldwide imposed measures that restrict people from entering their respective borders such as flight suspensions to border closures thereby resulting in billions of lost revenues from all sectors of the transport industry, aviation being the main one. This has led to rollover socio-economic impacts as well as.

3.2 Economic Impacts:

Recent studies show that COVID-19 pandemic has impacted Kenya's economy disrupting its recent broad-based growth path. Real gross domestic product (GDP) is projected to decline from an annual average of 5.7 per cent to 1.5 per cent- in 2020 (World Bank, 2020).[1] KIPRA and partners estimate the April-June lockdown in Kenya to reduce GDP by 5.6% in 2020 relative to the pre-COVID baseline leading to close to zero economic growth for the year, in annualised terms.

3.3 Transport Impacts:

In Kenya, the measures introduced by the Government included banning of all passenger flights, temporary closure of restaurants and bars, dusk to dawn curfew, cessation of movement in and out of some high-risk areas including Mombasa and Nairobi Metropolitan Areas. Some of those restrictions are still in place in one form or the other.

The above measures have been shown to result in significant impacts on travel and traffic volumes translating into economic impacts with reduced travel demands. With travel restrictions to Mombasa and Nairobi, cross country travel essentially came to a halt. In addition, many people in urban areas resorted to working from home, and are likely to continue doing so, even after COVID. Recent traffic volume counts indicate up to 15% reduction in traffic volumes along major highways in Nairobi. Similar were reported in other countries like the UK.

3.4 Government Economic Interventions:

In response to the pandemic, the Government of Kenya provided a fiscal stimulus package to help alleviate impacts of the pandemic to the vulnerable population and to spur back the economy in the long run. These measures included waiver of income taxes for low income earners, reduction of both income and corporation taxes as well as turnover taxes, allocation of KES10 billion (US$93 million) for social protection and allocation of KES5 billion (US$47 million) to county governments to assist in the fight against Covid-19. The Central Bank also put measures in place to increase liquidity in the banking sector to encourage borrowing.

1 https://publications.jrc.ec.europa.eu/repository/bitstream/JRC121284/jrc_technical_report_-_covid-19_kenya_final.pdf

Ngong road city mortuary roundabout


completed section of ngong road phase 1


completed section of outer ring


Red hill link road

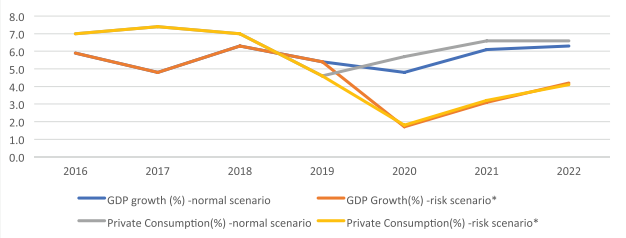

completed section of access road to embakasi infinity industrial park

4 Future Projections and Discussions

4.1 Economic and Social Projections:

The impacts of COVID-19 are projected to have significant adverse repercussions on key macro-economic indicators. GDP and private consumption are forecasted to be affected, **Figure 9** depicts forecasts of GDP and private consumption for Kenya.

Figure 7: GDP and Private consumption forecasts for Kenya – normal and risk scenarios



Source: KIPPRA: Kenya Economic Report 2020[2]

The risk scenario, which includes effects of COVID-19 (among other risks like locusts, droughts and floods, security risks) on the economy shows that GDP growth is expected to contract to 1.7 percent in 2020 and follow a constrained growth path relative to the normal scenario up to 2022. The same case holds for private consumption.

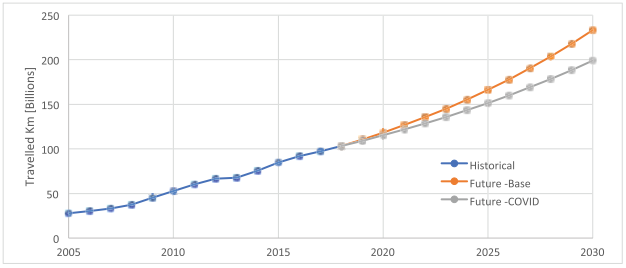
4.2 Transportation Projections:

In consideration of the above factors, we have made projections on the transportation indicators and related social outcomes with and without the impacts of COVID. The scenarios are as follows:

- **Baseline (Pre-COVID):** Without the impacts Covid-19, and in the absence of any significant policy redirection, the growth patterns experienced in the last decade would have continued.
- **COVID Reductions:** However, as a result of the contraction in the economy arising from COVID, it is expected that revenues from the transportation sector would reduce as a result of the reduced activities resulting in stifled investments in infrastructure. For the 10-year time frame considered for this paper, we have assumed a cumulative reduction of 10 to 20%.

Travel demands (vehicle km) projections assumed a rate that the historical rate of 7.0% that was observed for the last decade will continue. The rate, driven primarily by the growth in motor-vehicles, excludes in motorcycles that are used mostly off-road. The COVID scenario assumes a 10% suppression that rate due to the economic realities and travel demand measures like working from home that are likely to remain permanent. Projections are provided in **Figure 8**.

Figure 8: Travel Demand Projections



Source: KNBS Data and Authors Projections

The projection in network characteristics is summarized in **Table 2** below. While the growth in the network size is expected to remain relatively the same, the length of paved roads is expected to increase but the quality of the road surface is likely to deteriorate due to the shortfall in the available funds as noted in RSIP2 and is likely to be exacerbated due to COVID. The road safety situation is also expected to deteriorate with higher fatalities rates.

Table 2: Future Road Network Projections

	2009	2019	2030 - Base	2030 - COVID
Network Size	161,451	161,820	162,190	162,005
Paved Surface	13,401	16,986	21,530	19,258
Road Length in Good Condition	16,391	29,408	33,970	<33,970
Road Length in Fair Condition	50,288	71,083	25,309	<25,309
Road Length in Poor Condition	94,671	60,042	101,938	>101,932
Km-Travelled (Billions)	45	110	233	199
Fatalities /100,000	21.00	27.69	18.38	23.06

Source: Authors own projections

4.3 Discussion of Trends and Potential Initiatives:

The analysis confirmed that improvement in the quality of roads in counties could spur county's economic activities. The findings above have implications on a number of GoK programs and priorities and hence the occurrence of the pandemic at this time offers an opportunity to rethink the strategies and the investment options. The major areas that need a closer look include:

Reduced Funding due to Contraction of the Economy: This aspect will be broad cutting across several issues. It may threaten the total amount earmarked for infrastructure development and maintenance as well as for road safety programs.

2 https://kippra.or.ke/index.php/publications?task=download.send&id=226&catid=4&m=0

Fuel Levy Collections: The reduced demands will impact the revenue from the Fuel Levy Fund that is intended for the road network maintenance. As highlighted above, the anticipated shortfall in available funds will cause the shrinking the network length in good or fair condition by 40% from 100,000km to 59,000km.

PPP Project Financing: The reduced demands also threaten the viability of PPP projects as these are premised upon future traffic volumes. The government through this arrangement targets mobilising approximately KES 200 billion (US$ 1.85 billion) in the 2020/21 fiscal year by concluding the financing of several projects that are currently at an advanced stage of negotiations. Uncertainty in future traffic volumes arising from COVID impacts could impact the terms and conditions of those agreement and especially the contract duration that is expected to be 15 to 20 years.

As funding sources shrink, the formula for distribution of the road infrastructure funds amongst the various agencies will also need rethinking. As noted before roadways in the country are controlled by five agencies namely KeNHA, KURA, KERRA, KWS and Counties that are now individually responsible for the bulk roadways in their jurisdiction. Hence there is need for better realignment of roads sector to devolution to ensure that allocations are adequate to fully address their road development and maintenance requirements.

Finally, given the disproportionate modal split in favour of NMT, priority should be given to funding NMT facilities both in rural and urban areas. All road projects should include adequate NMT provisions. A sizable proportion of the budget should be intentionally earmarked for NMT.

5 Conclusions and Recommendations

5.1 Conclusions:

The COVID-19 pandemic has disrupted the normal ways of life with severe restrictions in travel and reduced economic activities thereby resulting in imminent economic down-turn. Although the GoK has responded with a raft of economic stimuli, the low down in economic activities will persist with reduced tax revenues thereby impacting the ability of the government to continue funding infrastructure development is the same levels as before. These circumstances thereby provide an opportunity to rethink the models for funding road infrastructure development and maintenance.

Analysis of past trends shows that funding has not been adequate to cater for the development and maintenance requirements fully and a shortfall has been identified leading to a backlog of maintenance projects. The impacts of COVI-19 with a contracted economy, less revenue for the exchequer and reduced travel demands will only act to exacerbate the problem. A number of priority areas need to be re-examined to mitigate the anticipated negative trends in transportation and socio-economic factors.

5.2 Recommendations:

The following recommendations are made to address the various priority areas identified:

- A more detailed assessment of the impacts of COVID on road travel demands and hence on fuel consumption should be undertaken in the short and medium term in order to facilitate reassessment of the **RMLF revenue** uptake scenarios and thereby realign the maintenance schedules with the expected revenues
- **PPP Project Financing and Tolling:** The planned rollout of tolling on a number roadways should be reassessed with a view of confirming validity of contractual agreements in view of reduced traffic demands
- Realignment of roads sector to devolution should be undertaken to ensure that allocations to counties are adequate for their share of responsibilities.
- Intentional initiatives should be started to attract road infrastructure funds in the various counties to increase the road network sizes.
- Consideration should be given allocating specific funding for NMT facilities not tied to road projects given the disproportionate modal share in their favour
- Consideration should be given to restarting long term Transportation Master Planning for Infrastructure with individual capital programs prepared by KRB in collaboration with the various road authorities

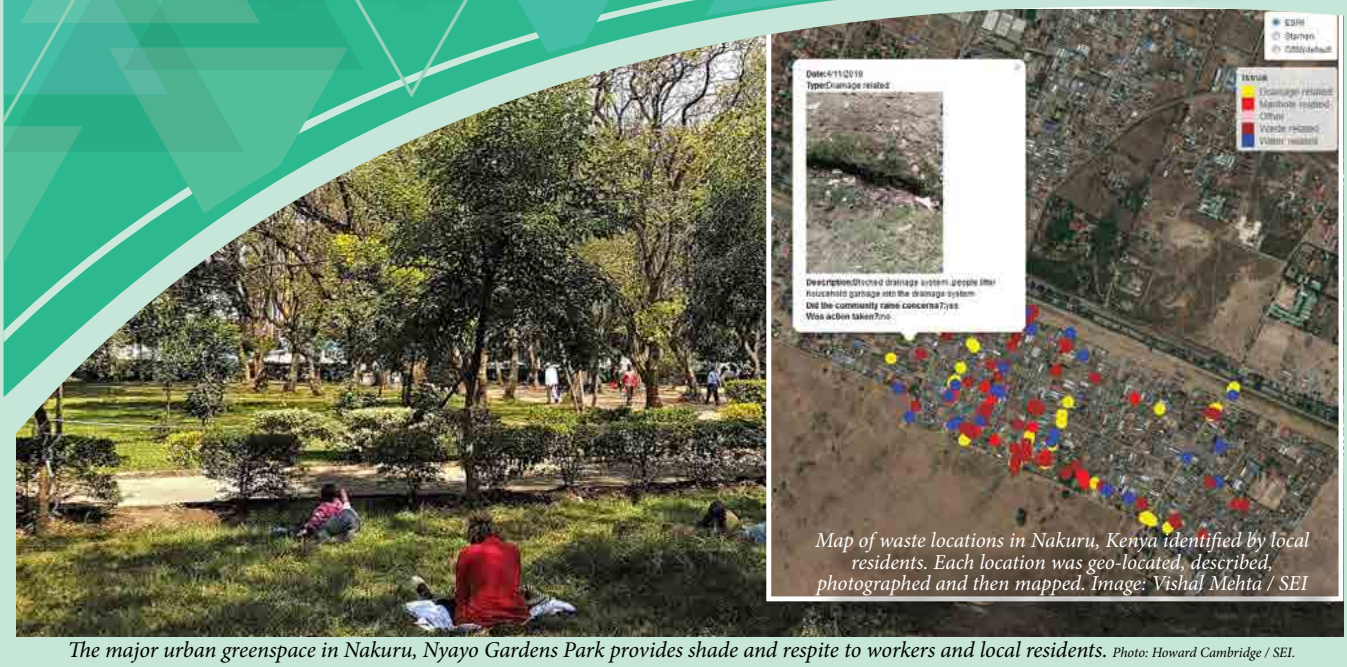
Authors:
Eng. Margaret Ogai
General Manager Planning & Programming,
Kenya Roads Board

Co-authors:
Dr. Eng. Timothy Oketch, Director – TIMCON Associates,

Dr. Evelyne Kihiu& James Gachanja both of KIPPRA

SEI Stockholm Environment Institute

Bridging Science and Policy



The major urban greenspace in Nakuru, Nyayo Gardens Park provides shade and respite to workers and local residents. Photo: Howard Cambridge / SEI.

