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Incorporating ICT in Engineering Projects Design, a Key Driver towards Post Pandemic Economic Recovery and Growth in Africa- Milestones and Challenges

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Abstract

The world was almost being disintegrated by the COVID 19 pandemic whose peak saw Information and Communication Technology (ICT) based solutions standing out as one of the best methodologies to counter the numerous challenges that were witnessed. These challenges ranged from job losses, reduced accessibility to health services, shutdown of education service delivery, shutdown down of major transportation modes, closure of religious worshipping places and International boarders, reduction in Justice Dispensations among others. ICT is anchored in UN SDG goals 9 and 11, however, a closer look at the other 15 UN SDG goals, shows that ICT is fully needed for full realization. Even though ICT has continuously been embraced worldwide over the years, some notable gaps still exist especially in developing countries. A brief focus on Africa indicates that 18% of the population have no access to a mobile broadband network, despite a 21% increase in 4G coverage since 2020 according to International Telecommunications Union (ITU). These constraints among many others are major impediments to deployment of ICT services in combating the pandemic and spearhead economic growth in Africa. This paper's objectives are geared towards showing how ICT can be incorporated in various Engineering projects designs, using applicable simulation tools and relevant desktop research, for the purpose of achieving UN SDG goals with a clear emphasis on the potential economic recovery and growth benefits for Kenya, East Africa and Africa at large.

Keywords
Economic growth, ICT, Mobile network, Internet, UN SDGs.

1. Introduction
The United Nations sustainable goal (SDG) 9 aims at ensuring that by 2030, there is a robust industry, innovation and infrastructure worldwide. The goal aims at having a reliable, sustainable, resilient, universally accessible and outstanding infrastructure across boarders for enhanced economic development and growth in addition to the well-being of people. The goal also targets achieving an all-inclusive and sustainable industrialization with accessibility to affordable financial credits and markets. This will increase employment opportunities as well Gross Domestic Product (GDP) and to some extent double GDP in the least developed countries. Another target is achieving innovations by focusing on development of sound technological advancements across borders with an enhanced focus on developing countries. Technological advancement is key driver of innovations and this calls for enhanced and diversified domestic and international legal, financial, technological and technical support to developing countries (United Nations).

SDG 11 aims at achieving Sustainable Cities and Communities by 2030. It targets universal and inclusive access to sustainable, safe, affordable basic amenities including housing, health, education, transportation, waste management among others. As this happens, the goal aims at strengthening all efforts to preserve, mitigate and safeguard cultural and natural heritage worldwide as well as prevent occurrence of disasters and vulnerable situations while adapting to climate change. In order for this goal to be achieved, ICT must be embraced at all stages thus calling for technical, financial support as well as capacity building globally by mending the existing bridges. Tjoa and Tjoa (2016) illustrated how ICT has potential in enabling the achievement of SG goals. The study notes that intelligent transportation system, smart power metering systems, electronic platforms for public participation and governance are key ICT aspects that will assist in achieving SDG 11. Tabar and Cilliers (2024) underscored the critical role that ICT plays as a fundamental element in the quest to achieve smart cities and communities as envisioned in SDG 11. The study however noted limitations due to limited or absence of studies on ICT as far as Sustainable evelopment is concerned across developed and developing countries. This need to adopt ICT in all engineering designs for a sustainable development.

SDG 15 focuses on Life on Land. The goal's aim is to ensure global conservation, restoration, protection and sustainable use and management of existing environmental ecosystem (water, forestry, mountains, dryland).This action would prevent the extinction of threatened species. It is evident that the above highlighted SDGs can be achieved through engineering and technological advancements with ICT being the cornerstone. These goals play a critical role towards adaptation to climate change as well as economic recovery.

Inadequate adoption of ICT may hinder the achievement of SDG as noted by Chisika and Yeom 2024. The study recommended that East Africa States must increase awareness and provide access to technology to fasten the journey towards achievement of SDGs.

1.1 Objectives

The objective of this paper is to demonstrate how Information and Communication Technology (ICT) can be incorporated in engineering designs to spearhead achievement of UN SDG goals as well as economic recovery and growth in Africa. In achieving this objective, the paper aims at exploring the milestones made in growth of ICT in the world and the existing gaps that are exhibited in Africa.

