Beyond Energy Access:

Reliability, System Losses, and Utility Sustainability in African Power Systems

Venue: Loughborough University, United Kingdom

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Hosts: Modern Energy Cooking Services (MECS), Climate Compatible Growth (CCG), Strathmore School of Computing and Engineering Sciences (SCES), Yale Research Initiative on Innovation & Scale (Y-RISE)

Chair: Prof. Ed Brown (Loughborough University / MECS)

Authors: James Miano Wanjiru and Anne Wacera Wambugu - Strathmore SCES

Co-author & Editor: Prof. Ed Brown - Loughborough University / MECS

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Executive Summary

Across much of sub-Saharan Africa, the binding constraint on the electricity sector is no longer the connection. It is what happens after the connection is made. Kenya has electrified approximately 76% of its population, yet consumption per connection remains low, operations and maintenance costs continue to rise, and the utility is financially strained. The workshop convened at Loughborough University on 21–22 May 2026, brought together electricity utilities, energy regulators, academic researchers, and private investors from across Africa, the Caribbean, and the United Kingdom to examine why, and what can be done about it.

The discussions that took place during the workshop showed that unreliable and poor-quality supply suppresses the productive demand that would otherwise materialise. Businesses invest in fewer appliances, commercial and industrial users install backup generation, and households continue to cook using biomass and LPG despite holding a grid connection. Observed consumption therefore understates real demand, and planning built on historical consumption entrenches the constraint it should be relieving. Suppressed demand and system losses together starve utility revenue. Kenya Power's total system losses stand at 22.07% against a regulatory threshold of 16.50%, a gap worth approximately KES 7.8 billion (~GBP 44.96 million) per year in unrecovered costs. A utility in that position might struggle to fund reliability investment that would unlock the demand.

Breaking the chain requires visibility that aggregated loss statistics do not provide. Power factor degradation, harmonic distortion from non-linear loads, and transformers operating at 20% of rated capacity alongside others in overload are each material contributors, and each is obscured at the system level. A diagnostic programme launched in April 2026 — covering 19,612 transformers in the Nairobi region, with a national audit of approximately 83,626 planned — combines feeder and power quality monitoring, smart meter analytics, geospatial and satellite-based analysis, targeted field inspections, and load fingerprinting to disaggregate these drivers and generate the evidence base for regulatory reform.

On the demand side, electric cooking (eCooking) offers the most immediate route to higher consumption from the existing customer base: transitioning one million households would add at least 1 GW of load. That opportunity is conditional. eCooking demand coincides with the 18:00–22:00 system peak, and the networks and premises wiring carrying it must be capable of doing so. Underpinning all of this is a modelling gap. Frameworks derived from contexts with different network conditions, regulatory environments, and consumption behaviours do not capture suppressed demand, uneven feeder loading, or localised power quality problems. Locally grounded, operationally validated models supported by high-resolution data are a precondition for sound planning, regulation, and investment, not a refinement of it.

1. Introduction: Moving Beyond Energy Access

On 21 and 22 May 2026, Loughborough University hosted the Powering Productivity in African Grids workshop, bringing together participants from electricity utilities, energy regulators, academic institutions, development finance institutions, and the private sector across Africa, the Caribbean, and the United Kingdom.

The workshop was convened by Modern Energy Cooking Services (MECS), Climate Compatible Growth (CCG), Strathmore School of Computing and Engineering Sciences (SCES), Yale Research Initiative on Innovation & Scale (Y-RISE), and was chaired by Prof. Ed Brown (Loughborough University/MECS).

The two-day programme covered electricity reliability and its economic consequences, system losses and power quality diagnostics, utility sustainability and bankability, electric cooking as a demand-side opportunity, regulatory frameworks and capacity building, and the need for locally grounded energy planning models. Participants shared findings from ongoing research, operational experience from utilities and regulators across multiple countries, and perspectives from development finance and the private sector.

Kenya, the focus for much of the discussion, has made significant progress in expanding electricity access, with approximately 76% of the population now connected to power. This reflects a broader trend across Africa, where grid extension, mini-grid deployment, and off-grid technologies have improved electrification rates and positioned energy access as a key indicator of development progress. However, improved access alone does not automatically translate into reliable power systems, productive economic activity, or financially resilient utilities.

Prof. Ed Brown (Loughborough University/MECS) opened the workshop by emphasising the value of multi-stakeholder dialogue in addressing electricity sector challenges. Solutions that appear effective from one perspective may create unintended consequences elsewhere in the system. For example, adding new electrical loads at peak load may increase electricity sales while simultaneously increasing grid stress, contributing to outages, deteriorating service quality, and ultimately causing demand suppression or grid defection. More systematic conversations across utilities, regulators, treasury officials, modellers, economists, technology adoption specialists, and researchers are, therefore, essential to ensure alignment.