Map of waste locations in Nakuru, Kenya identified by local residents. Each location was geo-located, described, photographed and then mapped. Image: Vishal Mehta / SEI

Stockholm Environment Institute (SEI) is an international non-profit research and policy organization that tackles environment and development challenges. We connect science and decision-making to develop solutions for a sustainable future for all. Across our eight centres in Europe, Asia, Africa and the Americas, we engage with policy processes, development action and business practice throughout the world. SEI Africa centre work focuses on three key areas: Energy and climate change, Sustainable urbanization, and Natural resources and ecosystems.

SEI Flagship Tools

Long-range Energy Alternatives Planning system (LEAP)

Water Evaluation and Planning system (WEAP)

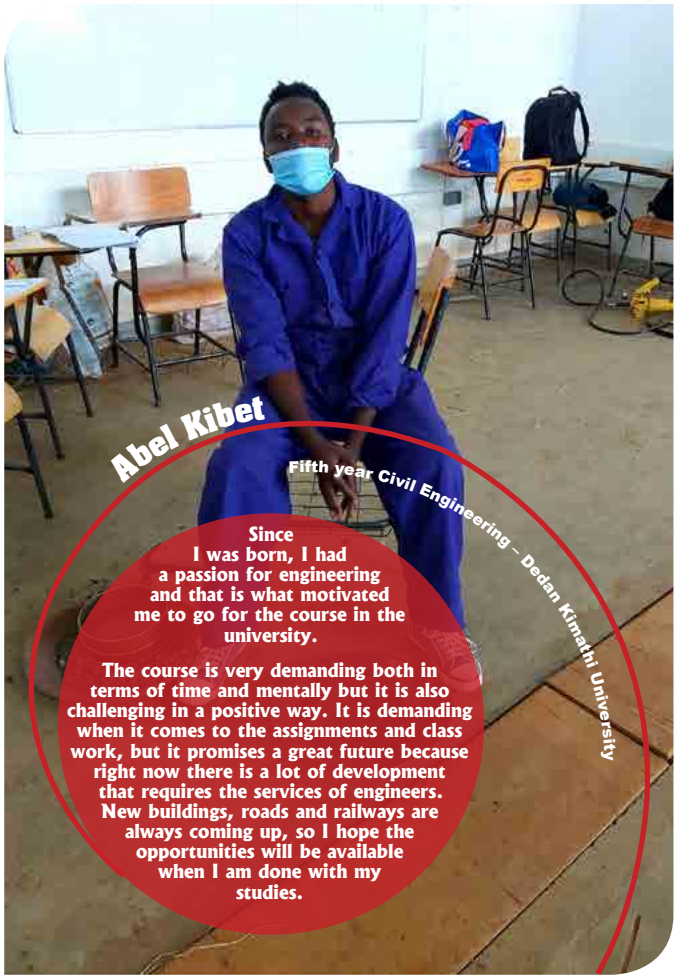
LEAP is a flexible platform for energy system and climate mitigation modeling and analysis, and WEAP is a tool for integrated water resources modeling and planning.

SEI Africa Programmes

- Research
- Capacity development (especially the use and application of decision support tools such as WEAP: *https://www.sei.org/projects-and-tools/tools/weap/* and LEAP: *https://www.sei.org/projects-and-tools/tools/leap-long-range-energy-alternatives-planning-system/).*
- Policy support; especially evidence based policy development and implementation on environment and development.

@SEIresearch @SEIclimate

Students voices

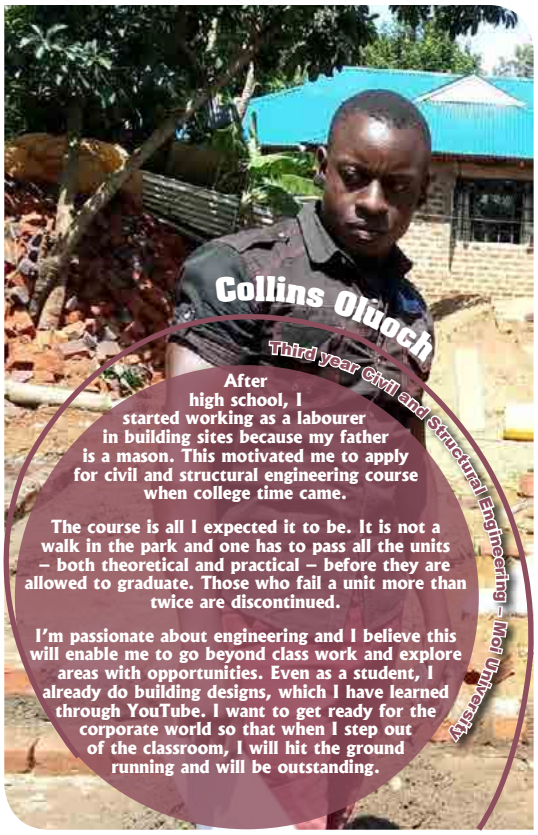


Abel Kibet

Fifth year Civil Engineering – Dedan Kimathi University

Since I was born, I had a passion for engineering and that is what motivated me to go for the course in the university.

The course is very demanding both in terms of time and mentally but it is also challenging in a positive way. It is demanding when it comes to the assignments and class work, but it promises a great future because right now there is a lot of development that requires the services of engineers. New buildings, roads and railways are always coming up, so I hope the opportunities will be available when I am done with my studies.



Collins Oluoch

Third year Civil and Structural Engineering – Moi University

After high school, I started working as a labourer in building sites because my father is a mason. This motivated me to apply for civil and structural engineering course when college time came.

The course is all I expected it to be. It is not a walk in the park and one has to pass all the units – both theoretical and practical – before they are allowed to graduate. Those who fail a unit more than twice are discontinued.

I'm passionate about engineering and I believe this will enable me to go beyond class work and explore areas with opportunities. Even as a student, I already do building designs, which I have learned through YouTube. I want to get ready for the corporate world so that when I step out of the classroom, I will hit the ground running and will be outstanding.

Dorcas Anono

Second year Electrical and Electronics Engineering – JKUAT

Safaricom's Technovation Challenge 2016, a programme that teaches girls aged 14-17 years how to code, introduced me to the world of engineering. I learnt how to use technology in order to create sustainable solutions for problems in my community through developing mobile applications. There was no turning back, the computer lab became my ideal Disney world, revealing a new passion.

After my KCSE examination, I wanted to combine my new-found passion in software with hardware. After consultations with different engineers, electrical engineering seemed fit for the job. I would describe my experience with engineering so far as quite interesting. First of all, there is a lot of Mathematics (which I really do not mind) in our everyday classwork. Secondly, it is very enlightening to know how most things work. Just knowing the details of the functioning of most devices gives me so much joy. Theodore von Kármán stated that "Scientists study the world as it is while Engineers create a world that has never been". That is my expectation as I continue to decipher this broad and exciting new world, to create a world that solves our current problems.

Rosemary Litunya

Electrical and Electronics Engineering finalist – JKUAT

As a young girl I was always interested in knowing more on how electronics worked. Right from the smallest interactions with subjects such as Science in primary school and Physics in high school, my interest grew in wanting to understand more of what made a bulb light and what was happening behind a television screen.

Once I made my decision to take my undergraduate studies in Electrical and Electronics Engineering, I was sure that I had to make several adjustments. During my first year in university, it felt like a roller coaster with a lot of unlearning and relearning of basic scientific principles. Studying engineering gave me a whole new perspective.

It has been an exciting journey for the past five years with a lot of ups and downs. I have been equipped with expertise that can help me jumpstart my career. Deciding on a specific career path is the most challenging part. I am keeping an open mind and looking forward to an exciting journey working in the industry.

Rosemary is currently a Fault Analysis Intern at M-KOPA as she awaits graduation.

Kendi Vivianne

Third Year, Electrical Engineering – JKUAT

Back to high school, I knew Electrical Engineering was it for me when we did the topic, 'Electricity' in Form Three. The topic unlocked something within me and that was when I made my decision. Afterwards, I immersed myself completely and ensured that my grades would get me to JKUAT to do electrical engineering.

Coming to university, I didn't really know what to expect, I was just really excited to have gotten here. Second year for me was the most interesting since we started to cover Electrical Engineering in depth. Engineering proved to be and still is very interesting, to see what goes on behind the scenes in the working of systems is always such a pleasure.

While I may not be able to come up with completely new inventions, I believe I could contribute greatly to helping improve already existing ones. The journey may not always be easy, but it is very fulfilling.

Typhone Oloo

Fifth year Mechanical Engineering – TUK

I got interested in engineering when I was in primary school. I used to see calendars on the walls written engineering works, and always wanted to know what engineering was all about. By the time I sat my Form Four exam, I had already decided that I would do biomedical engineering, which was only offered in TUK and Kenyatta University. However, when I applied through the Kenya Universities and Colleges Central Placement Service (KUCCPS), I was admitted for mechanical engineering.

I feel it is still the right course for me because I have not dropped out and I have never got a supplementary. This has motivated me to put more effort in my studies even as I undertake my final year.

So far, I have registered with the Engineers Board of Kenya (EBK) and the Institution of Engineers of Kenya (IEK) as a student engineer and I hope this will present the opportunity to be what I have always wanted to be; a hands-on engineer who provides solutions to everyday problems.

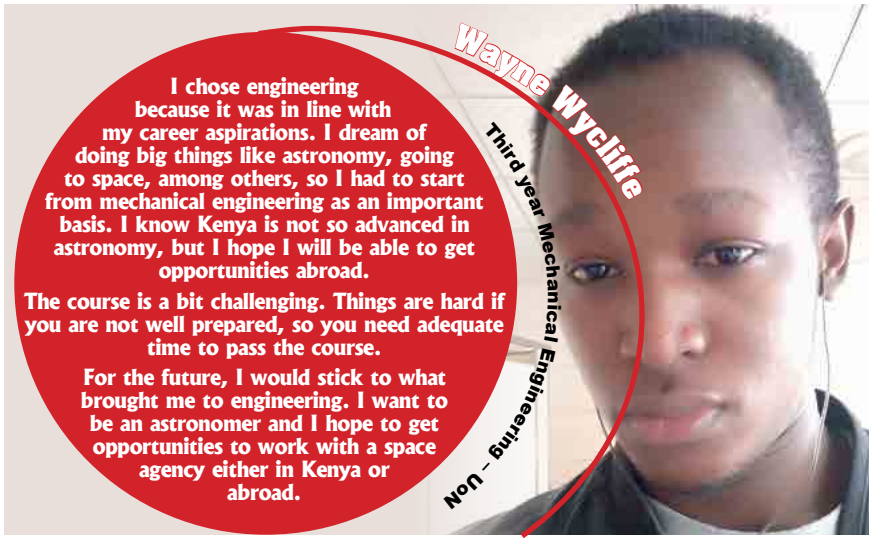
Dickson Onyango

Fifth year Mechanical Engineering - TUK

I have been fascinated with construction works since I was in Standard One, and that is when I developed a passion for engineering. As time went by, I kept the faith and worked hard until Form Four. Even my teachers would call me engineer.

We used to be told that there are limited opportunities for mechanical engineering, but I later learnt that no construction can be done without a mechanical engineer. There is no plant that can be erected without a mechanical engineer. This means there is an intermarriage of all these engineering professions. It takes time and requires a lot of enthusiasm but there is no challenge because when you decide to study engineering you must be prepared for the five years.

Kenya is still growing and I am sure there are many other structures that will come up. This means there are thousands of opportunities out there.