2. Literature Review

When the United Nations General assembly (UN-GA) was setting up the SDGs in 2015 to succeed the Millennium Development Goals (MDG), it did not foresee the emergency of COVID 19 pandemic which affected negatively their implementation. COVID 19 was declared a pandemic on March 11th, 2020 by the World Health Organization (WHO) following over 11,800 cases of coronavirus illness in over 110 countries and territories around the world with sustained risk of further global spread. The first case in Africa was reported on 14 February 2020 in Egypt. East Africa countries reported their first cases in March 2020; Ethiopia, Kenya and Sudan on 13th, Rwanda on 14th , Tanzania and Somalia on 16th, Djibouti 18th , Eritrea and Uganda 20th March and Burundi on 31st March (Africa CDC). This resulted to social-economic disruptions taken collectively or individually by countries in the world. Food shortage, Partial or full closure of educational, judicial, religious institutions, cancelation/postponement of numerous events. The most notable effect was closure of industries worldwide which caused numerous loss of jobs.

2.1 Economic impact of COVID 19 Pandemic

Industrial production declined on average by around 28% in G20 countries between February and April 2020. Larger declines of between 40 and 60 percent were recorded in India, Indonesia, Italy and South Africa and relatively small declines occurred in Korea and Russia. However, despite a rebound in activity, industrial production in June 2020 remained well below its pre-crisis level with the exception of China and Korea (ILO, 2020). Various East Africa countries adopted various mitigation measures, which negatively affected the economic progression, in response to the spread of COVID 19: Some of the common measures adopted by East African countries include: (i) Closure of Boarders and Suspension of international flights, (ii) Quarantine, (iii) Limitation (in some cases suspension) of Social, recreational and religious gatherings, (iv) Limitation in Public service vehicles capacity, (v) Closure of learning institutions (vi) Dusk to dawn Curfew for Kenya and Uganda and (vii) Lockdown of some areas in Nairobi, Coast and Northern parts of Kenya.

The above mitigation measures poised an economic hardship to the citizens forcing various countries to adopt other mechanisms to cushion its citizens economically such as, tax exemptions, enhanced tax and debt relief, loan rescheduling among other measures. Despite the measures above, East Africa economies still faced other sectoral economic challenges during the pandemic. World Bank data indicate that the global GDP contracted by 4.2 per cent in 2020 compared to a growth of 2.7 per cent in 2019. This was the general trend in various countries with USA experiencing a contraction of 2.2%, Japan 1.6%, Germany 1.0%, United Kingdom 4.2%, France 3.7%, Italy 6.0%, Canada 5.2% and Russia 11.8%. China on the other hand experienced a growth of 2.9% in GDP during the same period (World Bank).

Similarly, in Africa, the top three economies experienced a contraction in GDP with Nigeria's GDP dropping from USD 448.12 Billion in 2019 to 432.29 Billion in 2020. Over the same period, South Africa experience a drop from USD 387.93 Billion to USD 335.44 Billion. However, Egypt experienced a growth from USD 303.08 Billion to USD 365.25 Billion (World Bank). Table 1 shows East African countries GDP performance since 2015 in Billion dollars.

Table 1. East Africa's GDP performance since 2015 (in Billion USDs): Source: World Bank

Year /Country	2015	2016	2017	2018	2019	2020	2021
Kenya	70.12	74.82	82.04	92.2	100.38	100.67	110.35
Ethiopia	64.59	74.3	81.77	84.27	95.91	107.66	111.27
Sudan	84.99	102.94	129.72	32.33	32.34	26.99	34.33
Tanzania	47.38	49.77	53.32	57.00	61.14	62.41	67.78
Uganda	32.39	29.20	30.74	32.93	35.35	37.6	40.43
Rwanda	8.54	8.69	9.25	9.64	10.36	10.18	11.07
Somalia	5.33	5.53	5.61	5.85	6.48	6.97	7.29
Burundi	3.1	2.64	2.71	2.66	2.58	2.78	2.9
Djibouti	2.42	2.6	2.76	2.91	3.09	3.18	3.37

2.2 Road to Post pandemic recovery

Globally, by 22nd July 2022, cumulatively, there had been 565,207,160 confirmed cases of COVID-19, including 6,373,739 deaths, reported to WHO. As of 18 July 2022, a total of 12,219,375,500 vaccine doses had been administered (WHO, 2022). A look at Africa's data at the same period showed cumulatively 8,713,731 cases, 172, 919 deaths, 8,030,101 recoveries and 510,711 active cases with South Africa reporting the highest in Africa at 45.93%. East Africa data was as: Ethiopia 5.64%, Kenya 3.87%, Uganda 1.93% and Tanzania at 0.42% (WHO, 2022). With this data, the world has been slowly and progressively returning to normalcy with most countries recording growth in GDP in 2021 despite several resurgent waves of increased cases. Post pandemic economic recovery has been top on the list of most if not all the countries in the world. This has been made possible through use of ICT.