> *We need to move the energy agenda in the Global South from access alone (connections) to questions of utility viability, service quality, and socio-economic impact.*
>
> **Prof. Ed Brown, Loughborough University / MECS**

A key challenge facing many low-and-middle-income country (LMIC) settings is low productive electricity demand. In high-income countries, utilities benefit from dense, diversified demand bases, including commercial and industrial (C&I) users and households with high appliance penetration, which generate sufficient revenue to cover operations and maintenance, system expansion, and capital repayment, as well as investment in decarbonisation. In much of sub-Saharan Africa, the situation is different. While electrification rates have increased, electricity consumption per connection often remains low, limiting utility revenues while operations and maintenance costs continue to rise. In this context, discussions highlighted the importance of expanding productive electricity use, including through technologies such as electric cooking (eCooking).

> *We should not be financing energy access initiatives without taking into account the opportunities for electric cooking*
>
> **Prof. Ed Brown, Loughborough University / MECS**

An electricity system may therefore achieve high connection rates while still experiencing significant challenges, including frequent outages, voltage instability, poor power quality, tariff inefficiencies, high system losses, and low utility cost recovery. The sections that follow outline the discussions that occurred over the two days of the workshop which examined each of these challenges in turn, and the institutional, regulatory, and analytical reforms required to address them.

2. Reliability and Suppressed Demand

2.1. Reliability as an Economic Driver

To understand the economic impact of electricity reliability, preliminary findings from an ongoing study led by Prof. Ahmed Mushfiq Mobarak, Dr. Eric Hsu, Prof. Mitchell VanVuren, and Anne Wacera Wambugu (Y-RISE, Strathmore University) were presented.

The study compares businesses located in otherwise comparable neighbourhoods that experience persistently different levels of electricity reliability, allowing researchers to isolate the role of reliability in shaping economic outcomes.

> *Preliminary findings suggest that businesses operating in areas with more reliable electricity tend to own more appliances and productive equipment, and pay higher commercial rents compared to those on the less reliable side.*
>
> **Dr. Eric Hsu, Y-RISE**

Reliability was identified as an important prerequisite for realizing the benefits of electrification.

> *Access to electricity alone may not generate the expected economic benefits if users cannot rely on a consistent and stable supply of power.*
>
> **Dr. Eric Hsu, Y-RISE**
>
> *Electrification of production and consumption becomes harder when the electricity supply is unreliable.*
>
> **Prof. Mitchell VanVuren, Y-RISE**

Unreliable electricity imposes costs beyond immediate outages. Persistent power interruptions, voltage instability, and poor power quality may discourage long-term investment, reduce appliance adoption, and increase dependence on alternative energy systems.

To justify investments into a more reliable grid, quantification of these challenges is needed, which is the aim of the reliability project. Prof. VanVuren and Dr. Hsu noted that comparisons cannot be taken at face value due to potential spillovers and highlighted that a structural model is being developed to adjust for them and estimate the aggregate impact. Reliability should, therefore, be treated as a foundational component of mechanisms designed to enhance the impacts of electrification on long-term socio-economic transformation.

2.2. Suppressed Demand

Conventional electricity planning models often interpret observed electricity consumption as a direct indicator of underlying demand. However, workshop discussions highlighted that electricity demand is strongly influenced by supply quality and reliability. Where service quality is poor, grid-connected consumers may adapt by shifting energy use away from the grid. Commercial and Institutional users may invest in backup diesel generators or solar systems, while households may continue relying on LPG, biomass, or standalone solar systems despite having grid connections. Others may choose to relocate or reduce electricity-intensive operations.

As a result, electricity sales may not necessarily reflect the real economic demand for electricity. Instead, they may reflect suppressed or displaced demand arising from unreliable service. If utilities rely primarily on historical consumption data, without accounting for latent demand suppressed by poor reliability, future infrastructure investments may underestimate the actual productive demand that could emerge under improved service conditions.

Participants further noted that the electrification of productive sectors or additional loads (e.g., electric cooking, electric vehicles, data centres) becomes increasingly difficult when electricity supply is perceived as unreliable. In this way, poor reliability not only affects current electricity use, but may also suppress future demand growth and broader energy transition goals. Unreliable power supply thus creates the risk of planning future electricity systems around historically constrained demand rather than future productive potential.

3. System Losses and Power Quality

Kenya Power's total system losses and the distribution network's power quality challenges are closely linked: system losses reduce utility revenue, while poor power factor and harmonic distortions accelerate equipment degradation and widen the gap between energy generated and energy billed. The two are also linked in the opposite direction, in that the behaviour of loads connected to the network determines much of the loss the utility carries, and therefore much of the cost the consumer eventually pays.