Wayne Wycliffe

Third year Mechanical Engineering – UoN

I chose engineering because it was in line with my career aspirations. I dream of doing big things like astronomy, going to space, among others, so I had to start from mechanical engineering as an important basis. I know Kenya is not so advanced in astronomy, but I hope I will be able to get opportunities abroad.

The course is a bit challenging. Things are hard if you are not well prepared, so you need adequate time to pass the course.

For the future, I would stick to what brought me to engineering. I want to be an astronomer and I hope to get opportunities to work with a space agency either in Kenya or abroad.

In our next issue, we will feature the Young Engineers Chapter of IEK and the role they play in building a strong association of Engineers.

Stay tuned!

3RD IEK WOMEN ENGINEERS SUMMIT

LEVERAGING OPPORTUNITIES FOR WOMEN ENGINEERS POST COVID-19

The third IEK Women Engineers Summit took place during the 27th IEK International Conference held at PrideInn Paradise Beach Resort and Spa, Mombasa, on November 24, 2020. The one-day event was hosted by the Institution of Engineers of Kenya (IEK) and the Engineers Board of Kenya (EBK) under the theme "Leveraging opportunities for women engineers post Covid-19", in its relevance in the global push to improve women's rights.

The summit organised by the Women Engineers Chapter (WEC) of the IEK was graced by phenomenal speakers and panelists who are Women in Engineering from across the world. The chief guest was Dr. Marlene Kanga, the immediate Past President of the World Federation of Engineering Organizations (WFEO), who gave a keynote address.

Dr. Kanga commended women globally for making huge contributions towards the fight against the Covid-19 pandemic, despite the fact that they are among those who have been adversely affected. She said women engineers all over the world have had to adapt to the effects of the pandemic in order to ensure continuity in their personal and professional lives. She reiterated the important role of engineering in advancing the sustainable development goals and urged engineers to continue providing solutions to most challenges in the world.

In her welcoming address, WEC Chairperson, Eng. Christine A. Ogut, congratulated Dr Kanga for being the first woman president of WFEO. She also also celebrated and applauded her predecessors at the Women Engineers Chapter at IEK who she said had accomplished a lot by spearheading the initiatives that support the development of women in engineering and increase the number of women engineers. Eng. Ogut said women engineers were still a minority, accounting for only 7% of industry professionals in Kenya, and called for more efforts to empower and promote girls to undertake engineering.

> "We all know that Covid-19 has redefined the way we do a lot of things, it has taught us a new way of doing things. Women engineers will play a pivotal role in addressing the challenges facing our planet in the era of lockdown and physical distancing," said Eng. Ogut.

The President of IEK, Eng. Nathaniel Matalanga, commended the WEC for organising the summit with an aim of encouraging more women engineers to seek career pathway options that allow them to have both

fulfilling professional careers and vibrant personal lives post Covid-19. The president said the IEK was working to increase the representation of women within engineering by encouraging young girls to take up Science, Technology, Engineering and Mathematics (STEM) subjects in schools to help them to prepare for an engineering career, as well as by having more women engineers in top positions to ensure more equitable, inclusive and representative decisions.

The important role of women engineers in developing inclusive post-pandemic solutions was reiterated by EBK Board Chairman, Eng. Erastus K. Mwongera. "Women engineers are key in designing and developing smart, sustainable technology-based solutions that would allow us all to live better lives," said Eng. Mwongera.

He said attracting and supporting more women in engineering benefits everyone by increasing the potential to develop inclusive, innovative solutions for the complex problems the world is facing now during the Covid-19 pandemic and post pandemic. He noted that the EBK is developing programmes that will give women more chances to access equal opportunities in various engineering sectors.

Eng. Lucy Wanjiku Mutinda, the 1st Vice President of IEK, said the Covid-19 crisis has challenged the word like never before. She emphasised on the need for women engineers to rise to new heights as they will play a crucial role in the post Covid recovery of global and national economies. She also noted that women engineers are a catalyst to change and should be at the forefront in fostering the achievement of a sustainable future as well as the provision of homegrown solutions to societal problems.

Eng. Yetunde Holloway, the Vice President and Chair Women in Enginerring at the Federation of African Engineering Organizations, in her address, urged engineers to climb the corporate ladder and break the ice ceiling with integrity.

Other guests and speakers during the summit included IEK Hon. Secretary Eng. Margaret N. Ogai, Eng Linda Otieno, the CEO of IEK, Kentice Tikolo OGW (FPRSK, Strategic PR & Communications Consultant), Jane Ndirangu (Principal Officer, Advisory and Technical Support, Public Procurement Regulatory Authority), Dr. Romanus Opiyo (Research Fellow, Stockholm Environment Institute), Eng. Joan Otike, the Assistant Director (Structures) at the Kenya National Highways Authority (KENHA), Eng. Nancy Abira (Road Safety Engineer, TIMCON Associates, Kenya), Emily Claire Sebalamu (Project Manager, CiSco Systems, GmbH), Dr. Andriannah Mbandi (Research Fellow, Stockholm Environment Institute), Eng. Rovani Sigamoney (UNESCO Engineering Programme, HQ Paris) and Eng. Grace Kagondu (Chair, Capacity Building/CSR COVID Response Fund at IEK).
Others were Prof Faith Karanja, MISK, LS(K) (Geospatial Engineer), Chaltu Marta (Technical Sales Engineer – W.Giersten Energy, Kenya), Dr. Gladys Ngetich Chepkirui (Aerospace Engineer) and Amelea Omollo (Aeronautical Engineer).

Eng. Jeniffer Gache, Industrial Development Advisor, East African Community Secretariat, closed the presentations with a vote of thanks, appreciating the Stockholm Environment Institute, UNESCO, Liquid Telecom, Kenya Roads Board and Kenya National Highways Authority for sponsoring the summit.

Design Consideration and Eco-Environmental Assessment for Electric Propulsion Ships: Case Study –Cruise Ship

By Omar A. Abdulrehman Al-Baity, Ibrahim S. Seddiek & Mohamed M. ElGohary

Introduction

Currently, the marine sector is facing the greatest challenging standard of emissions in the world. More than eighty percent of the world trade has been carried by maritime transportation, which emitted about 10-20% nitrogen oxide, 2-3% global carbon dioxide, and several other pollutants [1]. To reduce global warming in this century [2], the IMO has taken essential measures and decided to decrease the shipping carbon dioxide to 50% of its 2008 level by 2050[3]. Precisely, Annex VI of MARPOL was implemented on May 19th 2005, to gradually reduce the released emissions from ships by describing emission control areas (ECA)[4].

The drive towards more effective and rational energy use due to global environmental concern is encouraging electric propulsion systems. Electrification have proved many advantages including; minimizing fuel consumption and emissions, flexibility in placing the power plants, an improved energy management than conventional systems [5], in addition to the reduction of the installed power and vibrations, increased manoeuvre flexibility, and ship architecture optimization [6].

Although the electrification of vessels is an attractive solution for various vessel types, it might not be a good choice for numerous vessels that sails mostly at a constant speed and power load. Any electrical components in electric systems such as generators, electric motors, transformers, and converters add extra losses[7]. Thus, in electric systems architecture, these losses at maximum power can exceed the traditional architecture losses. Before selecting the propulsion architecture, extra care should be taken for any given ship design. The operational load profiles and specific designs are the key factors to select the vessel's optimum propulsion architecture. Diesel engines consume higher fuel when operating in a lower power range. Here is where electric systems take the advantage over conventional since it has higher efficiency at low range speed. There are many old ships with a conventional system. These ships need an upgrade in the efficiency of their propulsion systems, to comply with the regulation enforced by the

new legislation. As a consequence, the electrification of an existing ship, by retrofit processes, gains interest both for the corporate and for scientific sectors. Based on the above considerations, in this paper the influence of replacing conventional systems of a cruise ship with electric systems is evaluated, concentrating on the fuel consumption, emissions, and operation and maintenance costs. This task is achieved by performance assessment of electric systems applied to the referenced voyage profile of the ship.

Case Study: The Cruise Ship M/S Birka Stockholm

The proposed case study, a cruise ship, built-in 2004, is selected as described in [8]. It is characterized by a length of 176.9m and a breadth of 28.6m. It has a capacity of 1800 passengers. Fig. 1(a) describes the operation of the ship between Stockholm and Mariehamn. She departs Stockholm at 6 pm to the open sea and halts the whole night. It arrives in Mariehamn in the morning. At 9 am, she goes back to Stockholm arriving at 4 pm. The route map is shown in Fig. 1(b).

Fig. 1: (a) Typical operation profile for the cruise ship (b) Voyage route of the cruise ship.

From the analysis carried out, it can be deduced that the ship does not operate at its design power but uses a portion of it. This is because she rarely cruises at its designed speed of 21 knots, rather the maximum speed attained is around 16 knots as illustrated in Fig. 2 [9]

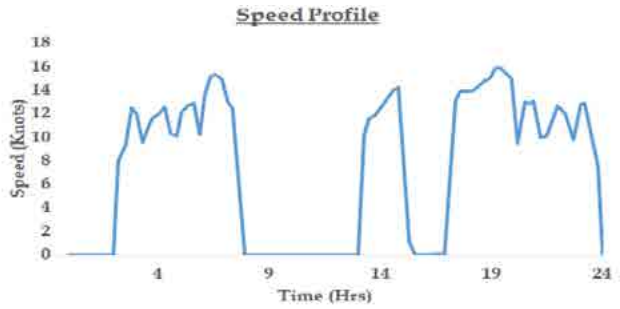


Fig. 2: Operational profile for the case study ship [8]

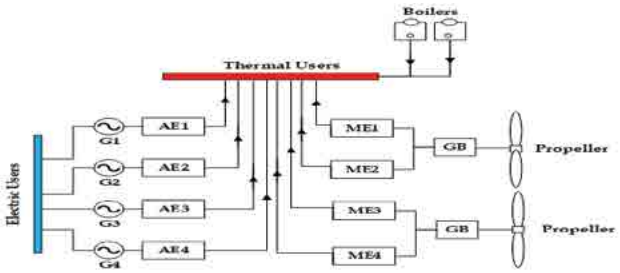


Fig.3: Case study's propulsion systems.

As observed in Fig. 3, the systems consist of two lines each with two main diesel engines. Four auxiliary engines running four generators for electric power demand are placed too. Table 1 below summarises the power components in the systems.

Table 1: Energy sources for the case study vessel.

Quantity of Component	Component Name	Design Power (KW)
4	Main engines	5850
4	Auxiliary engines	2760
2	Auxiliary boilers	4500

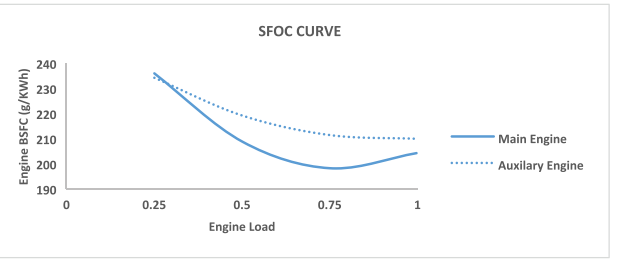


Fig. 4: Main and auxiliary engines BSFC versus engine load for conventional propulsion systems, from regression [10]

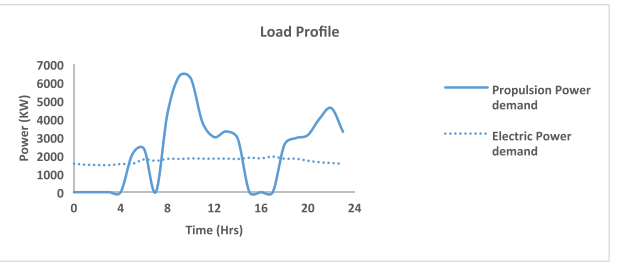


Fig. 5: Reference round voyage.

Fig. 5 presents the loading for the conventional systems; the main engines have a mean of 32% and a standard deviation of 29%, and the auxiliary engines have a mean of 53% and a standard deviation of 5%. Moreover, the energy generation for each main engine ranges from 13.7% to 15.8% while for auxiliary engines ranges from 8.8% to 12.9% [11]. Therefore, it is very clear that these diesel engines are under-utilized and therefore their efficiencies are lowered.