2.3 Role of ICT in achieving the UN SDG goals and Economic Recovery

ICT plays a pivotal role in achieving the UN SDG and in particular goals 9, 11 and 15 highlighted hereabove. Innovations, industrial advancements, infrastructure stability has been well achieved by ICT. Worldwide, there have been notable inventions and innovation in ICT that have come in handy way before the setting up on the UN SDG goals. Sustainable communities and cities have been supported fully by ICT. Globally, there's is a tendency of construction of Smart and green Cities which will enable the communities to live enjoyable if not comfortably. Similarly, environmental conservation of fauna and flora has been realized through ICT developments.

2.4 Overview of ICT infrastructure milestones and notable gaps

Despite reduction in various sectors in Kenya, the ICT sector faced some growth during the COVID 19 pandemic according to 2022 Economic survey published by Kenya National Bureau of Statistics (KNBS, 2022). The value of ICT increased by 2.5% although it was slower than the 5.8% experienced in 2019. Mobile cellular telephone and mobile money subscriptions increased by 13% and 9% respectively. Mobile commerce transactions grew by 35% majorly due to preference of cashless transaction during the pandemic and reduced tariffs. Internet subscribers grew by 7.81% points to 91.19% in 2020. Number of Internet service providers grew to 366 up from 302 in 2019 due to working from home and virtual transactions of business and other social events. This led to utilization of 49.5% of available bandwidth up from 43.5% in 2019. Digital TV subscribers and online newspaper visitor increased by 7.2% and 28.0% (KNBS, 2022).

2.5 Internet usage

Global statistics obtained from International Telecommunications Union (ITU, 2021) indicate that usage of internet increased during the pandemic from 54% (4.1 billion) in 2019 to 63% (4.9 Billion) of world's population in 2021. This is due to the fact that Internet remains a major player in working, learning, accessibility of basic services as well as keeping in touch. However around 2.9 billion of world's population remained offline as of 2021 ITU statistics majority of whom hail from developing countries. In Africa, internet use has been on the rise from 2019 and as of 2021 it stood at 33% of the population. This growth is significant since it will reduce the gap between the most and least connected countries in the world (ITU, 2021). Figure 1 shows global internet usage between 2015 and 2021.

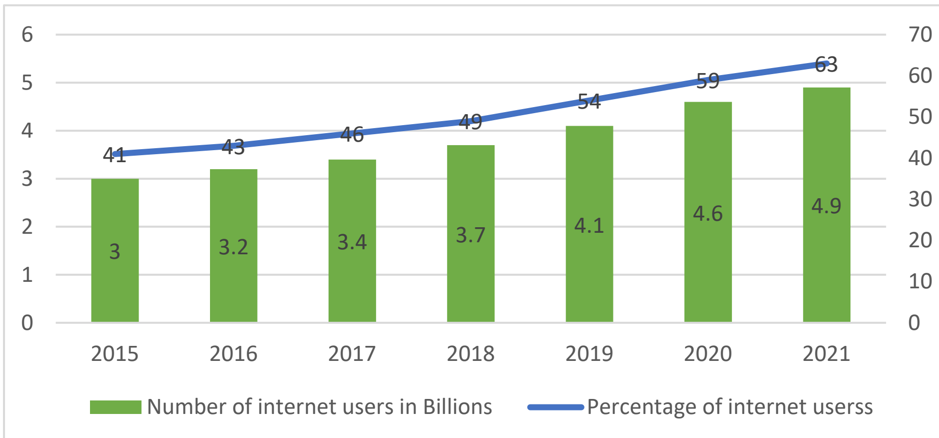

Figure 1. Internet uptake in the world (2015-2021): Source: ITU

Yang et al. (2020) underscored the use of ICT amongst various stakeholders like Governmental and Non-Governmental Organizations (NGOs) in responding to COVID 19 globally. Increase in Online service delivery, businesses, educational activities, inquiries, consultations as well as entertainment and arts was witnessed. With these observations, one can suggest that ICT was one of the key players in fight against COVID 19, reduction of economic constraints during the pandemic and as well as one of the enablers in economic recovery post pandemic. This calls for enhancement of ICT infrastructures, policies, standards and resources for full realization of the UN SDG goals and economic recovery.

2.6 Mobile broadband

Statistics (Table 2) show a significant coverage of mobile broad band signal to the entire world population with an increased 4G network coverage since 2015.

Table 2. Global Mobile brand band coverage (2015-2021): Source: ITU

Year	2015	2016	2017	2018	2019	2020	2021
2G (%)	17	11	8	6	4	3	2
3G (%)	35	20	13	11	9	9	7
4G (%)	43	64	75	80	83	85	88

In 2021, 95% of the world's population had access to internet due to availability of 3g and 4G, leaving about some 390 million people worldwide not covered by a mobile broadband.

Also, 18% of Africa's population was not covered by 3G or 4G thus could not access internet. There is need to enhance internet coverage with installation of advanced mobile technologies like 5G in Africa and developing countries. This will speed up the process of fighting outbreaks that may arise in future.