Better load behaviour means reduced system losses, which means lower utility costs, which means fairer tariffs, which means higher consumer productivity.

Eng. Hicks Waswa, Kenya Power and Lighting Company

The rest of this section sets out the discussions that occurred during the workshop around the identification of the principal drivers of loss and power quality degradation in Kenya, the diagnostic programme now underway to disaggregate them, and the regulatory gaps that currently prevent them from being priced or enforced.

3.1. System Losses

System losses, both technical and commercial losses, remain one of the most persistent barriers to utility performance across many African power systems.

Kenya Power's total system losses stand at 22.07%, having improved from a previous 24.08%, but remain significantly above the regulatory threshold of 16.50% set by EPRA, the regulator.

Eng. Hicks Waswa, Kenya Power and Lighting Company (KPLC)

The financial implications of these losses are substantial.

Each percentage point of system losses costs approximately KES 1.4 billion (~GBP 8.07 million) per year. The 5.57% gap between actual and allowable losses represents approximately KES 7.8 billion (~GBP 44.96 million) per year in unrecovered costs.

Dr. Eng. Fenwicks Musonye, Energy and Petroleum Regulatory Authority (EPRA)

Technical losses arise from the physical and engineering characteristics of the electricity network, such as:

- Line resistance and conductor losses
- Transformer inefficiencies
- Voltage imbalance
- Harmonic distortions
- Power factor degradation
- Network over- or under-loading

The revenue consequences of these physical effects can be traced at the level of the individual connection.

A case study of a C&I user showed that harmonic distortion was responsible for GBP 14,953 per year in unbilled energy.

Anne Wacera Wambugu, School of Computing and Engineering Sciences (SCES), Strathmore University

Commercial losses arise from non-technical factors that prevent full revenue recovery, including:

- Illegal connections and energy theft
- Meter tampering
- Estimated billing arising from metering gaps
- Weak collection systems
- Billing inefficiencies

3.2. Power Factor Degradation

Power factor (PF) is the ratio of real power (the power that does useful work) to apparent power (the total power drawn from the network). Operating on a scale from 0 to 1, a high PF (at or above 0.90) indicates that electricity is being used efficiently with minimal energy waste.

PF degradation occurs when reactive power demand increases relative to active power, typically due to inductive loads such as motors. When the PF is low, reactive power circulates through the network without contributing to useful work, while occupying network capacity and causing thermal stress on conductors and transformers. The result is accelerated equipment degradation and higher technical losses.

Power factor correction through installation of capacitors is the standard remediation measure. Power factor penalty fees are, in turn, intended to incentivize users to undertake this correction. Whether those penalties encourage the behaviour they are meant to correct depends on how PF is measured.

> *A Power Quality Analysis (PQA) case study revealed a facility whose average monthly power factor was 0.8, but granular measurements showed it collapsing to near zero during daytime operations, a pattern that also signals the absence of power factor correction.*
>
> **Anne Wacera Wambugu, Strathmore SCES**

Notably, billing is typically based on average monthly PF rather than time-resolved measurements. As a result, periods of extremely poor PF performance are offset by periods of improved performance, particularly during low-activity periods such as night-time operations. For the above case study, the evidence shows that the averaging approach underrepresents the actual operational stress imposed on the network during peak distortion periods and weakens incentives for corrective action.

3.3. Harmonic Distortion

Modern electricity systems are increasingly characterized by the growth of non-linear electrical loads, including LED drivers, inverter-based appliances, variable speed motor systems, and electric vehicle (EV) charging infrastructure. While the spread of these technologies support electrification and energy efficiency goals, participants noted that they may also introduce additional power quality challenges, if poorly managed.

Harmonics are electrical frequencies that occur at multiples of the system’s fundamental frequency (50 Hz in Kenya). The large-scale adoption of non-linear loads creates harmonics that contribute to transformer overheating, fuse failures, smart meters undercounting actual consumption, and additional stress on distribution infrastructure.

> *Energy efficiency means lower energy bills, but the large-scale adoption of non-linear loads creates harmonics. Consumers do not understand their role in generating these distortions, and the blame tends to be placed on the utility.*
>
> **Anne Wacera Wambugu, Strathmore SCES**

3.4. Reliability Beyond the Meter

Reliability is conventionally treated as a property of the network up to the customer's meter. Anne Wacera Wambugu (Strathmore SCES) and Eng. Hicks Waswa (KPLC) presented evidence that a material share of the reliability and loss problem originates on the other side of it. Conventional practice assumes that customers consume electricity, pay bills, and report outages, and that the resulting load is broadly predictable. Measurement at the metering panel indicates otherwise: the quality of customer-side load, expressed through harmonic injection and depressed power factor, propagates back into the network and degrades utility assets, while customer-side distortion causes correctly certified meters to under-record the energy actually delivered. On this evidence, the meter is not a boundary at which the utility's exposure ends.