This paper considers the diesel engines and not the boilers installed in the ship so that a good comparison between the propulsion systems is achieved. This makes sense as most of the power, about 97.5%, required by the ship for propulsion, electrical, and heat are provided by diesel engines [11]. Moreover, the paper considers the propulsion and the electrical power demand since they are provided by the diesel engines. The heat power is provided through the heat recovery system (about three-quarters of energy) and the boilers [11]. Outlining the above exceptions, a realistic comparison can be achieved between the conventional and the electric propulsion systems.

Methodology

The study of the design consideration, the economical and the emissions aspect of the electric systems is simplified in the flowchart shown in Fig. 6. The starting point is analysing the referenced voyage profile given in Fig. 5. Afterward, the design consideration and the technical layout of the components are considered as per the IMO and the classification society regulation. Next, the specification of the electric system components are evaluated. Later, the analysis of the performance of the electric systems is estimated. Finally, a comparison between the conventional and electric systems is made to determine the influence of the electrification and the battery pack in the fuel consumption, the emissions released to the environment, and the operation and maintenance cost.

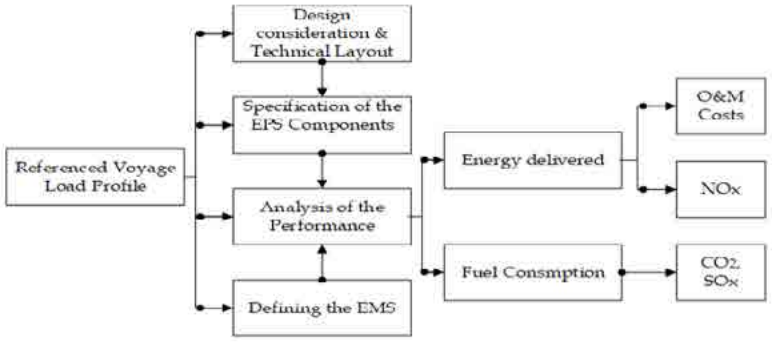


Fig. 6: Flowchart of the methodology to study electric propulsion systems

Design Considerations and Technical Layout

Proposing an ideal electric architecture for a specific ship is not a simple task. The choice normally depends on the type of the ship and its operational profile. The series propulsion systems is the better option for this cruise ship, since the diesel engine rarely operate at high power range, therefore the advantage of parallel architecture cannot be detected in this ship. The proposed electric systems is shown in Fig. 7.

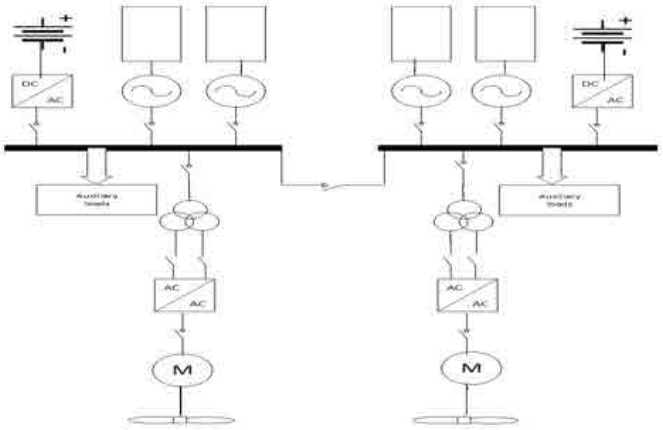


Fig. 7: The proposed Series Electric propulsion systems

The electric systems must abide by the rules established by IMO on emissions released to the environment. Another important design factor is the redundancy of the systems. The propulsion systems should be split into two lines. Each line of the propulsion systems should consist of at least two main engines of equal power rating that provide the maximum power required as per the requirement of IMO. The mass of the Energy Storage Systems is a significant design factor in the road vehicle, however, it can be disregarded in the marine industry because of the heavyweight of the ship [12]. The voltage level for the propulsion systems is 11KV, 60 Hz while utility distribution lower voltage used is 400/230.

Specification of the Propulsion System Components

In this section, the focus will be on the sources of energy, precisely the main diesel engines and the battery pack. Other components such as power electronics and electrical generators or motors are presented using power loss models. An average of 10% transmission loss is considered to present the losses of all other components.

Specification of the Diesel Engines

Adding the propulsion and the electric power demand of the load profile in Fig.5, gives the highest power demand roughly 8940 KW. This point does not exceed the optimum point of the two main diesel engines of the conventional systems that is 11520 KW. Therefore, instead of acquiring new engines, to save the cost, the available diesel engines are used since they are enough to provide the maximum power requested and to charge the battery pack while sailing. The original architecture has four main diesel engines, therefore redundancy of the system is accomplished; two engines per propulsion line. Table 2 gives the characteristic of the diesel engines for the proposed electric systems.

Table 2: Specification of the diesel engines for proposed propulsion systems[10].

Properties	Description
Model	Wartsila 6L46
Rated Power (KW)	5850
SFOC (g/KWh)	175-197
Fuel	HFO

Specification of Battery Pack

The battery pack aims at supplying the required auxiliary power while the ship stops, and to compensate for the excess or lack of power by taking or delivering energy, to maintain the engines at their optimum point when the ship is sailing. From Fig. 5 the total storage capacity of the battery will be calculated for 5 hours and 2000 KW, being the longest time and the highest auxiliary power demanded at the port. As a result,

The storage capacity = 2000 KW * 5 h = 10000 KWh (1)

The zebra and Lithium-ion battery has been considered since they have higher recharge cycles, and the highest energy density and efficiencies [13]. Table 3 shows the comparison between lithium-ion and zebra battery.

Table 3: Comparison between Zebra and Lithium-ion battery[13-15].

	Zebra		Lithium-Ion		
Parameters	Unitary Values	Total Values	Unitary Values	Total Values	Diff (%)
Volume (m^3)	180KWh/m^3	56	260KWh/m^3	39	43.6
Mass (Kgs)	115Wh/Kg	88261	150Wh/Kg	67667	30.4
Cost ($)	$12.7/Kg	1120915	$90/Kg	6090030	-81.6

Taking the characteristics of lithium-ion battery as reference in table 3, it is observed that the zebra battery occupy 43.6% more space, 30.4% heavier, and 81.6% cheaper than the lithium battery. Since the cost is considered to be more important than the volume and the mass, the zebra battery is the better option.

Energy Management Strategy

The energy management strategy is presented here to give light on the requirements for the studied cruise ship propulsion systems. The aim for energy management strategy is as follows;The battery is used when there's no propulsion power demand, that is when the ship is not sailing, hence the engines are switched off to minimize fuel consumption and emission.The diesel engines are operated at their optimum point and any excess or lack of power is compensated by the battery, either by taking or delivering energy. The state of charge of the battery is in the range of 20% to 100%.

In this paper, the rule-based energy management strategy is implemented to determine the battery usage using the following rules;

Rule 1: If Pp=0 and Preq=Paux: If the battery remains within a sufficient SOC level that is in the range of 20% to 100%. The system is run using battery only (all generators are turned off).

Rule 2: If Preq is less than PI: The system is run using one generator (other generators are turned off).

Rule 3: if Preq is larger than PI and less than Pm: The system is run using only one generator and battery (other generators are turned off).

Rule 4: If Preq is larger than Pm: The system is run using two generators and the battery.

Rule 5: If SOC of battery is less than or equal to 20%: Run extra generator to charge battery to an acceptable range; not to exceed 100%.

Where; Pp is propulsion power, Paul is auxiliary power, Preq is the power requested, PI is the low power requested, that is less than MCR of an engine, Pm is the medium power requested, that is more than MCR of an engine but less the power of two engines.

Analysis of the Performance of the Electric Propulsion Systems

The performance of the electric systems is evaluated by estimating its fuel consumption, exhaust emissions, and the maintenance cost. This is accomplished by simulating the power demand from the propulsion and the auxiliary systems of the studies cruise ship for a reference voyage profile.

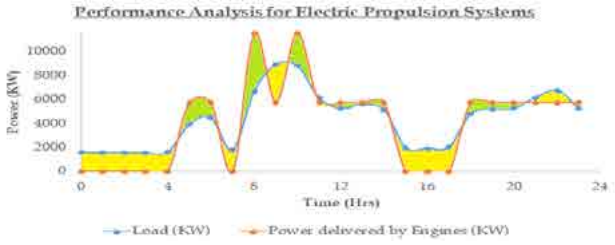


Fig. 8: Performance Analysis for Electric Propulsion Systems

Fig. 8 presents the performance of the electric systems. The discharge by the battery is illustrated by the yellow areas while the charge is shown by the green areas. The power delivered by the engines is calculated assuming that each Genset delivers an equal amount of power. Moreover, the compensation of energy by the battery pack is mainly concentrated for the three stops, at the ports of Stockholm and Mariehamn and the open sea. When the ship sails, the engines are running along with or without the battery pack. When both are running, the engines are kept at their optimum point whereas the battery pack compensates for the excess or lack of power by taking or delivering energy. When the battery pack is fully charged, the engines are switched off and only the battery pack provides the power. At the stops, the EMS only permits the battery pack to provide power until it reaches the minimum SOC.

Results and Discussions

Fuel Consumption of the Propulsion Systems

To determine the power to be delivered by the individual diesel engine for a given propulsion system, the load profile is taken as an input to the systems then the losses of individual component is calculated. The fuel required for the engine to produce the power demand is given by [16]:

$$\text{Fuel consumption} = \int_{ti}^{tf} n\, SFOC_x\, Engpow_x dt \qquad (2)$$

Where ti, tf are the time limits between samples, n is the number of the operating engines, the sub-index x is the sample number, SFOC is the specific fuel consumption of the engine; Engpow is the power delivered by engines in kW. For electric systems the loading is set constant at 80% of the MCR where the value of SFOC is 177 g/KWh.

Fig. 9 shows the estimated fuel consumption of the conventional and electric systems for a reference voyage with the load profile shown in Fig. 5.

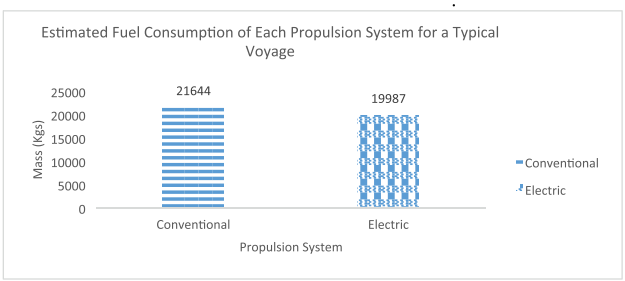


Fig. 9: Estimated fuel consumption for the propulsion systems

The conventional systems consume 1657 kgs more fuel than the electric systems per voyage. The difference in fuel consumption is about 7.66%.

Exhaust Emissions from the Ship Engines

The emissions from the ships that are mostly considered are: Sulphur Oxides (SO_x), Nitrous Oxides (NO_x), and Carbon Dioxide (CO_2)[17]. The NO_x emissions are specific for every engine depending on the power delivered and are given in g/KWh. The quantity of NOX released can be estimated by[13]:

$$NO_x\ released\ = (NO_x\ EF)\ \int_{ti}^{tf} n\ Engpow_x dt \quad (3)$$

Where NO_x EF is the Nitrous Oxides power emission factor in g/kWh$_2$, NO_x released is the total mass of Nitrous Oxides released in grams.

Carbon Dioxide and Sulphur oxide emissions are estimated using fuel-based factors since they highly depend on the quantity of fuel consumed. Moreover, sulphur content in the fuel is another factor that the SO_x emissions depends on. The quantity of CO_2 and SO_x released are estimated as follows[16]:

$$SO_x = (SO_x\ E.F) * \text{Fuel consumption} \quad (4)$$
$$SO_x\ E.F = 20 * \%\ \text{Sulphur cont} \quad (5)$$
$$CO_2 = (CO_2\ E.F) * \text{Fuel consunption} \quad (6)$$

Where SO_x E.F is the Sulphur Oxides fuel emission factor in kg per ton of fuel burned, % sulphur cont is the sulphur content of the fuel as a percentage of the total mass or volume, CO_2 E.F is the Carbon Dioxide fuel emission factor in kg per ton of fuel burned. The Sulphur Oxides and Carbon Dioxide mass is in kg. For each propulsion systems the exhaust gas emissions are calculated assuming the following [4]:

The fuel used is HFO and its sulphur content is set at the extreme percentage allowed by the MARPOL 73/78 Annex VI tier 3, which is 0.5%.