Advanced mobile technologies was used to fight COVID 19 pandemic and could be used for exploration of various aspects beyond the pandemic. Transmission of medical data, vital signals, detection, diagnosis, tracking of quarantined individuals and their contacts, commerce and mobile learning education systems could be explored through use of advanced mobile technologies (Chin and Chang 2023).

Furthermore, mobile applications were remodeled and developed for use in combating COVID 19. Anyanwu et al. (2021) demonstrated how an existing hospital mobile application was adapted for use in remote communication between a doctor and a patient thus reducing contact and maintain social distance protocols.

2.7 Bandwidth Usage

The global bandwidth usage in 2021 increased by approximately 29% having increased by a similar margin from 2019 to 2020. Even though Africa's usage of bandwidth is negligible when compared to global economies, available data from ITU indicate that during the pandemic, the usage doubled from 10 Tbits/s in 2019 to 20 Tbits/s in 2020 followed by an increase of 10% in 2021 (Table 3).

Table 3. Global Bandwidth usage in Tbits/s (2015-2021): Source: ITU

Year	2015	2016	2017	2018	2019	2020	2021
World	156	214	292	406	559	720	932
Asia Pacific	53	79	124	175	247	312	403
Americas	39	47	52	71	101	135	180
Europe	49	56	61	86	120	152	204
Arab	6	8	13	18	24	32	50
Africa	2	2	5	7	10	20	22
Others	7	22	37	49	57	69	73

2.8 How can ICT be incorporated in engineering designs

The world is currently experiencing the fourth industrial revolution dabbed as industry 4.0. The revolution has led rapid changes in technology, manufacturing, engineering, health sector and processes in this century. This has been made possible due to enhanced internet connectivity, need for smart cities, innovation, green energy, adaptation to climate change as well as Automation and artificial intelligence. Paudyal and Prakriti (2016) demonstrate how ICT is used in engineering construction projects, ICT plays a critical role at all the stages and ensures cheaper, faster and seamless flow of information amongst various stakeholders as shown in Figure 2.

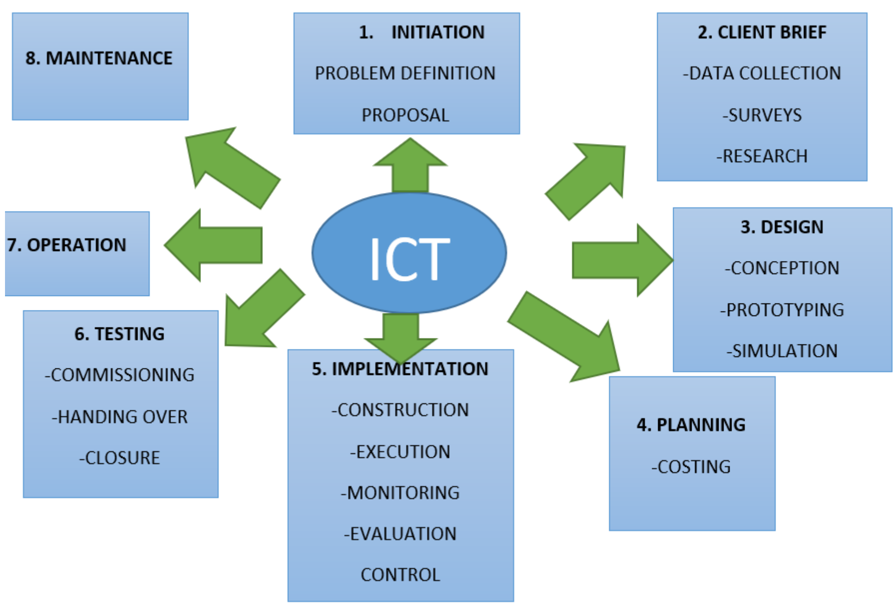

Figure 2. ICT incorporation in construction Project stages

At the design stage, various design, programming, modelling and simulation tools like CAD, Revit, BIM, SAP, STAAD, Matlab, solid works, internet applications that are anchored on ICT are majorly used to develop and visualize solutions that are capable of solving the problem defined and realizing client aspirations envisioned in the previous stages. At the construction stage, ICT can be used in the following processes, batching, compaction, curing etc. (Paudyal and Prakriti 2016). During operation and maintenance, ICT tools like PLCs, SCADA, BMS, play a major role especially in supervision, generation of reports, fault prevention and finding, efficiency and management.

3. Case Study and Methodology

In order to illustrate how ICT continues to play a critical role in engineering designs, I focused on a recently designed project in Kenya that is at procurement stage. The project is a modern green building facility for training and capacity building in Kenya's Smart (innovation) City, Konza Technopolis, an ICT hub, which is under development. Phase 1 of the project, which will host warehouses, industries, incubators, workshops, prototyping training and capacity building facilities, upon completion is projected to generate 17,000 jobs and contribute over USD 1 billion to Kenya's GDP.