The condition of premises wiring is a principal driver. A substantial share of low-voltage installation work is carried out by an informal technician workforce operating outside a quality regime, and the resulting workmanship is frequently substandard, with undersized conductors, omitted earth conductors, and routine improvised distribution arrangements. Individually, each installation is negligible but multiplied across several million premises, undersized conductors heat, losses accumulate, and utility equipment absorbs the cost of work the utility neither performed nor inspected. Participants emphasised that this is not a fault condition to be detected and cleared, but a standing characteristic of the installed base; nor is it theft, which utilities are already equipped to pursue. It is a quality problem that conventional loss accounting cannot disaggregate, because it presents as technical loss distributed across the network rather than as an identifiable event at an identifiable premises.

Regulations exist. Tariff design, power factor penalties, and harmonic limits regulate the price of the connection and the technical performance of the load behind it. The quality of the physical connection itself, or the competence of those installing is also regulated but enforcement is weak. Therefore, the impacts of investment in network reliability will continue to be partially dissipated in premises wiring and emerging loads will be loaded onto the grid through precisely these installations.

3.5. Diagnostics: The April 2026 Pilot Initiative

Each of the drivers described above is obscured at the level of aggregate loss statistics. To improve understanding of system losses and power quality issues, participants discussed an ongoing pilot initiative launched in April 2026. The first phase covers the Nairobi region, encompassing 19,612 transformers, with a subsequent national audit planned for approximately 83,626 transformers.

The initiative combines multiple analytical and diagnostic tools, including feeder monitoring, power quality monitoring, smart meter analytics, geospatial analysis, satellite-based analysis, targeted field inspections, and load fingerprinting.

Mr. Harrison Mwaura (Strathmore SCES) highlighted load fingerprinting as an important tool for distinguishing different categories of consumer electrical behaviour beyond conventional consumption averages. By analysing detailed load characteristics, utilities can better identify consumption patterns, abnormal network behaviour, and potential sources of system losses.

> *With load fingerprinting, two consumers who seemed similar electrically may turn out to be completely different: one harmonically clean, the other causing high harmonic distortions. It tells us what kind of consumers we have at the feeder level, and how they are affecting each other.*
>
> **Mr. Harrison Mwaura, Strathmore SCES**

The same technique addresses a parallel problem in asset utilisation. Distribution networks currently face a dual challenge: the ideal transformer utilisation rate is approximately between 60% and 70% of rated capacity, yet some transformers operate at utilisation rates as low as 20%, resulting in avoidable magnetisation losses and poor returns on infrastructure investment, while other parts of the network experience overloading and elevated operational stress. Poor power factor and harmonic distortions contribute to additional heating of cables and transformers, higher technical losses, and accelerated equipment degradation. Load fingerprinting can help identify both categories: underloaded transformers that may require resizing and overloaded ones that require reinforcement.

Mr. Kenneth Mugo (Strathmore SCES) presented a satellite-based approach, which entails examining temporal variation in night-time illumination, as a proxy for reliability. A key insight is that brightness and stability are not the same thing.

> *When an area has stable night-time radiance patterns, it shows that the infrastructure is absorbing demand well. Highly variable patterns (bright one night and dim the next) show that the infrastructure is struggling to maintain steady supply.*
>
> **Mr. Kenneth Mugo, Strathmore SCES**

This analytical approach helps identify two broad categories of distribution areas:

- **Balanced growth zones**: areas with relatively reliable grid infrastructure, which may be suitable for additional productive loads such as eCooking, EV charging, and other electrical loads.
- **Fragile access zones**: areas that are grid-connected but exhibit reliability constraints, where voltage stabilisation and reliability improvements should proceed before the introduction of significant new appliance loads.

3.6. The Regulatory and Cost Recovery Gap

The diagnostic capability described above has value only to the extent that the regulatory framework can act on what it reveals. At present, several of the loss drivers identified fall outside the reach of existing instruments.

Under Kenya's *Energy Act 2019*, the minimum power factor (PF) is set at 0.90, and penalties are applicable across all consumer categories. Under the current tariff framework, C&I users consuming more than 15,000 kWh per month are subject to PF penalties. However, as discussed in Section 3.2, billing is based on average monthly PF rather than time-resolved measurements, which underrepresents actual network stress.

At the same time, small commercial consumers below the 15,000 kWh threshold, as well as emerging loads such as EV charging infrastructure, are not subject to PF penalties. This means there are no regulatory incentives for proactive power factor correction among a growing category of non-linear loads.