The emission factor of Carbon Dioxide is 3.190 tons per each ton of fuel consumed, regardless of the type of fuel and engine.The Nitrous oxide emission factor is 2.5 g/KWh at 600 rpm whereas the ones at 720 rpm are set to 2.41g/KWh.

Considering the given conditions and the equations, together with the fuel consumption and the performance analysis, the emissions from each propulsion system for a reference voyage are presented in Fig.10 and Fig.11.

The conventional systems produce around 5.3 tonnes, 16 kgs, and 432 kgs more of CO2, SOX, and NOX respectively than the electric system. The CO2 and SOX are proportion to the fuel consumed while the difference in NOX is about 26.6%.

Operational and Maintenance Cost

The O&M expenses are 0.005$/kW for the medium-speed diesel engines and generator [13] while the battery pack is considered to be maintenance-free [18]. Other mechanical or electrical equipment needs the least maintenance, therefore they are not considered. The Operation and maintenance expenses for ten years are presented in Fig. 12.

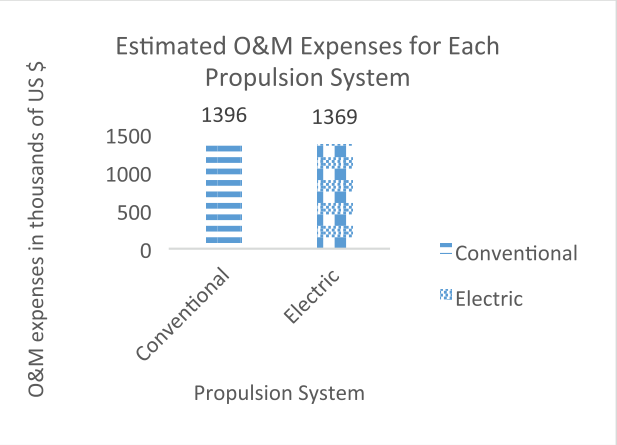


Fig. 12: Operation and Maintenance cost for the propulsion systems

There is little difference in O&M costs between the propulsion systems. The cost of the O&M for conventional systems is about 1.9% more than the electric systems. The difference is mainly because the battery-pack is considered to be maintenance-free.

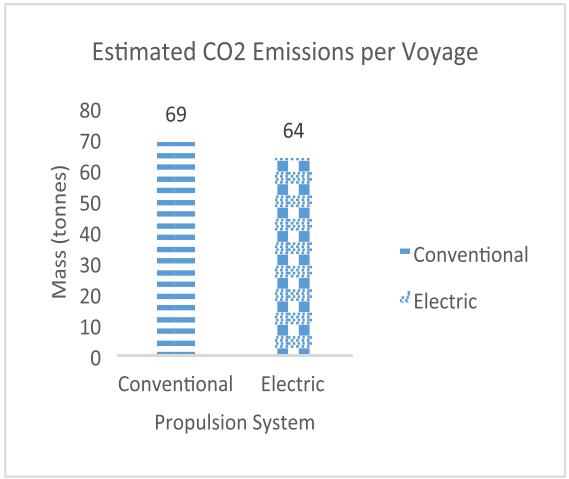


Fig. 10: Estimated CO2 for the propulsion systems

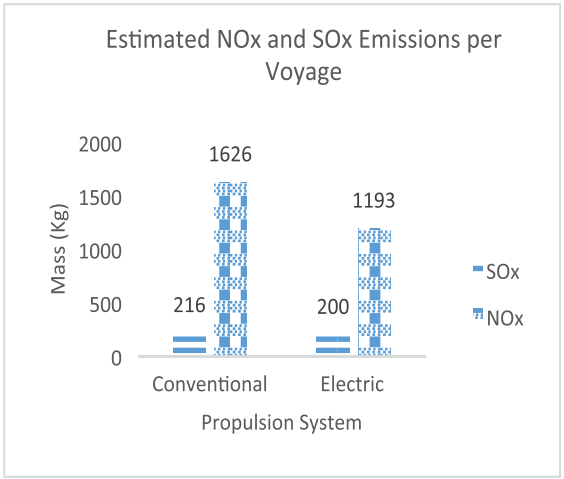


Fig. 11: SOX and NOX for the propulsion systems

The following observations are made from the results obtained:

The main and the auxiliary engines for the conventional systems are under-utilized, thus their efficiency is lowered and fuel consumption rises as illustrated in Fig. 5 and Fig. 9.

Due to the low SFOC, the estimated fuel consumption of the electric systems is considerably lower than the fuel consumption of the conventional systems by about 7.66 % as shown in Fig. 9.

Even though electric systems have higher transmission loss (10%) compare to conventional systems (4%), if properly selected for a particular load profile, it becomes more fuel-efficient compare to conventional systems as shown in this case study in Fig. 9.

The SOx and CO2 emissions are realized to be proportional to the fuel burned. SOx emissions are also dependent on the fuel type. The electric systems produces less SOX and CO2 compared to conventional systems by 16 kgs and 5.3 tonnes respectively as presented in Fig. 10 and Fig. 11.

As for NOx emissions, they are associated with the energy produced by the engines. The electric systems emit less NOx than conventional systems by 432 kg, 26.6%, according to Fig. 11.

Considering the effect of battery pack in combination with diesel engines, they are the best option to reduce the fuel consumption of ships, by maintaining the diesel engines at their optimum point. As a result, the emissions are also minimised as is evident in this case study.

Fig. 12 shows that there's no much difference in the operation and maintenance costs between the systems architectures. For ten years, the cost of operation and maintenance of the electric system is roughly 1.9% less than the conventional system. This is because the operational and maintenance cost depend on the energy delivered by the generator.

Conclusions

The influence of electrifying the conventional propulsion systems of a cruise ship in terms of; design consideration and technical layout of the propulsion systems, the cost of fuel and operation, and the environmental pollutant emissions was investigated based on real data of a referenced voyage. The electric propulsion systems showed a considerable reduction in fuel consumption by up to 7.66 %. This was achieved with the help of a battery pack that maintained diesel engines at their optimum point.

As for the exhaust gases released to the environment per voyage, the electric propulsion systems reduced the sulphur dioxide by 16 kgs and the carbon dioxide by 5.3 tonnes, proportional to the amount of fuel consumed. The NOX emitted by the electric propulsion systems was 432 kgs less than conventional propulsion systems, which correspond to 26.6%. Moreover, the electric systems showed better results in O&M expenses by 1.9% than conventional systems.

Al-Baity – Department of Naval Architecture & Marine Engineering, Faculty of Engineering, Alexandria University, 21544 Alexaandria, Egypt. (oalbaity@tum.ac.ke)

Seddiek – PhD, Vice Dean for Postgraduate Studies & Scientific Research, College of Maritime Transport & Technology, Arab Academy for Science, Technology & Maritime Transport, 1029 Alexandria, Egypt.

ElGohary – Professor, Chairman, Department of Naval Architecture & Marine Engineering, Faculty of Engineering, Alexandria University, 21544 Alexaandria, Egypt.

Embracing Resilience in the World of Industrial Automation

By Josiah Habwe

Digital technology has interrupted and virtually taken over all sectors, including the retail and service industry over the past years. Manufacturing is a fundamental part of the global, regional and national economy. However, last year, manufacturing took a huge hit, thanks to the Covid-19 pandemic. Some plants have had to shift production to help in producing medical supplies. Others have had to close down parts of their operations due to safety precautions. And then there is the impact on supply chains.

Manufacturing matters to us all. Every society needs a stable, regular supply of goods. Therefore, manufacturing needs to be more resilient. For many factories and plants, there is an over-reliance on traditional ways of working, of documenting operational procedures on paper. And when a crisis strikes, these operations cannot adapt.

Speaking to our customers across the region, it is clear how much they have benefited from digitising their manufacturing facilities. By embracing digital as a way of working, manufacturers have looked to improve their efficiency, make their operations faster and more sustainable. What they have appreciated the most this year is how much more resilient their operations have become.

Manufacturers across the globe are digitising their operations to improve plant design, engineering, operations and maintenance. These companies are investing in digitisation to achieve one common goal: increased productivity. Digital transformation brings sweeping benefits to manufacturing.

Manufacturers across the globe are digitising their operations to improve plant design, engineering, operations and maintenance.

Leading industrial organisations pursue digital transformation for five primary reasons, including correction of operational inefficiencies, creation of competitive advantage, elimination of inefficient processes, establishment of a stable IT/OT architecture base and creation of new customer value and new business models.

Digital technology is crucial to not only manufacturing industry, but virtually every organisation needs automation today. Engineers are therefore not excluded, they use digital technology in their everyday operations, including in construction, plant design and operation, architecture, among many others. This technological advancement is at the core of engineering, and many universities locally and globally now offer Telecommunication Engineering and other IT courses to help the professionals tap into this development.

The current wave of industrial transformation is about connecting and enhancing existing systems to achieve a business benefit. For this reason, connectivity platforms such as EcoStruxureTM provide an open framework for enabling new ways to solve business-driven challenges across industries.

Converging the IT and OT space needs domain expertise to drive it – someone who understands the process in the plant. People who know the industry and the customers' processes as well as the technology. As well as providing digital solutions, Schneider Electric provides expertise on both the automation and software sides. For example, our Industrial Process Automation teams work with customers from the basics of measurement and instrumentation, delivering process instruments such as pressure, temperature, level, flow transmitters and valves; to PLC-based Control Systems to optimisation and analytics.

The next practice is the end-to-end integration of industrial and engineering software, to help bring the digital plant to life. The digital thread, which connects the digital twin with real time data produces a holistic and up-to-date view of an asset, which may as well be the complete plant across its lifecycle.

Such integration helps connect people, assets and operations to boost productivity and profitability. And using technology that is built for the future, this model ensures manufacturers get the most out of their industrial operation over its lifetime.

The question is, are you ready to accelerate the pace of your industrial transformation?

The writer is the Director Process Automation at Schneider Electric East Africa
(email: josiah.habwe@se.com)

Exploring the Applicability and Challenges of Implementing Industry 4.0 Technologies in the Small and Medium Sized Industries in Kenya

By Obadiah Burugu Nganga

Introduction

Industrial 4.0 or the fourth industrial revolution represent a major paradigm shift from the previous industrial developments and is touted as the future of manufacturing (Liu & Xu, 2017). The 4th revolution combines the power of computer processing, advanced information technology with intelligent machines and robots (Pereira and Romero, 2017). It is expected to transform the industrial sector by integrating manufacturing activities with cloud computing, digital solutions, big data analytics, robotics, and Augmented Reality (AR). Cyber-Physical Systems (CPS) are at the heart of industry 4.0 and are comprised of a system that gathers real-time data, transfers this to a digital platform where decisions are made and these are relayed back to the machine tools as commands to control the manufacturing processes (Wang et al., 2016; Dalenogare et al., 2018).

Once implemented, industry 4.0 enables mass customization due to flexible manufacturing systems and thereby delivers end-to-end engineering as well as greater customer participation in the design and product development (Wang et al., 2016). Vertical integration is achieved through the combination of subsystems within an organization resulting to reconfigurable machines and equipment's that communicate and coordinate to produce different products under an Enterprise Resource Planning (ERP) system (Dalenogare et al., 2018). Horizontal integration is achieved when intelligent machines in different organizations communicate and coordinate manufacturing processes autonomously (Liu & Xu, 2017; Fonseca et al., 2018). Automated processes increase production efficiency by 40-45% since machines operate autonomously without human error (Wang et al., 2016).

While developed nations have laid proper plans to implement industry 4.0 such as Germany's Industries 4.0/ high-tech strategy 2025 which pioneered this technology, Made in China 2025, Make in India, Society 5.0 in Japan and Manufacturing USA; developing countries are still far behind in terms of industrialization and even lack a well-established communication system to support Industry 4.0 infrastructure (Wang et al., 2015; Kamble et al, 2018). In Kenya, SMEs relies on basic hand tools and intensive human labor for production. Successful implementation of Industry 4.0 by multinational organizations and globalization will result to intensive competition which has big negative impact on local SMEs.

This paper critically evaluates the requirements of industry 4.0 against Kenya's SMEs resource potential to identify potential gaps in implementing the technology. A vendor-based model, to enable Kenyan based SMEs leverage some, if not all, the benefits of industry 4.0 is developed.