The Electrical Engineering Services for the project included:

i) Electrical installation works

This entailed use of energy efficient, smart, automatic lighting system using PIR sensors for switching, Photocells, Timers and LED light fittings. Automatic Voltage Regulators was incorporated to ensure protection from voltage fluctuations. Surge arrestors, Automatic Changeovers, power factor capacitor banks and smart switchgears were also considered. UPSs were considered for critical loads to ensure continued supply of power during changeovers. Konza City boasts of reliable power supply with the ongoing construction of a 400-kV substation. The sources of electrical power considered for the project were: Mains supply from electricity grid, solar power and Standby generator. Lighting protection system as per IEC62305 was also considered.

ii) Security systems installation works:

This entailed modern day high resolution (4K) CCTV camera's with Artificial Intelligence analytics including but not limited to face, detection, motion detection, fog detection, directional detection, object counter, social distance detection, behavioral observation, audio/sound detection and classifications, Auto/Auto tracking of objects or persons, smart Auto notifications of Alarm events via emails, phone, SD card, redundant memory slots at the individual cameras. The access control system was designed to regulate movement of persons using door access control systems and pedestrians' access control and scanners (luggage, people) and vehicles using smart vehicle packing system whose simulation results have been shared herein. The packing smart system was designed to have under vehicle surveillance systems, gate barriers, Automatic hydraulic bollards, CCTV camera with number plate recognition, parking slots display.

iii) Renewable Energy installation works

This involved design of a 242 KW solar system incorporating Solar Photovoltaic (PV) panels, inverters, charge controllers and other accessories. Batteries (storage) was not considered due to high capital and maintenance costs. Stand-alone solar light fittings were designed for external lighting.

iv) Lift Installation works

This involved design of 6 No. passenger lifts as per BS EN 81-20: 2014 and BS EN 81-50: 2014. Access control and other security systems were incorporated in the design.

v) Voice and data.

The works considered for this design were: Structured cabling, IP telephony system, networking equipment, data center, and network/information security.

vi) Fire detection, alarm and Emergency Evacuation system

The design considered sensors/detectors, actuators and sounders as well as Control and processing panels as per BS 5839 Part 1:2017. The voice evacuation system was incorporated to the Audio-visual system.

vii) Audio visual

The design involved recording systems for podcast sessions, Smart classroom equipment including interactive digital electronic podium/lectern, interactive digital screens, multipoint displays and digital signage for exhibitions, teleconferencing equipment, virtual and augmented reality.

viii) Generator

The design considered a total of 3 No (100KVA, 350KVA and 500KVA) generators. 100 KVA generators was dedicated to emergency services like firefighting and evacuation whereas the 350 KVA and 500 KVA was synchronized to supply power depending on the demand as illustrated in the simulation results shown in Figures 6,7,8 and 9.

ix) BMS

The Building management system was designed to assist in energy efficiency, conservation and management and maintenance. The system was majorly designed to integrate all mechanical (heating, ventilation, air conditioning, fans, pumps, gas system, tanks, firefighting, water meters etc.) and electrical (Lifts, generators, Distribution boards, HT& LV boards, Energy meters, UPSs, AVRs, Fire alarm, Parking system, Power supply system, solar PV system, Security systems) systems into a centralized operation, supervision, monitoring and maintenance system. The major components of the system included: controllers (DDC, networks, IO modules, field devises (sensors), monitoring Software and hardware (server, PC workstations, Display) and associated cabling as per IEC 62443 standard.

In the design of these 9 electrical engineering services, ICT played a critical role. Virtually all the specifications were anchored on how ICT could be integrated. Most if not all the components had a requirement of being incorporated to the Building management system thus making it a Smart building with affinity to green energy. Due to the standards and regulations associated with smart cities globally, various design, modelling and simulation tools including but not limited to CAD, REVIT, and PLC were used to visualize the client requirements. In the end the optimized design, modelling and simulation outputs were able to get approval for planning and costing.

For the illustration purposes, this paper focuses on two critical services that were simulated; Parking management system and Power supply system. In doing the simulation of these systems, logics were fed in the simulation tool (Codesys the IEC 61131-3 programming system) for visualization and results optimization. The packing management system was designed to control vehicle entry, exits and display of available packing slots. The project was designed to incorporate three power sources: Solar power, Main supply from Kenya Power Company Limited and two synchronized generators of 350 KVA and 500KVA. Figures 3 to 5 shows example of illustration diagrams for power supply system and Vehicle parking system and a sample of Logics.