Furthermore, according to the *Kenya National Grid Distribution Code (KNGDC)*, harmonic limits on total harmonic distortion are set at 8% for low-voltage connections and 5% for medium-voltage connections. Despite these requirements, workshop discussions highlighted that enforcement and cost recovery mechanisms for harmonic distortions remain underdeveloped.

Discussions emphasised that aggregated loss statistics often obscure the underlying drivers of losses. Without improved disaggregation, utilities may struggle to:

- Design targeted interventions
- Improve enforcement
- Accurately quantify the impact of different operational problems
- Prioritize investments

There is, therefore, a need to improve visibility into how losses emerge across distribution systems and between consumer categories. The ongoing study is expected to generate the quantitative evidence required to justify regulatory reforms that consider evolving power quality challenges, including:

- Tariff structures that reflect time-resolved PF and harmonic performance
- Updated technical standards covering non-linear loads and EV charging
- Improved metering and monitoring frameworks capable of capturing harmonic distortions

- Consumer awareness and compliance initiatives that clarify the role of consumer equipment in generating power quality problems

Participants recognised that such reforms require investment ahead of the returns they generate, and that the tariff is the only real instrument through which that sequencing can be managed despite its potential implications for demand (and potentially equity depending on how increases are structured).

> *The tariff can be raised today to fund the investment that lowers the tariff tomorrow. Invest today, enjoy tomorrow.*
>
> **Dr. Eng. Fenwicks Musonye, EPRA**

4. Utility Operations, Sustainability, and Bankability

4.1. Operations, Maintenance, and Financial Recovery

Workshop participants noted that while energy transition discussions focus heavily on generation expansion, electrification targets, renewable energy deployment, and infrastructure finance, utility operations ultimately determine whether electricity systems remain reliable, financially sustainable, and capable of supporting productive demand growth.

> *We do not have major constraints on generation; the challenge is in the evacuation of power to the consumer. Grid expansion has increased access, but distribution infrastructure upgrades have not always kept pace, contributing to reliability challenges*
>
> **Eng. Raphael Ndolo, Operations and Maintenance, Kenya Power**

Long-term reliability depends on sustained investment in:

- Preventive maintenance
- Feeder monitoring
- Transformer health management
- Metering integrity
- Network reinforcement
- Rapid fault detection and response

While electricity access can be achieved through capital investment, reliability is maintained through effective operations and maintenance. That distinction carries directly into the utility's financial position. Poor reliability and high system losses contribute to lower revenue recovery, higher maintenance costs, reduced consumer confidence, lower productive electricity demand, and weaker investment attractiveness. Improved reliability and lower losses, conversely, contribute to higher productive electricity use, better asset utilisation, stronger revenue recovery, and improved long-term financial sustainability.

4.2. Utility Bankability

Dr. Hanaan Marwah (Lightrock) offered a private sector perspective on utility bankability. Several factors were identified as influencing utility bankability:

- **Policy alignment**: utilities require supportive policy environments that enable cost-reflective tariffs and sustainable revenue recovery. Where tariff adjustments are delayed or restricted without compensatory subsidies or government support, utility financial performance may deteriorate, reducing investor confidence.
- **Tariff design**: tariffs must be designed to recover prudent investment costs, fund infrastructure maintenance, and support service quality improvements over time.
- **Payment risk**: utilities depend on the ability to accurately bill and successfully collect payments from consumers. Metering gaps (e.g., Nigeria's reported 50% gap) leave large portions of consumption on estimated billing, which undermines revenue recovery.
- **Regulatory risk**: utility revenues are strongly influenced by regulatory decisions. Predictable regulatory processes and constructive regulator-utility relationships improve investor confidence and support long-term planning.
- **Stakeholder management**: effective management of relationships with governments, regulators, investors, and communities is critical. Infrastructure concessions and investments programmes often struggle when institutional relationships deteriorate.
- **Organisational culture**: utilities that foster strong performance management, innovation, accountability, and customer-focused service delivery are better positioned to improve operational and financial outcomes.
- **Social and environmental risk**: infrastructure investments may be affected by land acquisition challenges, community concerns, environmental compliance requirements, and displacement issues, all of which can influence project implementation and investment attractiveness.

5. eCooking as a Strategic Demand-Side Opportunity

The preceding sections establish the revenue problem facing distribution utilities. eCooking was identified as both a demand-side response to that problem and a clean energy transition strategy.

5.1. The Case for eCooking

Prof. Ed Brown noted that eCooking represents a significant opportunity to increase electricity consumption among existing customers, making it a relatively low-cost pathway for utilities to grow consumption and revenue without investing in new connections. Scaling eCooking adoption means better asset utilisation, more revenue per unit of infrastructure investment, and improved financial sustainability for utilities.