Methodology

The qualitative research methodology was applied as most peer-reviewed articles on industry 4.0 provide exploratory information (Creswell & Creswell, 2018). Data was collected from credible peer-reviewed publications in Scopus, Science Direct, Google Scholar, Emerald Insight, and IEEE databases. A total of 50 articles, sampled from a set of 130 articles were reviewed. The inclusion criteria were articles with keywords industry 4.0, key enablers, barriers, smart factory, Internet of Things (IoT), critical success factors, dimensions, components, models of industry 4.0. SMEs data was collected from the Kenya National Bureau of Statistics 2016 baseline survey on SMEs and other local sources (KNBS, 2016). Data were analyzed using qualitative techniques.

Results

Table 1 below shows a cross tabulation of the main requirement of industry 4.0 and challenges faced by SMEs regarding these requirements.

Table 1: Analysis of industry 4.0 requirements against Challenges faced by SMEs

Requirement	Details and requirements	Challenges Faced by SMEs
Knowledge, training, and skill development	Continuous training on industry 4.0, use of smart devices, CAD systems, simulations, IoT and other components of CPS.	SMEs owners and operators have limited knowledge. No documented training on Industry 4.0. Few owners have attended ICT trainings.
Sensors and signal conditioning	Motion, video recorders, vibration, ultrasound, level, temperature, vibration, ultrasound, pressure, infrared, proximity, video, among others.	Most machines tools used by SMEs have no automation and sensors feature. Most SMEs rely on hand tools. Where machine tools exist, they are manually controlled.
Machines / automatic machines/ robots and other manufacturing systems	CNC lathe, milling, shaper, drilling, sheet cutting machine, punching, gear making machines and other manufacturing machines etc	Most SMEs rely on hand tools and simple machines. Production machines are manually operated with limited automation, robots and automated machines are expensive and not affordable
Energy requirements	Industry 4.0 require stable, reliable, and cost-effective electrical energy on a 24-hour basis.	Energy is still expensive. Government committed to reducing electricity cost and adoption of renewables
Communication infrastructure	Fibre optics communication, Wi-Fi, high speed internet services and cellular network.	Fibre optics infrastructure is currently being installed and expanded in Kenya, the communication infrastructure is rapidly developing and can support Industry 4.0.
Cloud computing and cloud-based solutions	Big data analytics, ERP systems, internet services and connectivity, storage databases and IT management.	Available and offered by many vendors in the country. However, SMEs owners lack awareness and specialized training on how to access and use cloud-based solutions and analytics.
Cyber Security Systems	Involves applying systems that protect data and other processes running in industry 4.0 framework/ a good cyber security is mandatory for industry 4.0	Generally, there are many companies providing cyber security products in Kenya. However, they are not affordable to SMEs, lack of awareness among SMEs and there is limited use since most SMEs do not have computers, digital equipment's, or databases.

Discussions

The Kenya SMEs sector employs over 80% of all the working population and represents 98% of all the businesses in the country (KNCCI, 2019; KNBS, 2017). They are a critical driver of the economy contributing 34% of the annual GPD (KNCCI, 2019). Table 1 presents key requirements of the new system in relation to the challenges faced by SMEs.

Knowledge and skills

The attainment of knowledge and skills in multi-disciplinary areas of industry 4.0 is imperative for successful implementation (Moldovan, 2019; Kiel et al. 2017). Key skills include computer literacy, ICT, electronics, mechatronics, optimisation, mechanical and electrical engineering, cybersecurity, software development, simulations, digitization processes, problem-solving, knowledge on ERP systems, CAD/ CAM systems, applications of big data analytics and artificial intelligence, robotics and cloud computing (Kiel et al., 2017). Soft skills encompass project and time management, leadership, design and innovation, communication, understanding national and international languages, decision making, developing competitive strategies, bookkeeping, among others (Moldovan, 2019; Sousa et al., 2018). Considering licensed SMEs, only 33.3 % have a post-high school education and hence more exposed to technical and managerial skills to run a business but no training on industry 4.0. While 42.3% have received some training on the use of IT; there is limited application of ICT equipment for business activities with mobile phones (40.7%), computer (9.5%) and tablets (1.2%) be the most used devices.

To bridge the gap, trainers must provide basic practical training to technicians and craftsmen. This should be followed by more advanced courses that introduce Industry 4.0 concepts and their applications. Such training can be achieved through work-based study, vocational training, short courses on industry-specific software's. Since most models and knowledge on Industry 4.0 emanate from university-based research; collaborations between industry, academia, and the government is essential in the gradual and phased implementation of the new digital paradigm (Sousa et al. 2018; Horvath et al., 2018).

Physical infrastructure

Lack of equipment and the physical infrastructure to implement industry 4.0 is perhaps the greatest challenge facing SMEs. Most SMEs rely on simple hand tools and manually operated machine tools with very low levels of automation (KNBS, 2016). Industry 4.0, on the other hand, proposes the use of robots, autonomous machines, and highly complicated and interlinked factories (Wang et al., 2016; Liu & Xu, 2017). These are expensive and not affordable.

CAD/CAM Systems and Interoperability

The implementation of industry 4.0 cannot be achieved without establishing appropriate interoperability between CAD/CAM systems. Clients and engineers collaborate in the design process producing CAD drawings which are interoperable. These are then changed to machine-readable instructions without loss of data. This requires that engineers, employees, and clients have a high level of digital maturity and understanding (Horvath et al., 2019). This can be achieved through exposure to digital platforms as well as continuous training in graphic design and drawing. Kenyan based SME's however lack basic ICT equipment (only 9.5 % and 1.2% use computers and tablets respectively), knowledge on advanced design and drafting software and basic literacy skills. Most drawings and fabrication done by SMEs do not conform to national and international standards (KNBS, 2016).

Internet, cloud computing, and big data analytics

Cloud computing is operated as an on-demand service to subscribers (García et al., 2018). Services range from data analysis, networking, data storage, artificial intelligence among other services. There are numerous international and national companies offering cloud-based services in Kenya. The increasing ability to access the internet via broadband, Wi-Fi and cheap data-bundles for mobile phone internet access offered by telecommunication companies represent a great leap by the country in achieving faster, cheaper and more reliable access to cloud-based solutions. Kenya Ministry of ICT has many initiatives to support digitization, growth of the internet and cloud-based services. These include the national optic fiber backbone project that seeks to connect all 47 counties, ICT standardization, digital literacy program, use of E-citizen and mobile-based payment for government services and the 630-kilometre high-speed fiber optic cable, at Nadapal (Ministry of ICT, Innovation and Youth Affairs, 2020).

Policies and Implementation Frameworks

The adoption of industry 4.0 implementation framework and policies in developed and developing countries differ considerably (Bogoviz et al., 2019). In the developed countries, there are national wide policies and frameworks for industry 4.0 implementation (Kamble et al, 2018). In the developing economies, most initiatives are not national but implemented at the corporate level (Bogoviz et al., 2019). This is because most lack of institutional capacity, key competencies, and financial backing by relevant public bodies to formulate and implement appropriate strategies. In Kenya, the Kenya Association of Manufacturers in collaboration with oversees development institute (ODI) developed a 10-point strategy in expanding manufacturing in Kenya and increasing jobs using industry 4.0 framework (Banga & Velde, 2018).

Recommendations

Acknowledging that SMEs have serious funding issues, lack basic literacy skills as well as the physical infrastructure to implement industry 4.0; it is proposed that a vendor-based model best suits the SMEs sector for implementation of industry 4.0. Rather than full implementation of industry 4.0, a phased approach with smart factories connected with clients, engineers and SMEs is proposed. Figure 1 below shows a schematic diagram of the system. In this diagram, the vendors are either the national or county government, foreign or local private investor or a private-public partnership (PPP). Several vendors provide industry 4.0 services such as cloud computing, internet services, big data analytics, AI, autonomous machines, robots, software, and simulation packages. Engineers assist SMEs and their clients in the design, simulation, and conversion of CAD drawing to CAM codes. This is followed by production using autonomous or semi-autonomous machines. The vendors charge the SMEs for each service used (Müller, 2018). This could be based on pay – use model where the SME pays for service before using, a pay-as-you-go model where the SME is charged as they use the service or the conventional subscription model where SMEs are actively registered to use vendor services. This model could be used by millions of Kenyans without the requirements for any initial investments and thus promote more youths, jobless Kenyans, and unlicensed SMEs to actively compete with a large organisation as well as multinational companies. Currently, the ministry of industrialization has established 165 Constituency Industrial Development Centers (CIDC) centers where SMEs and youths can fabricate and physically produce goods at a fee (Ministry of Industrialization, Trade and Enterprise Development, 2020). These centers have tools for carpentry, metal fabrication, automotive and construction. Such an infrastructure could be expanded to industry 4.0 production and service centres.

Conclusions

Industry 4.0 has received considerable attention from developed countries as the next frontier in manufacturing and will result to increased production efficiency, manufacturing process optimization, increased flexibility, create more jobs and allow for vertical and horizontal integration of firms. It will also result in high competition both locally and internationally. Developing countries, like Kenya, need to explore ways of implementing this technology or risk being left behind. While SMEs in Kenya account for 98% of all business activities, they face numerous challenges such as lack of machines, energy, ICT equipment and knowledge which makes them disadvantaged to implement industry 4.0 technologies. This work proposes the use of a vendor-based model which bridges the knowledge, equipment, and infrastructure gap faced by SMEs in implementing industry 4.0. Using the model, the vendors establish the regional smart factories that charge a fee to SMEs to use these facilities and other services.

The writer is from the Faculty of Engineering, University Of Auckland (onga581@aucklanduni.ac.nz)

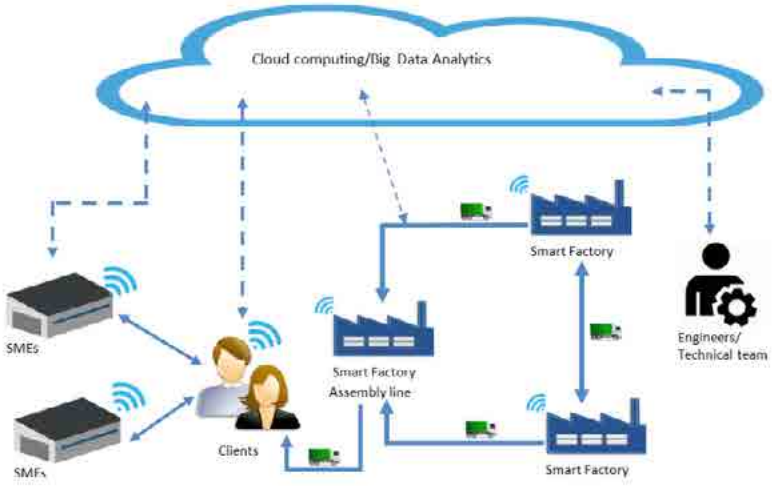


Fig 1: Proposed vendor-based model

IEK creates a path for engineering opportunities beyond borders

> IEK has managed to get the Board of Engineers Malaysia to mentor the Engineers Board of Kenya (EBK) on the application process and how the accord works.

The Institution of Engineers of Kenya (IEK) has successfully lobbied the Board of Engineers Malaysia (BEM) to accept to mentor the Engineers Board of Kenya (EBK) to apply to become a signatory to the Washington Accord. With this accord, EBK will join the International Engineering Alliance, which will enable the rest of the world to understand the qualifications of the IEK members and the services they are able to offer.

The IEK President, Eng Nathaniel Matalanga, says there are many engineering opportunities in Kenya, but a lot more exist beyond the country's borders. However, Kenyan engineers may still not be able to fully grab these opportunities because they are not yet recognized internationally.

With the Washington Accord, IEK members will be able to apply for contracts, consultancies or lecturing opportunities directly using their local certificates and without having to rely on other non-local partners.

Local universities will also have the opportunity to admit international students once their programmes are accredited by the Washington Accord.

"For now, we have no blanket agreement with the international community and opportunities only come on a case-by-case basis. But we have already applied for the accord and things will get better soon," Eng Matalanga said.

He said the IEK has managed to get the Board of Engineers Malaysia to mentor the Engineers Board of Kenya (EBK) on the application process and how the accord works.