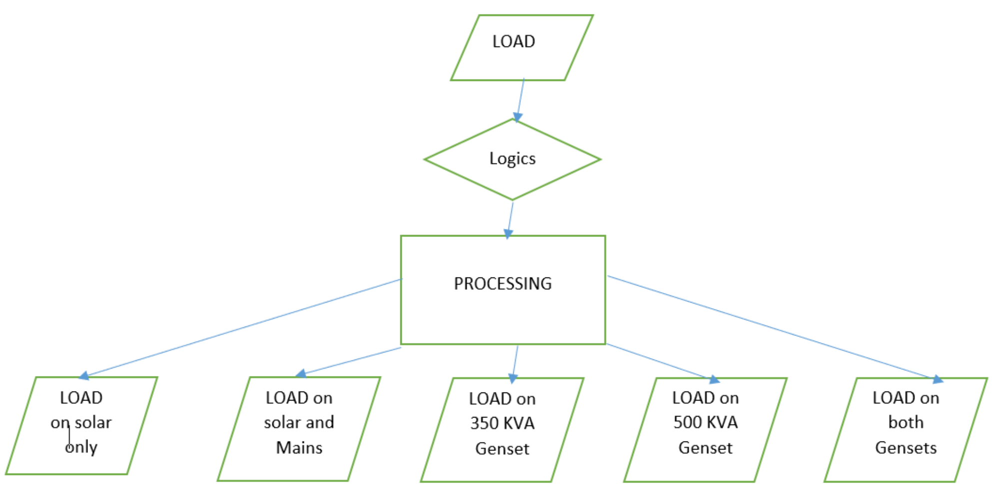

Figure 3. Power supply illustration diagram

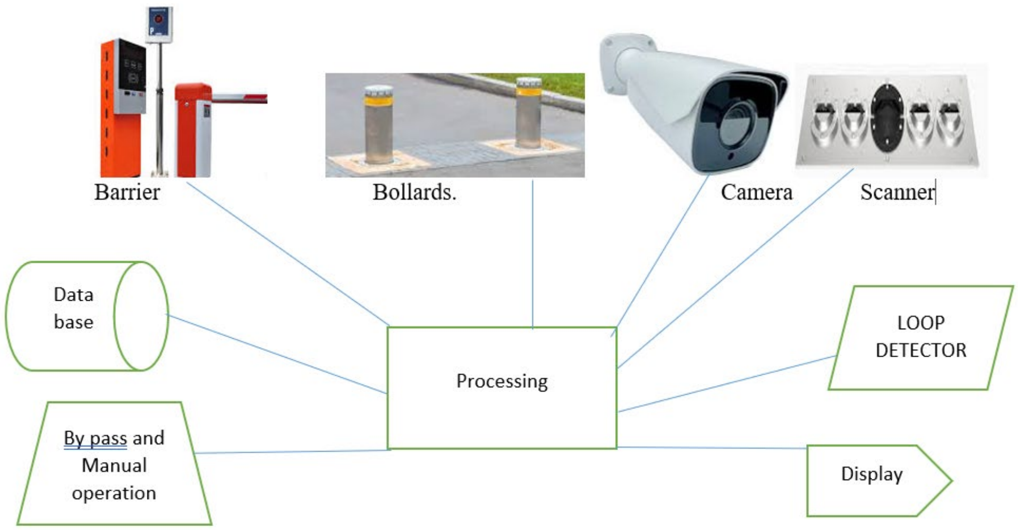

Figure 4. Parking system illustration diagram

```
PROGRAM  PLC_PRG
VAR
    System :  BOOL ;
    Stop :  BOOL ;
    Start :  BOOL ;
    SolarPower :  BOOL ;
    KPLC :  BOOL ;
    Generator :  BOOL ;
    G_1 :  BOOL ;
    G_2 :  BOOL ;
    G_3 :  BOOL ;
    Photocell :  BOOL ;
    Black_out :  BOOL ;
    wattage_load_meter :  UINT ;
    load_wattage :  BOOL ;
    solar_contactor :  BOOL ;
    main_supply_contactor :  BOOL ;
    main_supply :  BOOL ;
END_VAR
```

Figure 5. Power supply system logics

4. Results and Discussions

From the Figures 3, 4 and 5 above, we were able to visualize using the PLC ladder diagrams the operation of the parking and power supply systems for the project with all safety measures in place. For the Power supply, the solar PV system (without battery storage) was the primary supply mode during the day. In absence of solar PV system, the system switches to Main supply from Kenya Power Company limited. The two standby generators were synchronized to operate depending on the load demand. The simulations was able to demonstrate how switching could be done between these power sources as shown in Figure 6 below. Primarily, the main source of power during the day was designed to be solar with an optional supply from Kenya Power and two generators, depending on the load demand. At night, the main source of power was designed to be from Kenya Power with standby generators.