Mr. Murefu Barasa (Loughborough University) presented a series of reflections on whether lower electricity tariffs incentivize eCooking adoption. Existing evidence suggests that demand is relatively inelastic among the lowest-income households who are on lifeline tariffs and that a tariff reduction is therefore more likely to drive adoption among middle-income households. Murefu presented the methodology design considerations being taken into account within his planned fieldwork addressing these issues via experimental piloting of different tariff reductions amongst different consumer segments in Kenya.

Dr. Will Clements (Gamos/MECS) shared findings from the Cooking Support on Mini-Grids (COSMO) project. Case studies from PowerHut (Tanzania), a Southampton University pilot (Kenya), EarthSpark (Haiti), and NAMHUS (Nepal) led to three key conclusions: eCooking is most effective when integrated into mini-grid planning from the outset, reliable supply is essential to building consumer confidence, and eCooking offers significant revenue benefits for operators.

Participants emphasised that eCooking presents both opportunities and operational challenges for electricity systems. On one hand, increased electricity use can support productive demand growth and improve utility revenues. On the other hand, widespread adoption of new electrical loads may create additional network stress if infrastructure upgrades do not keep pace.

That constraint extends past the meter. An electric pressure cooker or induction hob draws substantially more current than the lighting and small appliance loads much existing premises wiring was informally installed to carry, and the wiring quality problem set out in Section 3.4 therefore potentially imposes a practical ceiling on how far eCooking can be scaled into the existing connected base. A tariff and a financing mechanism place the appliance in the kitchen but neither establishes that the circuit it is plugged into can carry it. Nevertheless, emerging evidence suggests both that the appliance draw for electric cooking appliances (particularly for EPCs) is substantively lower than frequently estimated. That's important because a common intuitive calculation is: “an electric cooker is 1–2 kW, therefore switching cooking to electricity adds 1–2 kW per household.” That calculation is wrong because **kW is instantaneous power, whereas the household's additional electricity consumption is measured in kWh**. A 1 kW cooker does not draw 1 kW continuously for the whole day. It cycles on and off, and efficient appliances substantially reduce the time and energy required to cook. Additionally, institutional eCooking loads can actually be supportive of grid efficiency.

> *Institutional eCooking can introduce additional resistive demand, helping improve overall power factor of the system, and improve network efficiency and transformer utilisation.*
>
> **Mr. Harrison Mwaura, Strathmore SCES**
>
> *eCooking is becoming increasingly cost-effective for urban residents. A shift from biomass to grid-based energy would also improve utility sustainability by expanding the customer base and increasing per-connection consumption.*
>
> **Patrick Tutembe, Electricity Regulatory Authority, Uganda**

Transitioning 1 million households to eCooking would translate into at least 1 GW of new load to the system, which means more revenues for the utility, but also more stress on network infrastructure during peak hours.

Mr. Murefu Barasa, Loughborough University

Peak demand typically occurs between 6 PM and 10 PM. Both eCooking and e-mobility are expected to introduce load profiles that coincide with these peak periods, creating challenges that utilities will need to plan for.

Eng. Hicks Waswa, KPLC

5.2. The eCooking Market

Dr. Jon Leary (Gamos East Africa/MECS) presented on the progress made advancing eCooking in Kenya. Kenya's eCooking ecosystem has evolved significantly over the past decade. Early efforts included Kenya Power's eCooking awareness campaigns launched in 2017, which used mainstream media, social media, and cooking demonstrations to build consumer awareness. This was followed by the publication of the eCookBook in 2019, which demonstrated the time and cost savings associated with electric pressure cooking, alongside research highlighting the role of utility-enabled finance in improving appliance access. In 2020, EnDev and CLASP launched Kenya's first result-based financing programme for electric pressure cookers. More recently, the eCooking Capacity Building and Market Development Programme (eCAP), launched through a partnership involving Kenya Power, MECS, UK PACT, and the Clean Cooking Alliance Kenya, has supported consumer awareness, technical training, tariff piloting, and the development of the Kenya National eCooking Strategy.

Participants noted that adoption remains constrained by consumer perceptions:

- Biomass-cooked food is considered to taste better.
- Electricity is deemed more expensive than alternative cooking methods.

Interestingly research undertaken into both issues shows that neither view is accurate (e.g. blind taste tests do not show a preference for 'smoky' flavours despite the popular perception) so it is the perception that limits adoption rather than the reality. Nevertheless, affordability remains a critical determinant of eCooking adoption. Interestingly, evidence from Nigeria shows that most households use illegally obtained electricity to support cooking activities, among other uses. This indicates that underlying demand for eCooking exists. Workshop participants debated the interplay of these issues vigorously with the discussion ultimately returning to the question of price and the observation that well-designed eCooking tariffs could play an important role in accelerating eCooking uptake while supporting utility revenue growth (alongside mechanisms for reducing the upfront cost of appliances). Patrick Tutembe (ERA) shared that Uganda has already implemented an eCooking tariff, which is meant to make additional loads such as eCooking more attractive and affordable. Similarly, Dr. Leary expressed support for the introduction of an institutional eCooking tariff as part of Kenya's ongoing tariff review process.