Originally signed in 1989, the Washington Accord, is a multi-lateral agreement between bodies responsible for accreditation or recognition of tertiary-level engineering qualifications within their jurisdictions who have chosen to work collectively to assist the mobility of professional engineers.

As with the other accords, the signatories are committed to development and recognition of good practice in engineering education. The activities of the Accord's

signatories include developing exemplars of the graduates' profiles from certain types of qualification and are intended to assist growing globalisation of mutual recognition of engineering qualifications. The Washington Accord is specifically focused on academic programmes, which deal with the practice of engineering at the professional level.

The Accord acknowledges that accreditation of engineering academic programmes is a key foundation for the practice of engineering at the professional level in each of the countries or territories covered by the Accord.

But even without the Accord, says Eng Matalanga, many Kenyan engineers currently work in other countries, especially South Africa and Botswana and they are supported by various international organisations that IEK is part of.

Regionally, for example, IEK is a signatory to the East African Mutual Recognition Agreement (MRA), which recognises engineering qualifications from Kenya, Uganda, Tanzania and Rwanda across the four countries on a reciprocal basis.

The MRA, signed on December 7, 2012 in Arusha, Tanzania, enables professional engineers within the EAC countries to move freely across the common borders without any impediments. This is to facilitate economic integration and increase greater consumer choice of engineering services within the region.

The IEK is also a member of the East African Federation of Engineering Organisations (EAFEO), which played a pivotal role in pushing through the MRA. The current President of EAFEO is Eng Collins Gordon Juma, the immediate Past President of IEK. Then there is the Federation of African Engineering Organisations (FAEO), a continental body for engineers whose objectives include, but not limited to, to establish appropriate standards of engineering education; to support the advancement of knowledge in critical areas required for development; to build engineering resource capacity in every country; and to promote the development of standards of professional engineering practice appropriate for the continent and share knowledge on best practice.

FAEO also represents the interests of all engineering practitioners in Africa at the World Federation of Engineering Organisations (WFEO), of which IEK is also a National member. Eng Matalanga says it is through WFEO that the IEK was able to get the Board of Engineers Malaysia to mentor the EBK on the Washington Accord application process and operations.

"I am an executive council member of WFEO and through this we are able to get global opportunities and share with our members," said the president.

He urges IEK members not to shy away from looking for the many opportunities that exist outside the country and assures them of the institution's support where necessary.

COMPLIANCE WITH ENGINEERS ACT 2011

About the Board

The Engineers Board of Kenya (EBK) is a statutory body established under Section 3(1) of the Engineers Act 2011. The Board is responsible for the registration of engineers and engineering consulting firms, regulation of professional engineering services, setting of standards, development and the general practice of engineering. The development and regulation of engineering practice is a key component in the realisation of the National Economic Agenda.

> Professional engineers are required to hold paramount the safety, health and welfare of the public in discharging his or her professional mandate; ....

Categories of Engineers

The Board Registers Graduate Engineers, Professional Engineers, Consulting Engineers, Accredited Checkers, Temporary Engineers and Engineering Consulting Firms.

Graduate Engineers are fresh graduates from accredited university programmes. To be registered as a professional engineer one must demonstrate achievement of practical experience in the engineering field for a period of not less than three years as a graduate engineer. Consulting engineers must demonstrate the achievement of practical experience as a registered professional engineer for a period of not less than five consecutive years immediately preceding the application.

An accredited checker is a registered peer review consulting engineer. A person registered as an accredited checker is able to evaluate, analyse and review the engineering designs and perform such original calculations with a view to determining the adequacy of the design and compliance with safety requirements.

A foreign person may be considered for registration as a temporary professional engineer if the person is not ordinarily resident in Kenya, intends to be present in Kenya in the capacity of professional engineer for the express purpose of carrying out specific work and possesses the necessary qualifications recognised for the practice of engineering as a professional engineer in the country of origin and was immediately before entering Kenya practising as a professional engineer and holds a valid licence from his country of origin.

An engineering consulting firm may be registered as a sole proprietorship, partnership, limited liability company or foreign firms. Engineering consulting firms are controlled and managed by a consulting engineer with a valid practising licence; a person authorised through a board resolution of the consulting firm to make final engineering decisions on behalf of the consulting firm with respect to the requirements under the Act or any other law relating to the supply of professional engineering services or works for an engineering consulting firm.

Who is a Professional Engineer?

A professional engineer is a registered and licensed engineer who can undertake both professional engineering services and professional engineering works. Licensing is renewed annually for engineers who comply with the requirements set in Engineers Act, 2011 and Engineers Rules, 2019. These set conditions include submission of a continuing professional development certificate issued by the Board and swearing of a statutory declaration confirming that they have not engaged in professional misconduct, and payment of the prescribed fee.

Professional engineering services are engineering services and advice in connection with any feasibility study, planning, survey, design, sketch, drawing, specifications, construction, commissioning, operation, maintenance, supply of specialised engineering equipment and management of engineering works or projects and includes any other engineering services approved by the Board.

Professional engineering works are consultation, investigation, evaluation, planning, designing or responsibility for supervision of construction or operation and maintenance in connection with any public or privately owned utilities, building, machines, equipment, processes, works or projects that requires application of engineering principles and data.

Professional engineers are required to hold paramount the safety, health and welfare of the public in discharging his or her professional mandate; act as a faithful agent or trustee of the employer or client and shall avoid conflicts of interest; uphold and enhance the honour, integrity, and dignity of the profession.

How to Identify a Professional Engineer

Engineers Act and Rules have provided several avenues to identify a validly licensed engineer. The Board is required by the Act to publish in the Kenya Gazette all licensed engineers by March 31 annually. Engineers Identification Card (ID) is the second tool. Engineers Rules mandates the Board to issue every registered professional and consulting engineer with a practising identity card. The engineer is required to carry the practising identity card whenever he is practising and produce it to the Registrar or any designated person upon request. Previously, there was no framework of identifying an engineer other than the use of a licence and certificate which is cumbersome.

The issued engineers' identity cards are smart cards mainly to assist in identification of licensed engineers and help weed out unlicensed persons. The smart card contains the name, passport photo and registration number of the engineer. The details in the smart card can be confirmed by scanning the QR Code to the Board or sending a text message or checking the Boards' website. The card has additional features such as enhanced security, financial convenience in form of financial transactions such as payment for board activities and quicker services offered by the board.

The other important compliance tool is the Engineers Stamp. Engineers Stamp is used for approving or certifying engineering documents, including design calculations, drawings, technical reports and any other engineering documents. A registered engineer is required to sign, date and affix the stamp on any approval or certification given by the engineer. This will help ascertain the ownership as well as the validity of the engineering documents issued by the engineer. The clients should always ensure that any engineering document issued by an engineer has been stamped, signed and dated. The stamps have been procured and the issuing process is ongoing.

Conclusion

Compliance to the Engineers Act, 2011 and Engineers Rules, 2019 is therefore critical for a well-developed and regulated engineering practice for a safe, efficient and effective engineering infrastructure, systems and processes for Kenya; leading to the realisation of the National Economic Agenda.

IEK MEMBERSHIP

IEK has got various membership categories tailored to suit diploma holders to degree holders. These categories are designed to support the advancement of one's profession and becoming a member of the institution is part of it.

By enhancing membership engagement while promoting inclusivity in Engineering, IEK pursues, in the course of implementation of the strategic, efforts to grow membership numbers through various approaches at recruitment. This targets all membership categories as listed below:

a) Fellow – (FIEK)
b) Honorary
c) Corporate (MIEK)
d) Graduate
e) Graduate Technician
f) Graduate Technologist
g) Graduate Engineering Technologist
h) Graduate Engineering Technician
i) Associate
j) Companion
k) Student

In addition, the following are available as temporary membership:

1. Visiting member
2. Temporary member

To improve efficiency of conducting Professional Interviews (PI), the number of panelist has been increased in the previous two years from fifteen (15) to sixty (60). As result of these expanded panels, the frequency of conducting professional interviews has increased and reduced applicants waiting time to less than 1 month.

By January 2021, the institution membership had the following numbers:

S. No:	Class	Number as of April 2020	Accepted May – December 2020	Number by January 2021
1	Fellow	133	6	139
2	Corporate	2,981	115	3,096
3	Graduate Engineer	4,932	540	5,472
4	Graduate Technologist	0	0	0
5	Graduate Technician	0	0	0
6	Graduate Engineering Technologist	0	4	4
7	Graduate Engineering Technician	0	21	21
8	Associate	107	0	107
9	Companion	1	0	1
10	Student	723	146	869
	Total number of members December by 2020			9,709

The institution is geared towards empowering women engineers through the Women Engineers Chapter (WEC), whereby the number of women has increased by 11%.

S.No:	Class	Total number
1	Female	798
2	Male	8,911

The Council is committed to growing the membership by improving ways and benefits of being an IEK member through:

Net working
- Appointment to international engineering organisations (FAEO/WFEO/EAFEO)
- Appointment to government institutions and parastatal boards

Discounted or free publication
- Differentiated (discounted) IEK trainings and event cost

Professional development
- Collaborative opportunities and education
- Professional reference to employers and recommendation letters
- Internship, attachments, mentorship and sponsorship

Seminar and conferences
- Educative seminar on professional courses
- Annual conference

Others
- Lobby for Engineers Scheme of service,
- Prursue common welfare schemes eg savings cooperatives, benevolent funds
- Lobby for increased local content for in projects
- Lobby for appointments of Engineers to lead engineering organisations
- Support mobility of Engineers in the region and internationally through mutual recognition agreement,

Engineers have contributed significantly towards achieving Kenya's Vision 2030 and the Big Four agenda.
All our members practicing both locally and international cover a wide range of the engineering sector: Manufacturing, Agriculture, Water and environment, Roads, Railways, construction and building, power and energy, chemical and processing, instrumental and control, electrical and telecommunication among others.

IEK Council members

ENG. NATHANIEL MATALANGA
President, IEK

Member of Institution of Engineers of Kenya, member of Architectural Association of Kenya – Engineers Chapter, member of Uganda Institution of Professional Engineers, member of Institution of Engineers Rwanda, registered Engineer – Kenya, Uganda, and Rwanda, Executive Council Member of World Federation of Engineering Organizations (WFEO), Hon. Secretary of IEK 2015-2016 & 2018 - 2020, registrar at Architectural Association of Kenya – 2013-2017 and Chairman of Architectural Association of Kenya, Engineers Chapter – 2007-2013

He has over 32 years' experience in the structural and civil engineering design of buildings and surrounding infrastructure. He has hands-on experience in designing and implementing schemes in the Horn of Africa and the Great Lakes Region (Rwanda, Burundi, Uganda, Kenya, Sudan, South Sudan, Tanzania, and Somalia).

ENG. LUCY WANJIKU MUTINDA
1st Vice President, IEK

Member of Prac Committee

Founder & CEO Ecocycle Ltd; Top 40 under 40 Women in Kenya, 2018. She holds a Bachelor of Technology (Production Engineering) from Moi University, a Diploma in Sustainable Business & Responsible Leadership from Swedish Institute, Sweden, a Certificate in International Leadership and Management through GIZ, Germany. She is a Fellow of Launch and Grow - Babson College, Boston; and the Tech-women Fellowship, US, for Women in Science Technology, Engineering & Mathematics (STEM). She is a Mechanical Engineer specialising in "onsite waste water treatment and recycling for reuse technology". She has an experience of over 14 years spanning automotive, software and environmental engineering, and is passionate about environmental conservation, mentorship and philanthropy.

ENG. ERICK OHAGA
2nd Vice President, IEK

Chairman of the Membership Committee, member of Capacity Building and Mentorship Committee

A Fellow of the Institution of Engineers of Kenya and a consulting Engineer with Engineers Board of Kenya. He holds an MSc. in Nuclear Engineering (KINGS), Master of Business Administration, BSc. in Electrical/Electronic Engineering and Post-graduate Diploma in Project Planning and Management. Currently, he is the Director, Nuclear Energy and Infrastructure Development at Nuclear Power and Energy Agency (NuPEA). He previously worked at Kenya Power and Lighting PLC, and rose through the ranks to the position of County Business Manager. He has over 16 years' experience in power system design, construction, contract management, operations, maintenance and planning of power systems. Eng. Ohaga has intense experience in power purchase, contract administration and regional power trade and participated in the development of Kenya's standardised Power Purchase Agreement for Renewable Energy Sources under the Feed-in-Tariff regime. He has conducted grid impact studies for deployment of solar and wind power sources in the National Energy Mix. He is also a full member of the Kenya Institute of Management and class A1 holder of Energy and Petroleum Authority licence and he sits in the national interviewing panel for Electrical Engineers for both IEK and EBK.