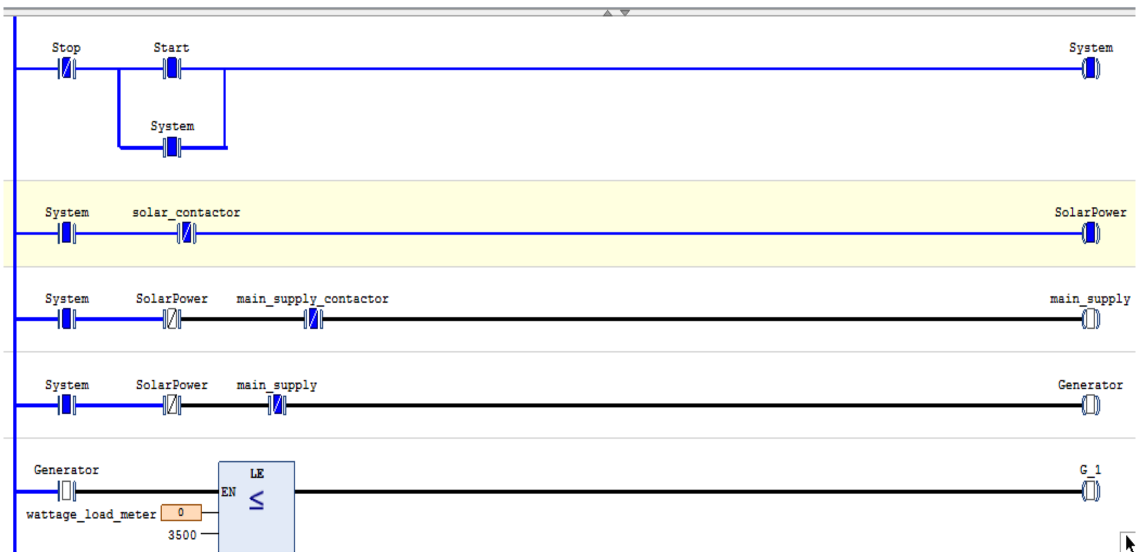

Figure 6. Simulation results of power supply system when using power from Solar

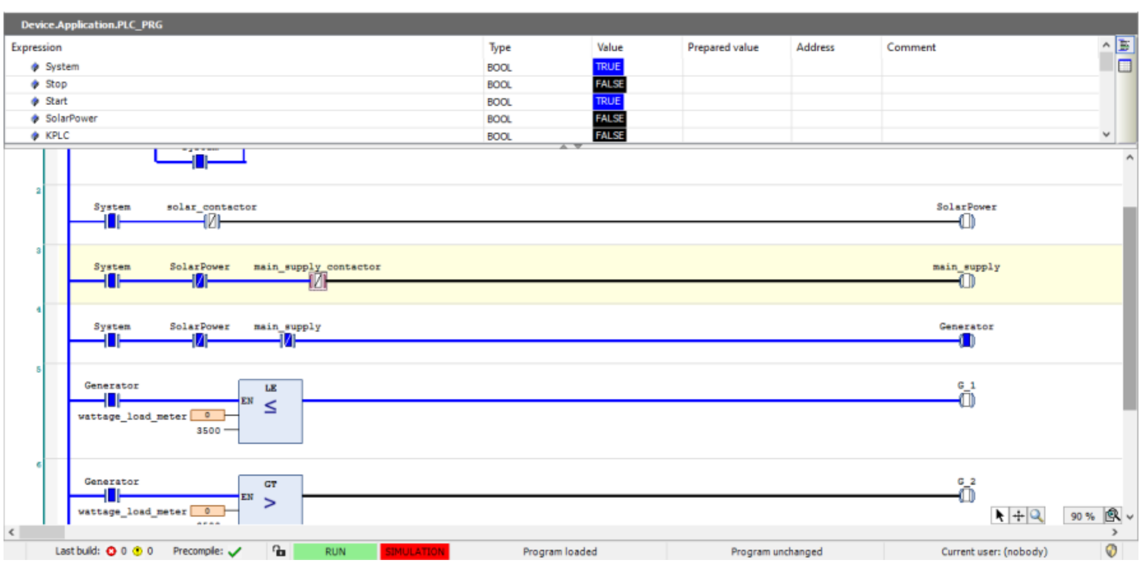

Figure 7. Simulation results of power supply system when using power from 350 kVA Generator

In Figure 7 above, the system is using power from 350 kVA Generator. This implies that power is unavailable from solar, and Kenya Power and the load demand is less than 350 kVA. This scenario is likely to take place at night since the solar system was not meant for or storage.