Despite the progress already made, scaling eCooking will require significantly greater investment. Dr. Leary discussed the experiences that MECS has had in unlocking financing from the African Development Bank (AfDB) for eCooking initiatives in East Africa, noting that development finance institutions are generally not looking to develop nascent markets; rather, they aim to scale markets that have already demonstrated demand and an operational track record. Kenya is well-positioned to attract such financing, given the progress of its eCooking ecosystem.

6. Institutions, Regulation, and Capacity Building

6.1. Coordination, Partnerships, and Regulatory Independence

Participants emphasised that electricity sector challenges are not solely technical; they are also institutional, financial, regulatory, and social in nature. Addressing these challenges requires stronger coordination among: utilities, regulators, universities and research institutions, development partners, and financial institutions.

> *There is a need for continued collaboration between academia and industry. This allows the identification of the skills sets required by industry and the design of programmes that prepare graduates to solve real-world challenges. This is particularly important as the energy transition introduces new loads such as eCooking, e-mobility, and data centres.*
>
> **Eng. Dr. Julius Butime, Strathmore SCES**

> *We must keep learning from one another to ensure decisions are informed by multiple perspectives rather than made in isolation. Even within a utility, the perspective you receive depends on who you engage with. Meaningful collaboration therefore requires bringing together the right people and viewpoints before decisions are made.*
>
> **Eng. Hicks Waswa, KPLC**

Participants further discussed the realities of regulatory independence, noting that regulators operate within broader political, economic, and institutional environments. While governance structures may involve political appointments and regulatory decisions may be influenced by wider prevailing conditions, the importance of maintaining technical rigor and evidence-based decision-making was emphasised.

> *Technical independence is what ultimately matters. Sound decisions depend on sound evidence. If the underlying data and models are wrong, decisions will be based on the wrong variables.*
>
> **Dr. Eng. Fenwicks Musonye, EPRA**

6.2. Common Challenges and Emerging Responses

Discussions from across Africa and the Caribbean highlighted that many electricity sector challenges cut across markets of very different sizes and levels of development.

In small-island systems such as St. Lucia and Jamaica, regulators face significant institutional and resource constraints, including limited staffing, dependence on government funding, low public awareness of regulatory functions, and reliance on external partnerships to supplement technical capacity.

In larger electricity markets such as Nigeria, Uganda, and Kenya, participants reported collection losses associated with continued electricity theft and metering gaps, alongside affordability concerns. Unsafe wiring practices were also raised across these markets, identified both as a safety risk and, as set out in Section 3.4, as a driver of technical loss that conventional loss accounting does not capture.

Several other challenges emerged across jurisdictions:

- High technical losses
- Underdeveloped data systems that constrain data analytics, modelling, evidence-based decision-making, and more accurate billing
- Limited power quality monitoring capabilities
- Infrastructure planning challenges
- Human resource and technical capacity concerns
- Reliability concerns that discourage productive electricity use
- Limited awareness of the safety of eCooking technologies

Nonetheless, several initiatives demonstrate how collaboration and innovative mechanisms can produce meaningful results.

> *With over 10 million electricity installations and only a limited number of enforcement officers, enforcement efficiency remains a challenge. Collaboration with academia is helping introduce more innovative and scalable detection and enforcement approaches.*
>
> **Lee Okombe, EPRA**
>
> *Through the whistle-blower reward policy, citizens who report illegal connections receive 6% of the amount recovered from offenders. This transforms community members into active participants in reducing electricity theft and improving compliance.*
>
> *Under Ghana's Self-Help Electrification Programme, communities invest in electricity poles and the government undertakes grid connection. This has helped accelerate electrification across many rural areas in Ghana.*
>
> **Dr. Ishmael Ackah, Technical Advisor to the Minister of Energy and Green Transition, Ghana**

6.3. UK Partnerships and Industry Engagement

The workshop included a dedicated session on the UK's engagement in supporting energy sector initiatives across varied economies of the Global South. Peter Weston (UK Energy Systems Catapult) provided an introduction to some of the partnerships that he has been nurturing in support of the strengthening delivery capability across the energy value chain through partnerships with utilities and other stakeholders. This was supplemented by short presentations from a number of UK-based companies and institutions who have been supported by Innovate UK under the Energy Catalyst programme: these included enTrust Microgrid (Xiongwei Liu), Microgen Renewables (Martin Cowsill), Solarpak Development Ltd. and the TEA@SUNRISE initiative (Mark Spratt) and PAS Automation System (Priyesh Gosai).