ENG. MARGARET NGOTHO OGAI
Hon. Secretary, IEK

Member of Executive Committee, member of Editorial Board, Joint Secretary of Constitution Review Committee, Vice Chairperson of Policy Research and Advocacy Committee and member of Transportation Sub-Committee

Registered as a Consulting Engineer with Engineers Board of Kenya and Fellow of IEK. She currently works at Kenya Roads Board as General Manager Planning and Programming responsible for preparation and monitoring of road maintenance programmes funded by Road Maintenance Levy Fund. She has a Bachelor's Degree in Civil Engineering and Master of Business Administration from University of Nairobi. She has over 25 years' experience in the field of transportation, planning and management gained in both private and public sectors. She is a board member of Women in Water and Sanitation Association. Committed to strengthening corporate governance and enhancing professionalism in engineering practice in Kenya. Also passionate on promoting diversity and inclusivity.

ENG. CARREN A. OYOLLA
Hon. Treasurer, IEK

Chairperson of Welfare Committee, member of Conference Committee

Currently employed at Kenya Urban Roads Authority as Assistant Director Regional Urban Roads Coordination. She is responsible for coordination of regional maintenance programmes funded by Road Maintenance Levy Fund. Registered as a Professional Engineer with Engineers Board of Kenya and Corporate Member of IEK. She has a Bachelor's Degree in Civil Engineering and Master of Project Planning and Management from University of Nairobi. She has over 11 years' experience in the field of highway planning, design and management gained in both private and public sectors.

ENG. COLLINS GORDON JUMA, MBS
Immediate Past President

Events and Conference Committee Chairperson

Chief Executive Officer of the Nuclear Power and Energy Agency and National Liaison Officer with the International Atomic Energy Agency (IAEA). He has worked in the energy sector for over 20 years, including stints at Kenya Power and Kenya Electricity Generating Company PLC (KenGen). He holds a Bachelor of Engineering (Mechanical) and Master's degree from the University of Nairobi. He is currently pursuing a PhD. Eng. Juma is the Vice Chairperson at the International Framework for Nuclear Energy Cooperation (IFNEC). He is also the President of East African Federation of Engineering Organizations. He is a registered Consulting Engineer with Engineers Board of Kenya.

ENG. LINDA OTIENO
CEO, IEK

Engineer Linda is a holder of BSc in Civil and Construction Engineering from the University of Nairobi. She is currently pursuing MSc in Transport Engineering at the same institution. She has over eight years of experience in Highway Engineering and the CEO of IEK.

Her other appointments at IEK include, Member Mentorship and Capacity Building Committee, Member Women Engineers Chapter, Member Young Engineers Chapter.

ENG. DOREEN KIRIMA
Corporate Member, Ordinary Council Member

Member of Young Engineers Chapter, FAEO

Currently works with Kenya Urban Roads Authority as a Senior Engineer. Registered as a Professional Engineer with Engineers Board of Kenya and Corporate Member of IEK. She has over eight years' work experience. She has a Bachelor's Degree in Civil Engineering, a continuing master's student in Civil Engineering (Transportation) at the University of Nairobi and a Diploma in Business Information and Technology from Strathmore University. She is an Associate Lead Expert at the National Environment Management Authority and a member of Young Professionals Forum under the Association of Consulting Engineers of Kenya.

ENG. JUSTUS AUFRIDUS OTWANI
Ordinary Council Member

Chairperson of Policy, Research and Advocacy Committee and Vice- Chair of Alternative Dispute Resolution Committee

A Civil Engineering consultant with 24 years' experience in design and construction supervision of roads in Kenya and South Sudan. He has vast experience in contract management, particularly on the application of International Federation of Consulting Engineers (FIDIC) Conditions of Contract for GoK and donor funded projects. He holds a Bachelor's Degree in Civil Engineering from JKUAT and a Master's Degree in Project Planning and Management from Maseno University. He is currently pursuing a Master's Degree in Transportation Planning at the University of Nairobi. Eng. Otwani is a corporate member of the Institution of Engineers of Kenya (IEK) and Architectural Association of Kenya where he is currently the Vice-Chair of the Engineers Chapter. He was the project team leader and resident engineer for the dualling of General Waruinge and First Avenue Eastleigh road projects in Nairobi as well as the Meru Eastern and Western Bypass road rojects. He served as a Director of the Rural Electrification Authority (now Rural Electrification and Renewable Energy Corporation) from 2015 to 2018 where he chaired the Human Resource Committee of the Board. He is currently the project team leader and resident engineer on the Kakamega–Webuye road project.

ENG. CHRISTINE ADONGO OGUT
Ordinary Council Member

Member of World Federation of Engineers Organization (WFEO) Committee on Engineering and Environment, member of Women in Engineering Standing Committee at WFEO, Chair of Governance Audit and Risk Committee, Chair of Women Engineers Chapter, member of Capacity Building & Mentorship Committee, member of Technical Sub Committee of IEK Conference Committee.

Heads the Safety Audits and Inspections Department at the National Transport and Safety Authority. She made headlines as the first President of Africa Technet, CLGU Africa in 2017, coordinating capacity building for technical officers in Africa. With over 30 years in public sector, she has experience in policy formulation, project planning, road design, contract management and road safety audits. She holds a Master of Science in Urban Infrastructure Engineering Management from UNESCO–IHE Institute of Water, Delft, Netherlands, where she was awarded the Professor Wil Segeren MSc Fellowship. She has a Bachelor of Science in Civil Engineering from the University of Nairobi. As the chair of Women Engineers Chapter, she is passionate about empowering and motivating women engineers for professional development. She has previously held various positions of leadership in the government, including Board Member Public Procurement Administrative Review Board, Director Nairobi Water & Sewerage Company, Manager Roads at Kenya Urban Roads Authority, Chief Officer at Nairobi City County and acting City Engineer at Nairobi City Council.

ENG. GRACE MUTHONI KAGONDU
Ordinary Council Member

Chair of Capacity Building and Mentorship Committee, Vice Chair Events and Conference Committee

Holds a Bachelor of Science in Civil Engineering and Master of Business Administration (MBA), both from the University of Nairobi. Has over 28 years' experience at two consulting engineering firms and a financial institution in the areas of structural engineering, design, supervision, project management, risk management and general managerial responsibilities. She is a corporate member of IEK and Executive Committee member, Association of Professional Societies of East Africa (APSEA). She is also a member of Global Association of Risk Professionals (GARP), corporate member of Architectural Association of Kenya, Engineers' Chapter (MAAK) (E) and member of AAK Board of Trustees. She is a registered professional engineer by the Engineers' Board of Kenya (EBK), and a member of Board of Trustees for Architectural Association of Kenya (AAK).

ENG. GODFREY MARAMBE
Ordinary Council Member

Vice Chairman of Welfare and Diversity Committee, member of Mentorship and Capacity Building Committee

He holds a Bachelor's Degree in Mechanical Engineering, MSc. in Energy Management both from the University of Nairobi, and an MBA from USIU- Africa. He is a registered engineer and corporate member of IEK. A trained and professional Mechanical Engineer with experience in the areas of mechanical and energy engineering in design, procurement and construction project management. He also has a wide experience in the renewable energy and energy efficiency industry, having been involved in more than 100 energy audits, several feasibility studies and several renewable energy projects. He has previously served as a Board Member of the Kenya Green Building Society and currently a Director/Cofounder at Energy Intelligence Africa Ltd. He is also a Board Member of The Nairobi Hospital.

ENG. SHAMMAH KITEME, PE, PMP®
Ordinary Council Member

Member of Mentorship and Capacity Building as well as Policy Research and Advocacy committees

A registered Civil Engineer with Engineers Board of Kenya and a Corporate Member of IEK. Currently a Principal Engineer and Director of Projects at CengProm Services LTD where they offer services as Civil and Structural Engineers, and Project Management services. Holds a BSc in Civil Engineering (UoN), MA in Project Planning and Management (UoN) and currently pursuing MSc in Geotechnical Engineering (DeKUT). Has over 12 years' experience as an engineer, having practised in structural engineering, waste water treatment and storm water management. Is involved in development of design standards and codes as well as capacity building for engineers and engineering in Kenya. Is passionate about advocacy for engineers and their welfare.

Eng. Stanley K. Musau
Ordinary Council Member

Member of Membership Committee

Currently the Director at Schneider Electric. He has a Bachelor's Degree in Chemical and Process Engineering. He has over 17 years' experience with multi-national corporations in areas of process engineering, oil and gas, research and general business management in East, Central and West Africa. He also has interest in charity work and is chair/member of a number of non-profit organisations.

PROF ENG. LAWRENCE GUMBE
Ordinary Council Member

Has a PhD from the Ohio State University, USA, an MSc from Cranfield University, UK, and a BSc from the University of Nairobi, Kenya. He is a professional consulting engineer with the Engineers Board of Kenya. He is also a lead consultant with the National Environment Management Authority (NEMA), as well as a chartered environmentalist in the United Kingdom. He is a member of several learned societies, including Institution of Engineers of Kenya, Association of Consulting Engineers of Kenya, Architectural Association of Kenya, American Society of Civil Engineers, American Society of Mechanical Engineers and fellow at Kenya Society of Environmental, Biological and Agricultural Engineers. He is also a member of American Society of Heating, Ventilating and Air-Conditioning Engineers, American Society of Agricultural and Biological Engineers and Institution of Agricultural Engineers, UK, and a fellow at Kenya National Academy of Sciences. He is currently the CEO of Log Associates, which is a firm of consulting engineers, economists, environmentalists and planners. He currently continues his academic career as a Professor and adjunct professor at the Technical University of Kenya and Kenyatta University, respectively. He has published widely and successfully supervised many masters and doctoral candidates.

ENG. MICHAEL KAMAU MUNGAI
Chair, South Rift Branch

Chairperson of Outreach Services Committee, member of Constitution Review Committee

Currently works with the Geothermal Development Company (GDC) as a Senior Engineer, drilling specialised services. He has over 10 years' experience in the energy sector. His key interests are in future's energy and politics.

ENG. ROSELANE JILLO
Chair, Coast Branch

Eng. Jilo holds a BSc in Electrical and Electronics Engineering from the University of Nairobi and an MBA in Strategic Management (KeMU). She has over 21 years' experience as a seasoned oil and gas engineer. Currently, she is the Senior Electrical Engineer at KPC, Coast Region. At IEK, she is the chairperson of Coast Branch.

ENG. ERICK NGAGE
Chairperson, Western Branch

Vice Chairperson of Governance, Audit and Risk Committee

A corporate member of IEK and a professional Engineer with EBK. He is a full member of Kenya Association of Project Managers (KAPM) and committee member of the East African Society of Sugarcane Technologists (member). Currently, he is the Director of Mechanical Engineering and Transport in the County Government of Kisumu. He holds a BSc in Mechanical Engineering (UoN), MSc in Project Management (JKUAT), Certificate in Practical Operation Management, International Certificate in Sugar Manufacture from Yokohama Kenshu Centre (AOTS), Japan and Robert Antoine Sugar Training Centre (Mauritius). He has core competencies in Project Management, Strategic Planning, Installation and Commissioning, Machine Operations and Maintenance, and Budgeting and Cost Optimisation. He is the Chairman of Infrastructure Committee in Onjiko Boys High School Board of Management, Chairman of Infrastructure Committee at Ahero Girls High School, Chairman of Engineering and Process Division at the Kenya Society of Sugarcane Technologists and member of Process, Research and Marketing Committee at the East African Society of Sugarcane Technologists.

JOIN US IN CELEBRATING THE SECOND

WORLD ENGINEERING DAY

4th March, 2021

Engineering for A Healthy Planet:

Celebrating the UNESCO Engineering Report

#WorldEngDay2021

WFEO-YEFL

ENG. FOR INNOVATIVE TECHNOLOGIES

worldengineeringday.net

WFEO / FMOI