The simulation of Power supply system was based on assumption that the load will be adequately balanced, there would be reliable supply of power from Kenya Power and there would be sufficient sunlight to provide required power levels. These limitations pose a challenge of simultaneous use of power from two sources like Solar and Mains supply from Kenya Power.

The simulations for the packing system as shown in Figure 8 below demonstrated how the system senses the available parking slots, displays them promptly when the vehicle arrives or exits the premises while capturing the number plate registration details of the vehicle and transferring them to the Data storage. The tool illustrated the system's override and idle mode mechanisms especially during failure, emergency or maintenance. The system was also designed to be user friendly since the users only interact with system thrice during entry, online payment via mobile phones and exit.

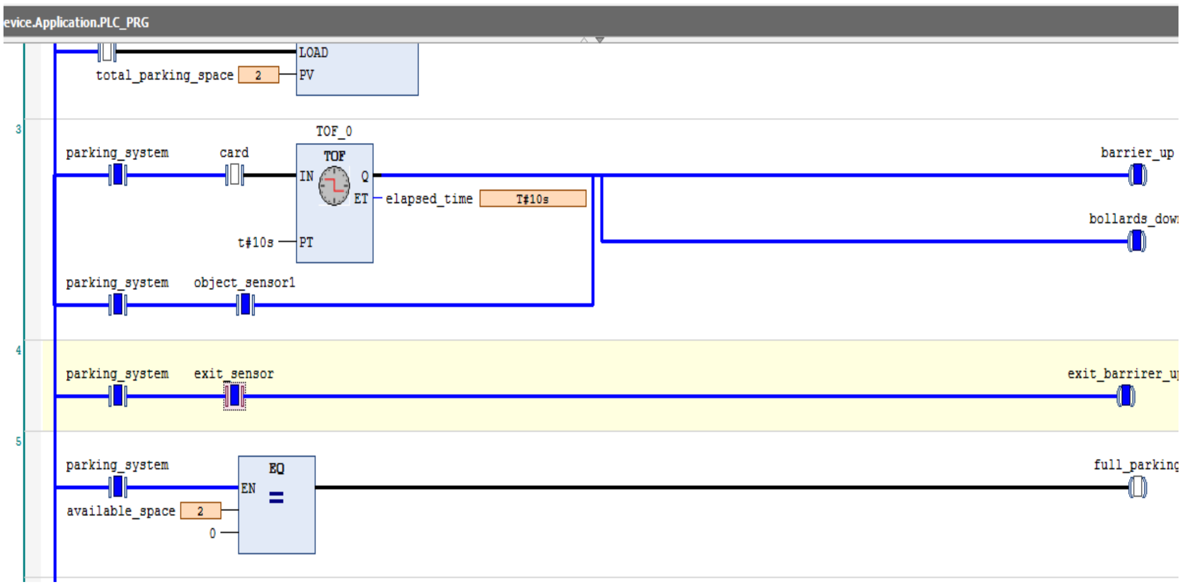

Figure 8. Simulation results of vehicle parking system

5. Conclusion And Recommendation

In order to achieve the UN SDG goals, ICT has to be applied at all stages of Engineering designs. Despite the existing gaps and variance between ICT deployment in Africa and the rest of the world, there is need for Africa to fully embrace ICT and the fruits that come with it. Engineering professionals are the heartbeat of this dream and we should be number one on the list. Incorporation of ICT in engineering designs as demonstrated above will yield optimum results and will save the client some significant costs. Engineers should embrace ICT in all their designs for the benefit of Africa and the entire world. This paper recommends the use of ICT in all engineering designs especially in modern day designs of green buildings. The paper also calls upon the nations and the entire world to close all the existing gaps in the ICT sectors despite the milestones made. This will lay down a solid foundation for enhanced application of ICT in economic recovery, Growth and combating effects of climate change as well as any unforeseen pandemic(like COVID 19) that may arise in the future. The simulation results above were able to bring out the visualization of how technology will be used in energy management system and parking system. The results have demonstrated the important role played by ICT in running systems. Further exploration of the study can be enhanced to include various aspects of the systems especially uncertainties and unreliability in mains power supply, system maintenance and increased load demand.

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Biography

Joel Nadebu Ouma is an Electrical Engineer with a solid record of accomplishment of over 9 years of experience in design and construction of Electrical, Telecommunications and Energy projects both in Public and Private sectors in Kenya. Eng. Nadebu is currently working at State Department for Public Works as a Senior Superintending Engineer and is responsible for design, documentation, supervision and management of government projects in the Built environment. He's interested in Building Automation, Artificial Intelligence, Energy Management and Telecommunications. Eng. Nadebu is a registered and licensed professional Engineer by Engineers Board of Kenya (EBK) and a corporate member of Institution of Engineers of Kenya (IEK).