7. The Need for Locally Grounded Models

7.1. Existing Modelling and Decision-Support Frameworks

Alongside the wide-ranging discussion of operational challenges and the detailed discussion of outages, voltage instability, power quality, tariffs, system losses, and utility cost recovery, the workshop also explored the role of energy modelling within these contexts. Dr. Vivien Foster (Imperial College London/CCG) presented the Data-to-Deal framework and CCG's open-source modelling ecosystem, which encompasses geospatial, techno-economic, and financial models, alongside capacity-building programmes to support energy planning and investment decisions.

Dr. Foster also discussed the economics of e-mobility in developing countries, noting that EV purchase costs premiums are expected to decline substantially, potentially reaching 20-40% by 2030.

> *While electric vehicles may have a relatively modest impact on overall electricity generation, their impact on local distribution networks can be substantial. This makes the timing and location of e-mobility deployment critical planning considerations.*
>
> **Dr. Vivien Foster, Imperial College London/CCG**

CCG's financial modelling tools were also highlighted as mechanisms for linking energy planning with investment and financing decisions:

> *Many LMICs access only a fraction of available climate finance. FinTrack helps countries identify what climate finance is available to them, the terms, and how accessible it is.*
>
> *Clean technologies are highly sensitive to cost of capital, which drives a large share of total project costs. FinCoRE enables users to assess how policy and market changes impact financing costs, and provides robust inputs for energy system modelling and investment planning.*
>
> *MINFin translates investment needs into financing requirements, estimates funding available to service those financing requirements, and assesses technology-level bankability.*
>
> **Ms. Ginny Ip, CCG**

Finally, Dr. Pietro Lubello (University College London/CCG) presented modelling work that he and his colleagues had carried out related to Kenya's National eCooking Strategy. Key appliance efficiency benchmarks include:

- Coil hotplate: 64% efficiency
- Induction cooker: 76% efficiency
- Electric pressure cooker: 100% efficiency

Dr. Lubello also highlighted analytical approaches used in energy planning and uncertainty analysis, including:

- Robust Decision Making — a framework combining exploratory modelling and stakeholder engagement to identify robust strategies
- Latin Hypercube Sampling (LHS) — a statistical method for efficiently combining multiple uncertainties in scenario analysis

7.2. Why Local Context Matters

The workshop highlighted the limitations of applying generalized electricity planning models to African distribution environments that lack sufficient localization and operational validation.

> *"Least-cost" models are not always reflective of operational realities. For example, they can underestimate the economic and reliability costs associated with transient outages, such as lost production, reserve activation, and equipment stress.*
>
> **Eng. Hicks Waswa, KPLC**

More broadly, many conventional planning approaches rely on assumptions derived from contexts with significantly different network conditions, regulatory environments, and consumption behaviours. As a result, they may not adequately capture realities commonly observed within African electricity systems, including:

- Suppressed demand
- Reliability-driven behavioural adaptation
- Localized power quality challenges
- Informal consumption patterns
- Rapidly evolving productive electrical loads
- Uneven feeder loading
- Underutilised or overloaded transformers

Participants emphasised that while existing planning and financing frameworks provide valuable analytical foundations, their effectiveness ultimately depends on the quality and contextual relevance of the underlying assumptions and data. Stronger, locally grounded modelling approaches, supported by high-resolution operational data, are therefore essential for improving planning, regulation, and investment decisions across African electricity systems.

8. Conclusion

The workshop highlighted a significant shift in how African electricity systems need to be understood and planned. While expanding access remains important, electricity sector success increasingly depends on the reliability, quality, affordability, and productive use of power.

In many LMICs, low per-connection consumption means that operations and maintenance costs outpace the revenue generated per customer. Expanding productive electricity use through applications such as eCooking, e-mobility, and productive C&I electrification is therefore critical to improving utility sustainability and maximizing the value of existing infrastructure investments.

Participants emphasised that unreliable and poor-quality electricity suppresses productive demand, distorts planning assumptions, increases system losses, and weakens utility financial performance. Emerging challenges, including power factor degradation, harmonics, and new electrical load profiles, further underscore the need for greater operational visibility, stronger analytical capabilities, and more adaptive regulatory frameworks.

Addressing these challenges will require closer collaboration among utilities, regulators, researchers, development partners, financial institutions, and consumers. Supported by locally grounded data and evidence-based decision-making, such collaboration can help create the conditions for reliable, productive, and financially sustainable electricity systems across Africa.

> *The question is no longer whether these challenges exist; the evidence is already clear. The question is what each of us will do next. The value of this workshop will ultimately be measured by the partnerships, research, policies, and investments that emerge from these discussions.*
>
> **Prof. Dan Parsons, Pro-Vice Chancellor (Research and Innovation), Loughborough University**